Lea: Environmental Engineer Career Pathway Lesson

Trash Pollution & Engineering Solutions

Storm Water Career: Engineer

All Careers Full- Course Lesson Plan #:
6 of 15

Next Lesson Plan Title (Full-Course):
Sampling: When, What, & How Much

Select Career Short-Course Lesson Plan #:
4 of 6

Next Lesson Plan Title (Short-Course):
Scope Quest: Unraveling Project Possibilities

SUMMARY

In this lesson, students will explore the challenges of trash pollution in storm water systems by calculating their site's waste and examining material persistence. They will also design trash capture solutions, enhancing their critical thinking and engineering skills while learning to protect local waterways.

FOCUS & GOALS

In learning the principles of structures and trash capture, students will:

- Understand the link between trash pollution and storm water systems
- Examine real-world examples of structural trash capture technologies and examine how they reduce pollution
- Use design thinking and engineering principles to evaluate and develop trash capture solutions

MATERIALS NEEDED

- Optional: measuring tape, access to dumpster location information, clipboard & colored pens or pencils
- Trash Item Cards, Decomposition Rate Cards, and Voting Cards
- Timer
- Mock Site SWPPP Map (Lesson Plan 2)
- Trash Capture Technology Technical Sheets and Voting Cards
- PBL Track: Materials to create a trash capture device prototype; Access to CAD software or PowerPoint/Google Slides.

LEARNING OBJECTIVES

- Analyze site trash production
- Investigate trash degradation
- Evaluate types of structural trash capture technologies
- Create a trash capture plan and device design

VOCABULARY

Decomposition - The process of breaking down a whole substance into simpler parts.

Constraints - Limits or restrictions that must be considered when designing a solution.

Engineering Design Process - A step-by-step method engineers use to solve problems and build effective solutions.

Source Reduction - Cutting down waste at its origin by using fewer materials or creating less trash.

Trash Capture Device - A structure that traps solid waste to prevent it from entering storm water systems.

Background

In previous lessons, students explored the storm water cycle and the movement of water through natural and built environments. They investigated how impervious surfaces like roads and buildings increase runoff, carrying pollutants such as sediment, oil, and trash into storm drain systems. Students also examined the concept of watersheds, assessed local land uses, and learned to map runoff patterns and pollutant sources.

Students also previously learned about Best Management Practices (BMPs), including both structural and non-structural approaches to storm water management. Non-structural BMPs include public education and policies that reduce waste generation. Structural BMPs physically treat and control the flow of storm water, and can include inlet protection, permeable pavements, and more.

This lesson builds on that structural BMP knowledge by introducing those specifically designed to capture trash. Structural trash capture technologies prevent solid waste from entering waterways by trapping debris at storm drain inlets, within storm drain pipes, or in treatment chambers. Examples include curb inlet covers, catch basin inserts, hydrodynamic separators, netting systems, litter booms, and full-capture systems. These technologies fall into three major categories:

- Inlet Devices: curb inlet covers, catch basin hoods, etc.
- In-line or End-of-pipe Devices: netting systems, hydrodynamic separators, etc.
- Open Water Devices: litter booms, floating traps

These technologies vary in design, location, and visibility. For example, curb inlet covers are common and easy to observe on many roadways, while catch basin hoods are installed underground, making them difficult to see. Students will learn about and evaluate these trash capture technologies as they prepare to design their own.

Local and national regulations have helped drive the use of trash capture technologies. In Hawai'i, the Hawai'i Department of Transportation (HDOT) has implemented a Trash Reduction Plan as part of its Municipal Separate Storm Sewer System (MS4) Permit. Similar efforts across the country, like the full-capture mandates in California, have pushed innovation in trash capture design. These regulations create opportunities for engineers to solve practical environmental problems in their communities.

In this lesson, students will learn how trash impacts the health of water systems and examine the role that engineered structures play in minimizing pollution. Through multiple hands-on activities, they will calculate how much waste is generated on their site, test how long various materials last in the environment, investigate trash capture device options, and design their own trash capture device. Students will also practice skills related to the engineering design process, including brainstorming, designing, and evaluating environmental and structural solutions. By applying engineering practices to a storm water issue, students will gain a deeper appreciation for how interdisciplinary thinking can lead to innovative ways to protect our oceans, streams, and communities.

