



ENGINEERING LANDFORMS

FIELD STUDY

Educator Curriculum

Fall 2017

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Program Description:

What Teachers read on our Website:

In this Next Generation Science Standards-aligned field program, students actively engage in the engineering design process to tackle stormwater engineering problems. This program is designed for students studying the FOSS Landforms Unit, the STC Land and Water Unit, or topics including erosion, deposition, stormwater, and environmental engineering.

As part of their day, students will use an Engineering Design Process to:

- *Define a stormwater problem using a model in the lab.*
- *Investigate the design of Brightwater's streams, hills, and wetlands to gather data that will help them develop a solution for their stormwater problem.*
- *Apply their knowledge back in the lab to design solutions, test them in their models, and optimize their designs.*

As a result of this program, students will be able to:

- *Explain how an Engineering Design Process can help them develop solutions to problems.*
- *Make connections between a stormwater model and stormwater in the real world.*
- *Gather and record data on data tables and maps.*
- *Recognize ways that engineers build features to slow down water and reduce erosion.*
- *Design and defend a solution to an engineering problem using their observations and data;*
- *Understand the effects of human decisions on the land, both positive and negative.*
- *Understand the effects of fast-moving water, erosion, and flooding on living things and property;*
- *Identify the ways they could positively affect stormwater systems in their own communities.*

(Please note: This program DOES NOT include a treatment plant tour.)

CONNECTIONS TO USP OUTCOMES

Students will leave the program with the capacity to:

- Identify how what they have learned during the program connects to their personal experiences, prior content knowledge, and community.
Ask students to relate their experiences with engineering and water, connect the program to the landforms unit, and use stormwater examples (when possible) from their local community.
- Recognize their use of NGSS practice(s) and/or crosscutting concepts.
Making our use of NGSS practices and the concept of Structure and Function explicit during the program.
- Describe how stormwater is affected by other parts of an urban system.
Students are examining this in each location they visit during the field study.
- Analyze a variety of solutions people have engineered to solve the problem of too much stormwater in an urban setting.
Students should be doing this at each location and as a part of designing their stormwater solution.

General Schedule

Although there are 4 sites, groups will only visit 3 during the day. Before the day begins, look to the table below and decide where each group is going.

9:00	Educators Arrive and Set up Lab												
10:00	School(s) arrive Split into Field Groups and engineering teams. Field Group Introductions												
10:05	Whole Group Introduction In the Lab Introduction to Stormwater Stormwater Runoff Model Intro to the Day's Field Work	<table border="1"> <tr> <td colspan="2">At Each Site:</td> </tr> <tr> <td>1.</td> <td>Explore & Observe</td> </tr> <tr> <td>2.</td> <td>Determine Slope & Soil and Record</td> </tr> <tr> <td>3.</td> <td>Share & Discuss Results</td> </tr> </table>				At Each Site:		1.	Explore & Observe	2.	Determine Slope & Soil and Record	3.	Share & Discuss Results
At Each Site:													
1.	Explore & Observe												
2.	Determine Slope & Soil and Record												
3.	Share & Discuss Results												
10:30	First Field Site												
11:30	Lunch												
11:55	Second Field Site												
12:45	Third Field Site	Class 1	A	Pond	Lunch								
			B	Wetland									
1:30	Conclusion in Lab	Class 2	C	Stream									
2:00	Bus departs – wave goodbye		D	Hill									
				Site 2	Site 3								
				Stream	Wetland								
				Hill	Pond								
				Wetland	Hill								
				Pond	Wetland								
2:00	Educators Clean Up												
2:30	Educators Post Program Discussion												
3:00	Educators Depart												

INTRODUCTION (20 minutes in the lab)

Learning Target: “I can use the engineering design process to solve a stormwater runoff problem.”

Science & Engineering Practices

- Asking Questions and **Defining Problems**.
- Developing and **Using Models**
- Planning and **Carrying Out Investigations**

Disciplinary Core Ideas

- **Defining and Delimiting Engineering Problems**
- Natural Hazards

Cross-Cutting Concepts

- **Structure and Function**

Coming off the bus, each class is split into two field groups.

Field Groups

1. Introductions of field group members
2. Share with students that they will be solving an engineering problem today. Give an example of a simple engineering problem (a sandcastle built to stop the waves, a lego spaceship tough enough to not break when dropped, etc.) that you’ve solved and have them discuss with a partner when they’ve engineered something.
3. Divide field group into three “engineering teams” with an adult in charge of each. Make clear that it will be important to pay attention to the adult in their team as the adult will have specific instructions to lead them through.
4. The two field groups then meet back up in the lab. Try to have engineering groups sit together.

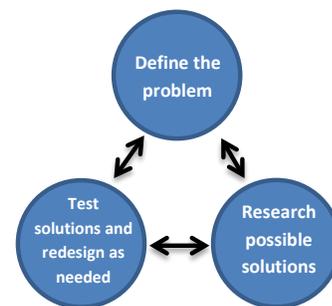
In The Lab

1. Student volunteer reads aloud the learning target.
2. Stormwater Runoff is the water that we see collecting together and moving during a big rainstorm.
3. Students will be using engineering to solve a stormwater runoff problem. They will be examining a stormwater problem, investigating what engineers have done here at Brightwater to help with stormwater, and then coming up with a plan to solve the problem.
4. When a big storm happens, the water has to go somewhere. Begin by having students discuss at their tables:
 - **Where does water in your neighborhood go when it rains?**
 - *Does anybody know where the water that goes into storm drains goes?*
 - *Do you have any streams, lakes, or beaches in your community where the water is likely to end up? [you may be given this information beforehand by the coordinator]*
 - All of this water is defined as stormwater.
 - **What problems related to water occur in your neighborhood when there's a big storm? (Write these problems up on the board).**
 - Have students share some of these problems.
 - Record them on the board.
5. Engineers use an **engineering design process** to solve problems (share the three steps on the board). They also have certain skills or practices as they go through the process (point out the **Science and Engineering Practices** cards). Today we will be using the same design process and practices that engineers use every day.

Write ahead of time on the board:

Learning Target: I can use the engineering design process to design a structure that solves a stormwater runoff problem.

Engineering Design Process



Stormwater Model Investigation

Procedure:

1. Make sure your whole team is ready.
2. Pour all the water into your cup.
3. Collect the runoff in the sample container until the instructor says "Stop" (remaining water can empty into the bucket).
4. Record observations in your journal.
5. Save sample for later comparison.

Stormwater Runoff Model

1. Show the students the Stormwater Runoff Model they will be using.
2. The **model** is designed to help us, as engineers examine a problem created by stormwater and (at the end of the day) test out ideas for solutions to the problem.
3. *Have you worked with a model like this in your classroom?* See box =>
4. Parts of the model represent the real world:
 - Dirt = Land in a community.
 - The water we add to the model is going to represent stormwater from a big storm.
 - The water that flows out is water going downstream where we have people's houses, salmon eggs in the stream, and a beach where kids like to swim.
5. The students will be "**carrying out an investigation**" to **define the problem** that is being modeled. They will follow a procedure that they will repeat at the end of the day to **test their solution**.

A similar model is used by many classes in science units (Landforms, Community Waters, & Land and Water). **Help the students make that connection!**

Explain the Investigation Procedure:

- 1) Make sure your whole team is ready.
 - 2) Pour all the water into your cup.
 - 3) Collect the runoff in the sample container until the instructor says "Stop" (remaining water can empty into the bucket).
 - 4) Record observations in your journal.
 - 5) Save sample for later comparison.
6. Each engineering team gathers around a work table with one of the Stormwater Runoff Models.
 7. Students will be collecting water in the cup labelled "Before".
 8. One of the educators talks all the teams through the procedure and students record their data, including their observations on Page 8 of their journal.
 9. Questions to discuss in teams:
 - *What does the water do to the soil?*
 - *Did the "stream" change at all?*
 - *What do you notice about the water that we captured?*
 10. **Define the Problem** as a group (record answers on the white board for reference at the end of the day).:
 - **What would you identify as the problem that we are going to need to fix?**
 - *What problems that we wrote up on the board previously appeared in your model?*
 - *Which one's didn't? (Erase or cross out any problems that weren't represented by the models).*

- We want our problems to be narrowed down to (1) Too much water (flooding) and (2) Dirty water.
 - **What are our *criteria for success*?** = *What should our sample cup look like in the afternoon if we were successful at solving these two problems?*
 - It helps to hold up a sample cup from one table, as well as an empty sample cup.
 - (1) Too much water → Less water
 - (2) Dirty water → cleaner/clearer water
11. *At the end of the day today, we are going to come back to these models to propose and try out solutions to our problem. But first we need to research some possible solutions....*

Introduction to the Day's Field Work

1. The outside area we will be exploring today used to be a baseball field with water running through a ditch and a pond that emptied into Little Bear Creek. During big rainstorms houses along the creek were flooding and salmon eggs in the creek were being washed away. When engineers were planning a redesign of the area, part of their **criteria** was to reduce flooding and improve salmon habitat. The engineers used a variety of different approaches all aimed at reducing the amount and speed of water flowing off the land. These different approaches have **different structures but are all trying to serve the same function.**
2. Show Brightwater construction pictures.
3. We are using this engineered site to **research possible solutions** for the very similar problem being represented in our model.
4. We will visit three different field sites and your teams will be **carrying out a similar investigation** at each.
5. At the end of the day we will meet back. Each engineering team will choose a solution to add to their model and test with the same procedure we just used!