I. Identify Need & Constraints Activity

1. Share with students that according to the Keep America Beautiful 2020 National Litter Study Report, overflowing containers contribute almost 2% of the litter found on our roadways. While this may not seem like a large amount of litter, it adds up alongside litter from motorists, pedestrians, and improperly secured loads. The litter from overflowing containers has a larger impact on local roadways, such as the ones near your site school or home, and has a larger impact on local roadways than any other source roadway type.
2. Provide students individually or in small groups the *Measuring Trash Volume* worksheet. Take students on a 10-minute walk around the site to identify where trash actually accumulates (e.g., near fences, the cafeteria, or storm drains). Optional to also measure an available dumpster.
3. Have students complete the worksheet and discuss their answers to the reflection question.

II. Research the Problem Activity

1. Divide the students into small groups.
2. Hand each group a shuffled deck of *Trash Item Cards*.
3. Create a timeline path on a flat surface, using the *Decomposition Rate Cards*, stretching from fastest to decompose to slowest to decompos*e,* and point it out to the students.
4. Give students five minutes to talk it out and physically lay your trash cards next to the decomposition rate scale markers where you think they belong after each material has been buried in soil for 4 weeks.
5. Gather the groups around the timeline. Go down the line from fastest to slowest, revealing the scientifically accepted decomposition timeline.

II. Research the Problem Activity Continued

6. As you correct the cards' placements, have students visually analyze the items by prompting them to consider if a material is buried in soil or trapped in a storm drain for several weeks, what physical changes may be expected.
7. Conclude the activity by asking students to reflect on the following::
    - Question 1: Why does an environmental engineer need to know that a plastic bottle takes 450+ years to break down when they are designing a trash capture device for a storm drain?
    - Question 2: If a material degrades quickly, does it mean we don't have to worry about catching it in our water systems? Why or why not?

III. Exploring Possible Solutions Activity

1. Set up three stations with corresponding printed *Trash Capture Technology Technical Sheets* at each station.
    - Station 1: Inlet Devices (e.g., Curb Inlet Covers, Catch Basin Hoods).
    - Station 2: In-Line Devices (e.g., Netting Systems, Hydrodynamic Separators).
    - Station 3: Open Water Devices (e.g., Litter Booms, Trash Skimmer Vessels).
2. In their small groups, assign a group to a station.
3. Give every student a *Exploring Trash Capture Technologies* worksheet. Tell them they have 5 minutes to read the tech sheets and log one "Strength""(Pro) and one "Weakness" (Con) for the rows matching their station. Let them know they should learn as much as they can as they will become the experts that will inform the other groups about their features.
4. Bring everyone back together. Provide each group with a set of *Voting Cards*: Green (Low Cost / High Efficiency / Easy Maintenance), Yellow (Moderate), and Red (High Cost / Low Efficiency / Difficult Maintenance).
5. Inform the students that you are going to share a community problem. Everyone will vote using their cards based on gut instinct or what they can see. But when the cards go up, the designated Station Experts will be called on to share the exact features of their technology that justify that score.
6. Read a scenario, allow students to vote with their colored cards, and then call on the correlating expert group to look at the room's votes and share one specific feature about their technology that influences the ratings.
7. Wrap up the activity by challenging the students to bring their collective expertise together, Provide each group with the *Operation: Trash Capture* worksheet and guide them through completing Part 2: Design Your Trash Capture Solution.

Scenarios

Scenario 1: The Tight-Budget Drainage Project

Our local neighborhood has an issue with plastic wrappers washing into roadside storm drains. However, the town has almost zero budget for construction. Look at the Inlet Devices on display at Station 1. On the count of three, everyone vote on this device's Cost!

Scenario 2: The High-Flow River Rescue

A large local river is carrying massive loads of floating trash. We need something that can handle strong currents and heavy debris, but our crew doesn't have specialized heavy machinery to maintain it. Look at Open Water Devices (Station 3). On the count of three, vote on a Litter Boom's Maintenance! (Following the vote and feature discussion, ask students if they would recommend a different device and why.)

Adaptations and Resources

Storm Patrol Project-Based Learning Track:

Selecting a Possible Solution Activity

1. Provide students with the *Operation: Trash Capture* worksheet.
2. As a team have students use the worksheet to help them determine the category and type of trash capture device they would design for their project site.
3. Students will work together to brainstorm their device design by using the provided planning table to consider installation location, maintenance needs, safety concerns, etc.
4. They will then sketch and describe their design, and list the materials they would need to build it.

Project-Based Learning Track Continued

5. Students then finish the worksheet by answering the reflection questions about design challenges.
6. Lead a discussion with students about how they would create better or more efficient trash capture technologies if they had access to unlimited resources.

In creating their design, ensure students:

- Refine their designed sketch before either building the small-scale prototype or building it in the design software.
- Test a physical prototype to assess performance using simulated pollutants in water. They will then record and analyze the results, and then adjust their design and retest if needed.
- Students should also develop a maintenance plan and identify who would be needed to maintain the device, how often, and what tools would be needed.
- Encourage including the student's final prototypes in their final project designs and presenting them during the final group presentations in Lesson 14.

Students continue to utilize the Engineering Design Process to design a BMP for their project site by completing Section 4 of their *Storm Patrol Project Workbook*.

Activity-Centric Learning Track:

Conduct Activities I, II, and II.

Tips to Truncate Lesson:

- Give students a summary of the amount of trash expected from the mock site instead of having them work through the work sheet.
- Provide students a summary of trash degradation rates instead of having them conduct the activity.
- Skip students sharing with the class their device selections and designs.

Tips to Extend Lesson:

- Start the full biodegradability experiment or have students conduct this experiment at home. Use the Science Buddies experiment (in resources) to learn how to conduct this activity.
- Research robotic trash capture solutions and revisit their design with a robotic or hybrid concept. Encourage the teams to identify the benefits and challenges of automation in trash capture. Use the Science Buddies science project for inspiration (link in resources).
- Have students complete the additional section of Exploring Trash Capture Technologies
- Invite students to check out the interactive trash capture map at TrashFreeHawaii.com to explore what HDOT is doing across the state.

Resources:

- Environmental Protection Agency (EPA), *Trash Capture Technologies*, https://19january2021snapshot.epa.gov/trash-free-waters/trash-capture-technologies_.html

Reference Experiments and Projects

- Science Buddies, *Do Your Storm Drains Keep the Ocean Trash Free?*, https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvEng_p031/environmental-engineering/storm-drains-keep-the-ocean-trash-free
- Science Buddies Staff, *Clean Up The Water with a Trash-Skimming Robot*, https://www.sciencebuddies.org/science-fair-projects/project-ideas/Robotics_p061/robotics/trash-skimming-robot
- Science Buddies, *How Long Does Trash Last?*, https://www.sciencebuddies.org/science-fair-projects/project-ideas/EnvSci_p010/environmental-science/what-materials-are-biodegradable
- Science Learn, *Learning Hub: Pokapū Akoranga Pūtaiao*, https://www.sciencelearn.org.nz/resources/1543-measuring-biodegradability

Additional Extension Resources

- Hawai'i Department of Transportation (HDOT), *Trash Free Hawai'i Interactive Maps*, https://www.trashfreehawaii.com/trash-reduction-plan/
- HDOT, *Trash Reduction Plan*, https://www.stormwaterhawaii.com/wp-content/uploads/2020/10/Trash-Reduction-Plan_FINAL-10-18-16.pdf
- HDOT, *Post-Construction BMP Manual*, https://www.stormwaterhawaii.com/wp-content/uploads/2022/07/PC-BMP-Manual_220718-FULL.pdf
- EPA, *Advancing Sustainable Materials Management: 2018 Tables & Figures: Assessing Trends in Materials Generation and Management in the United States*, https://www.epa.gov/sites/default/files/2021-01/documents/2018_tables_and_figures_dec_2020_fnl_508.pdf
- City and County of Honolulu, *How Long Until It's Gone*, https://www.honolulu.gov/swq/wp-content/uploads/sites/32/2023/08/HowLong-final-scaled.jpg