FIRST SITE VISITED (see site details in each section below)

Learning Target: “I can carry out investigations to find possible solutions for our stormwater runoff problem.”

Science & Engineering Practices

- Planning and Carrying Out Investigations

Disciplinary Core Ideas

- Developing Possible Solutions

Cross-Cutting Concepts

- Structure and Function

The order you visit sites will vary but, take the time at the first site you visit to overview the steps they will be going through as they **carry out an investigation** at each site:

Rainy Day Teaching Tip

Consider doing the overview in the classroom with the whole class or in your field groups under a sheltered area.

1. Remind students and adults they will be investigating each site with an adult in their engineering teams to better understand stormwater runoff and **find possible solutions they can use in their models at the end of the day.**
2. Overview the steps and equipment before they begin. They will:
 1. **EXPLORE & OBSERVE**
 - They will have time to explore each area and figure out what is there. *Go off and explore it! What is special about the site? Who lives here? What is your favorite part? Get a feel for it!*
 - They will record detailed and specific observations on the map of the area. The key on each map includes features they should always record, but they can add symbols to the key to represent things that they discover when exploring. **Encourage them to look for signs that engineers did something at each site.**
 - Teach the students a call you will use when they are to gather in their engineering teams (or as a whole class) and finish adding observations to their maps.
 - Adults role is to help make sure the keys are used and observations are recorded.
 2. **COLLECT & RECORD DATA**
 - They will be collecting a soil sample on the hill and in the wetland. At the stream, they will be investigating the effects of water speed on erosion. At the pond they will be using models to show how a retention pond can hold onto water, slowing it down.

- Demonstrate how to use the soil sampler to take a sample of the soil and explain the questions about the soil on each locations question page. They will do this at each location in their smaller engineering teams.
 - *What are some good descriptive words we could use to describe the soil to someone else who is here to see it?*
 - *What would you say about its moisture, texture, color, smell...*
- Emphasize the importance of taking care of the tools and to carry them safely. They can break and some have sharp edges.
- Continually remind students about the problems of dirty water and too much water at each station. Tie back what we're discussing at each station to those problems.

3. SHARE RESULTS AND DISCUSS POSSIBLE SOLUTIONS

- This gives an opportunity to discuss what features at the site would be useful to slow down the water. What solutions will they want to consider using in their models at the end of the day?

HILL (page 6)

Learning Target: “I can carry out an investigation to find possible solutions for our stormwater runoff problem”

Big Ideas

- 1) Plants store and slow down stormwater and retain soil. This helps keep sediment out of streams and reduces the amount of water moving quickly into them.
- 2) Plants also provide habitat for other creatures.
- 3) Humans can reduce runoff by planting plants and not trampling them.

Science & Engineering Practices

- Planning and Carrying Out Investigations

Disciplinary Core Ideas

- Developing Possible Solutions
- Biogeology

Cross-Cutting Concepts

- Structure and Function

1. EXPLORE & OBSERVE

- Students will have an opportunity to find solutions at the hill they might use in their model later.
- Turn to Hill Map on page 6

Teaching Considerations at the Hill

Grass on the hillside can be slippery, both in wet and dry conditions.

2. COLLECT & RECORD DATA

- **Hill Soil Sample**
 - Collect sample somewhere on hillside
 - Describe sample in the box on page 8
 - Note on map where collected

3. SHARE RESULTS AND DISCUSS POSSIBLE SOLUTIONS

- *If it were raining very hard, where would you expect to see the most soil washed away (erosion) on the hill? Why?* [**Plants help keep the soil in place.**]
- *What plant structures are helping serve the function of keeping the soil from washing away?*
- *What solution did engineers come up with on the hill to keep the soil from washing away?* [Planting plants slows it down and roots hold soil together. Trampling plants, and/or creating paths straight up a hill kills plants and exposes soil to be washed away.]
- We'll want to keep the plants solution in mind when thinking about adding solutions to our models at the end of the day.

How do plants help control runoff?

If students need help visualizing why plants help control runoff focus on the plant's roots:

- 1) The roots are like tiny fingers holding onto the soil
- 2) The roots are also like straws sucking up some of the water for the plant to use.

WETLAND (Page 2)

Learning Target: “I can carry out an investigation and use a model to explore possible solutions for our stormwater runoff problem”

Big Ideas

- 1) Wetlands are like big sponges; they slow the water down and hold it in place so it can soak in slowly through the ground. This keeps water from moving quickly into streams, which then results in less erosion and less flooding.
- 2) Water in wetlands is still, providing habitat for plants and animals that need still and shallow water.
- 3) Humans can create wetlands or similar water-storing areas by building rain gardens, restoring natural wetland areas, and creating ponds with wetland edges.

Science & Engineering Practices

- Developing and Using Models
- Planning and Carrying Out Investigations

Disciplinary Core Ideas

- Developing Possible Solutions
- Biogeology
- Earth Materials and Systems

Cross-Cutting Concepts

- Structure and Function

1. EXPLORE & OBSERVE

- Turn to Wetland Map on page 2

2. COLLECT & RECORD DATA

- **Wetland Slope**

- Measure **between** the two ponds and record in the box on page 2.
- Note on wetland map where measured

- **Wetland Soil Sample**

- Collect sample between the two ponds and describe sample in the box on pg. 3
- Note on wetland map where collected

3. SHARE RESULTS AND DISCUSS SOLUTIONS

- *How would the wetland look different after a heavy rain storm? How would it look different in the middle of a hot summer day?*
- **WETLAND SPONGE MODEL** (using a dry sponge and full Nalgene water bottle with the whole class at once). The sponge represents **soil and plants** in a wetland and the water represents stormwater.
 - 1) *What do you predict will happen when I pour water on this sponge?*
 - 2) Pour the water *slowly* on to the sponge and have students observe what happens.

Teaching Considerations at the Wetland

- ✓ It is helpful to use the map to illustrate what “In between the two ponds” means. We want them to measure somewhere in the middle.
- ✓ In the Fall, students should stay out of the pond areas, even if dry. These are sensitive areas and we want to minimize our impact.

- 3) *What do you think would happen if this wetland (the sponge) was covered over?*
 - 4) *Using the plastic sheet, cover the sponge and pour the water slowly onto the plastic*
 - 5) *How would this **affect the water in a stream that was getting water from this wetland?** How would it affect the **speed of the water?** **The amount of erosion** we would observe?*
- *Why do you think engineers built a wetland here? [they hold water for wildlife year-round so water doesn't drain out! They slow down water, decreasing erosion]*
 - *We'll want to remember wetlands as a possible solution to consider using in our stormwater models at the end of the day today....*

STREAM (Page 4)

Learning Target: “I can carry out an investigation to find possible solutions for our stormwater runoff problem”

Big Ideas

- 1) Streams are where stormwater runoff collects and speeds up.
- 2) Faster water has more force, picking up more soil and causing more erosion.
- 3) People can affect streams in positive and negative ways like building native plant buffers, rain gardens, retention ponds, adding bends and pools, etc.

Science & Engineering Practices

- Ask Questions and Define Problems
- Planning and Carrying Out Investigations
- Analyzing and Evaluating Data

Disciplinary Core Ideas

- Developing Possible Solutions
- Natural Hazards
- Earth Materials and Systems
- The roles of water in Earth’s surface processes

Cross-Cutting Concepts

- Structure and Function
- Cause and Effect

1) EXPLORE & OBSERVE

- Turn to Stream Map on page 4.
- Demonstrate to students to illustrate their stream map with a left-to-right orientation (not top-to-bottom).
- Make sure to draw a connection between where engineering elements are located and how they slow down the stream.

Logistical Considerations at the Stream

- 1) There are many sections of stream to explore, encourage groups to spread out.
- 2) Students should stay on the trail side of the stream.
- 3) Logs at the stream can be exceptionally slippery when wet! Exercise caution.

2) COLLECT & RECORD DATA [Students do not measure the slope at this site]

- *We are gathering engineering ideas from the locations we are visiting, but are they working? Why would engineers work to slow this creek down. We’re going to do a short investigation to see how the speed of water can affect what things get picked up by the water. **Sometimes engineers need to do scientific investigations to figure things like this out.***
- Students split into engineering teams to **carry out an investigation** that will help explain how the speed of the stream will affect the soil.
- Pass out tools. Each team gets a large and small rock tied to a string. Make sure to emphasize how these tools will get used (NO swinging the rocks).
- On page 5 of the journal, engineering teams are tasked with answering the questions. They will be asked to immerse the small and large rocks at different points along the stream, and make observations about what happens.

3) SHARE RESULTS AND DISCUSS POSSIBLE SOLUTIONS

- Gather students back together to discuss what they discovered.
 - *What differences did you observe between the two rocks?*
 - *Where would the small rock go if it hadn't been tied to the string?*
 - *What would this stream look like if there were no structures to slow down the water?*
 - *How does this help with the problems we identified this morning?*
- **Considering this stream was built by engineers, which of the items in the stream do you think were deliberately put there to slow the water down?** [logs in the water, constructed pools, deliberate bends in the stream]
- **How does the structure of those objects help them slow the water down?**
- *We'll want to be thinking about what we might do similar to this in our models later today....*

RETENTION POND (Page 8)

Learning Target: “I can carry out an investigation to find possible solutions for our stormwater runoff problem”

Big Ideas

- 1) Surfaces where water doesn't soak in increase stormwater runoff problems.
- 2) Drains can keep an area from flooding, but move the problem (stormwater) elsewhere.
- 3) A retention pond is a great way to hold onto water after it's been diverted from another area. Holding onto the water and slowing it down reduces erosion downstream. The retention pond also helps to collect sediment.

Science & Engineering Practices

- Asking Questions and **Defining Problems**.
- Developing and **Using Models**
- Planning and **Carrying Out Investigations**
- **Engaging in Argument from Evidence**

Disciplinary Core Ideas

- Developing Possible Solutions
- Earth Materials and Systems

Cross-Cutting Concepts

- Structure and Function
- Cause and Effect

1) EXPLORE & OBSERVE

- Turn to the pond map on page 8.
- Make sure to set up safety parameters during this time. See box →
- This location is the most similar to what the students would see around the city.
- Provide each team water bottles and point out they can pour them on various surfaces to **investigate** where water soaks in and where it moves.
- They should mark dots on their maps to show where the water soaks in and arrows to show where water would travel during a rainstorm.
- *Where does the water runoff and where does it soak in? Where does it end up and how does it get there?*

Logistical Considerations for this site

- 1) Part of this exploration takes place in a road. Position chaperones in the middle of the road to look out for oncoming vehicles.
- 2) If it's raining that day, you may not need to use water bottles as the curriculum describes.
- 3) Bring a flashlight to look in the drains!

2) COLLECT & RECORD DATA [Students do not measure the slope at this site]

- Discuss what groups recorded on maps:
 - *What did groups figure out about the movement of water at this site?*
 - *Where does the water end up? How does it get there?*
- Encourage students to get down and look in the storm drains. Can they find any sign of where the water goes after it enters the drain? Use flashlight to help them see the big pipe that heads out towards the pond down the hill.
- To help visualize the pipes: If not raining, gather group at second storm drain from the corner and have a chaperone pour water in the storm drain at corner.

- Have students add the pipes to their maps if they haven't already (dotted lines?)
- All the water that doesn't soak in becomes MORE water to cause problems where it ends up. At this site, engineers were thinking about and came up with a solution that might be useful to us another solution we could consider for our stormwater models.

3) RETENTION POND MODEL

- Take time to show pictures of storm pond during construction. Pipes leading out of Storm Pond lead to Little Bear Creek across the highway.
- Engineers built the pipes from the storm drains to direct water into this human-made pond called a "retention pond". We're going to **use a model** to understand how the structure of a retention pond might help with our problems of too much water and dirty water.
- Each engineering team will get to work with a set of two models. Each model has one box filled with sand and gravel. This represents a streambed. Each model also has a piece of piping where water is added, representing a storm drain. One of the models has a model of a retention pond between the pipe and stream, while the other only has piping leading directly to the stream.
- Show students how to add water to their models. They will use the questions on page 9 to guide their investigation.

4) SHARE RESULTS AND DISCUSS POSSIBLE SOLUTIONS

- Gather students back together to discuss what they discovered in their investigation.
 - *In which model did you observe more erosion?*
 - *How did the pond change the amount of erosion in the streambed? What was happening to the water in the pond?*
 - *Why would engineers use a retention pond to collect stormwater?*
 - *How would a retention pond help with our problems of dirty water and too much water?*
- We'll want to remember this as a possible solution to use in our models later....

CONCLUSION (30 minutes in the lab)

Learning Target: “I can use the engineering design process to solve a stormwater runoff problem.”

Science & Engineering Practices	Disciplinary Core Ideas	Cross-Cutting Concepts
<ul style="list-style-type: none">• Asking Questions and Defining Problems.• Developing and Using Models• Planning and Carrying Out Investigations• Constructing Explanations and Designing Solutions• Engaging in Argument from Evidence	<ul style="list-style-type: none">• Defining and Delimiting Engineering Problems• Developing Possible Solutions• Optimizing the Design Solution• Natural Hazards• Earth Materials and Systems	<ul style="list-style-type: none">• Structure and Function

Stormwater Runoff Model

1. Each group will have available the following “engineering features” in their model to design a solution that meets the **criteria for success** decided on at the start of the day [(1) less water and (2) cleaner water].
 - a. **2 large rocks**
 - b. **Petri dishes to be buried to create “pools”**
 - c. **Shovel to alter stream channel**
 - d. **Sponge (represents wetland)**
 - e. **Sticks (large woody debris)**
 - f. **Cheesecloth**
2. Because of “budgetary considerations” a **limitation (or “constraint”)** on their project is that they will only be able to use three of the items available.
3. They will have 5 minutes at their table to **brainstorm** as a team which of the things they observed in the field they feel would be most effective and **choose three to test in their model** (could be three different things or three of the same thing) as their **design solution**.
4. One instructor is in charge of passing out features. Each group must explain to their chaperone what features they are testing and how they are going to model the features with the items provided before they “purchase” the items from the front of the room.
5. Students add features to their stream tables (10 min). *Where could they place their designs to maximize their effectiveness?*

Evaluating possible solutions is an important part of the engineering design process. As you circulate, encourage the students to really talk through why they are proposing certain solutions. Why do they think their idea would meet the **criteria for success?** See the list of engineering “talk moves” in Appendix for good questions to ask of students in their groups.

6. Follow the same **procedure they used to carry out an investigation** at the start of the day, this time collecting in the cup labeled “After”:
 - a. Make sure your whole team is ready.
 - b. Pour all of the water into your cup.
 - c. Collect the runoff in the sample container until the instructor says “Stop” (remaining water can empty into the bucket).
 - d. Record observations in your journal.
7. Groups compare their runoff from the engineered model to that of unaltered model from the morning and record results on page 8 of their journal.
8. Each group shares and defends their engineering solution with the other groups.
9. If time, students are given a chance to **optimize their solution** and test a second time.
10. Review the **Engineering Design Process** and some of the **engineering practices** students used during the day.

Encourage students to share **specific evidence as they argue for or against their solution.**

Plan enough time to do a redesign! The students benefit greatly from a chance to optimize their solution.

Final debrief question: *“How do people affect the speed and cloudiness of streams?”*

- Increase speed by building roads, sidewalks, parking lots, near streams, the water flows into the stream much faster – causes more erosion and becomes cloudier, removing wetlands and other areas that slow down surface water.
- People can slow water down by building rain gardens to capture water, restoring wetlands to store water during storms, green roofs, etc.

Appendix I: The Landforms Science Unit

The Landforms Science Unit is a FOSS kit taught to many (but not all) of the students that do this program. Teachers do not always do every lesson in the unit. Here is a synopsis of the lessons:

LANDFORMS MODULE MATRIX

SYNOPSIS	SCIENCE CONTENT	THINKING PROCESSES
<p>1. SCHOOLYARD MODELS</p> <p>Working in pairs, students create models of their school site, using a sand mixture and plastic cubes. They transfer the model to a plastic grid and draw a map on paper from the overlay. They observe and compare features on the models and corresponding maps.</p>	<ul style="list-style-type: none"> • Models represent objects that are very large or processes that occur over long periods of time. • Models and maps are ways of representing landforms and human structures. • Maps can be made from models. 	<ul style="list-style-type: none"> • Observe the schoolyard area and create a model of it. • Make a representation of the schoolyard using a grid system to transfer information to a smaller map. • Compare features on the models and the corresponding maps.
<p>2. STREAM TABLES</p> <p>Students set up stream tables with earth material and run water through the system. They observe the processes of erosion and deposition and become familiar with the landforms created.</p>	<ul style="list-style-type: none"> • Water is an important agent in shaping landforms. • The wearing away of earth is erosion; the settling of eroded material is deposition. • Landforms that result from running water include canyons, deltas, and alluvial fans. 	<ul style="list-style-type: none"> • Observe and measure the effects of flowing water in the stream table. • Compare the features created in the stream tables. • Communicate the results of the investigations. • Relate the processes in the stream table to the processes of erosion and deposition.
<p>3. GO WITH THE FLOW</p> <p>Students continue their stream-table investigations, studying variables that affect erosion and deposition—slope of the land and the rate of flow. They design further investigations, recording events and mapping the results.</p>	<ul style="list-style-type: none"> • The slope of the land over which a river flows affects the processes of erosion and deposition. • During flooding, the rate of erosion and deposition increases. • Humans affect the processes of erosion and deposition. 	<ul style="list-style-type: none"> • Observe and measure the results of stream-table investigations. • Experiment to find the effect of slope and floods on erosion and deposition. • Communicate the results of experiments in a conference. • Relate the stream-table results to natural processes.
<p>4. BUILD A MOUNTAIN</p> <p>Students are introduced to the study of topography by building a model of a landform—a mountain. They use the foam model of Mt. Shasta to create a topographic map, and the map to produce a profile of the mountain.</p>	<ul style="list-style-type: none"> • Topographic maps are two-dimensional representations of three-dimensional surfaces. • Topographic maps show contour lines, which represent points of equal elevation. • Topographic maps use symbols and color to represent landforms. 	<ul style="list-style-type: none"> • Observe features on a foam mountain and compare them to a two-dimensional representation, a topographic map. • Organize information from a model to create a topographic map and profile of a mountain. • Relate topographic features to symbolic representations on maps.
<p>5. BIRD'S-EYE VIEW</p> <p>Students learn to read USGS topographic maps and compare them to aerial photographs. They study Death Valley, Mt. Shasta, and Grand Canyon maps and photographs, and make landform maps from the aerial photographs.</p>	<ul style="list-style-type: none"> • Cartographers use aerial photographs as one tool in constructing topographic maps. • Landform maps can be generated from aerial photographs. 	<ul style="list-style-type: none"> • Observe and describe the types of information represented on a topographic map. • Compare the Mt. Shasta foam mountain to the topographic map. • Interpret aerial photographs. • Relate information on maps and aerial photographs to the actual landforms.

Appendix II: Next Generation Science Standards

The Next Generation Science Standards (NGSS) are made up of Performance Expectations that incorporate three dimensions: the **science and engineering practices**, **disciplinary core ideas**, and **crosscutting concepts**. For more in depth information on the NGSS, visit the Equip or NSTA websites.

All three dimensions are used during the course of this program. To help educators recognize where we are using them, the relevant dimensions are listed at the beginning of each lesson. In addition, the dimensions are **color coded** when they show up in the text of the lesson. To keep it simple, full descriptions are not provided during the lesson, but below you can find specifics for each category including where it is used. We do not list all the parts of each dimension; just the specific bullets relevant to this lesson.

The program also supports (but does not replace), specific NGSS performance standards that should be a part of 4th grader’s science units in the classroom. These can be found listed at the end of this section.

Science and Engineering Practices

There are eight key “practices” that are essential to the work of scientists and engineers. They are not used in any specific sequence, being applied as needed to build understanding (science) or solve problems (engineering). By reinforcing these practices and making our use of them explicit during this program we help students see that THEY can be engineers and to see how the practices can be applied towards building understanding and solving problems in the real world.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

In this program: the students define the problem (including criteria for success) when using the model in the lab. They research the problem by visiting various field sites and looking for possible solutions at each of them and do some listing of possible solutions as they go. At the end of the day, they return to the lab to (quickly) brainstorm and choose a solution. Then they use their model to build and test a prototype. Finally they communicate to the rest of the class how the solution they tested did.

Science and Engineering Practices	Where it is used in our program?
<p>Asking Questions and Defining Problems</p> <ul style="list-style-type: none"> • Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3-5-ETS1-1) 	<ul style="list-style-type: none"> • The criteria for success (less water and cleaner water) are laid out during the introduction and constraints on materials are added at the end of the day.

<p><i>Developing and Using Models</i></p> <ul style="list-style-type: none"> • Develop and/or use models to describe and/or predict phenomena. • Develop a diagram or simple physical prototype to convey a proposed object, tool, or process. 	<ul style="list-style-type: none"> • The landform models are used at the beginning of the day to better understand the cause of the problem. • At the end of the day prototypes of solutions are added to the models.
<p><i>Planning and Carrying Out Investigations</i></p> <ul style="list-style-type: none"> • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. (3-5-ETS1-3) • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. 	<ul style="list-style-type: none"> • Students conduct (but do not design) a fair test investigation on their landform models and when measuring stream speed at the stream. • Students make observations and measurements at each of the field sites to better understand and compare the locations. Their work with the landform models lets them test a design solution.
<p><i>Constructing Explanations and Designing Solutions</i></p> <ul style="list-style-type: none"> • Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design problem. (3-5-ETS1-2) • Apply scientific ideas to solve design problems. (4-PS3-4) 	<ul style="list-style-type: none"> • Each team tries only one solution out, but with multiple teams creating solutions they have an opportunity to compare them. • Understanding of how water moves over the land is applied as the students design and place their proposed solutions.
<p><i>Engaging in Argument from Evidence</i></p> <ul style="list-style-type: none"> • Respectfully provide and receive critiques from peers about a proposed procedure, explanation or model by citing relevant evidence and posing specific questions. • Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem. 	<ul style="list-style-type: none"> • Students should be doing this when they are discussing possible solutions for the groups to add to their model. • After students finish testing their proposed solution, they have an opportunity to share with others how well it met the criteria for success.

Crosscutting Concepts

“Crosscutting concepts have value because they provide students with connections and intellectual tools that are related across the differing areas of disciplinary content and can enrich their application of practices and their understanding of core ideas.” — Framework p. 233

Crosscutting Concepts	Where it is used in our program?
<p><i>Structure and Function</i></p> <ul style="list-style-type: none"> • Substructures have shapes and parts that serve functions. 	<ul style="list-style-type: none"> • This concept is used throughout the program as students look at various structures that have been built on site by engineers and figure out how their structure helps serve the function of slowing down stormwater.
<p><i>Cause and Effect</i></p> <ul style="list-style-type: none"> • Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1) 	<ul style="list-style-type: none"> • At the stream and/or the retention pond students discuss the effect of too much stormwater on stream speed and erosion. Cause and effect is also a part of thinking about what solutions do and which will work in their model.

Disciplinary Core Ideas

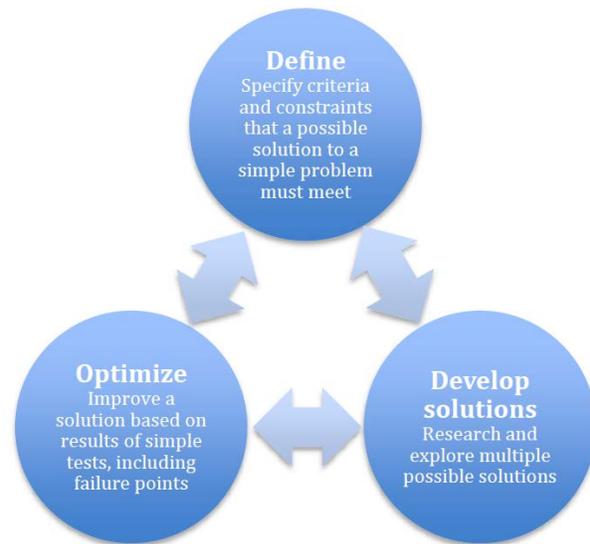
The Disciplinary Core Ideas we are teaching most clearly in this lesson are the ones related directly to engineering (ETS1.A-C). See the “3-5 Engineering Design” section below for more information about the Engineering Design Process. The remaining core ideas listed below are used during the lesson but only briefly. They are not taught in a deep way.

Disciplinary Core Ideas	Where it is used in our program?
<p>ETS1.A: Defining and Delimiting Engineering Problems</p> <ul style="list-style-type: none"> Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). (3-5-ETS1-1) 	<ul style="list-style-type: none"> Students Define the problem through discussions and observations of their models at the beginning of the program. They add a bit more to their understanding of the problem at the stream and bring in constraints (on amount of materials to use) when designing their solution.
<p>ETS1.B: Developing Possible Solutions</p> <ul style="list-style-type: none"> Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) 	<ul style="list-style-type: none"> Research is occurring as the students look at possible solutions at each site they visit. They test their solutions in their models (but do not test a range of possible solutions). Student teams should be discussing pros and cons of possible solutions before they decide on what they want to model.
<p>ETS1.C: Optimizing the Design Solution</p> <p>Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)</p>	<ul style="list-style-type: none"> Student sharing about how their solutions did at the end of the program is an opportunity to compare how well various solutions met the criteria. If they have time to improve their solutions they are putting the idea into action.
<p>ESS3.B: Natural Hazards</p> <p>A variety of hazards result from natural processes (e.g., earthquakes, tsunamis, volcanic eruptions). Humans cannot eliminate the hazards but can take steps to reduce their impacts. (4-ESS3-2)</p>	<ul style="list-style-type: none"> This comes up at the start of the program: Floods are a natural hazard that we make worse in an urban setting. When possible we connect it to flooding in the student’s own communities.
<p>ESS2.A: Earth Materials and Systems</p> <p>Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)</p>	<ul style="list-style-type: none"> The landforms unit spends a lot of time with this core idea. We reinforce it when we are talking about stormwater and the resulting fast water affecting the land and causing erosion. It also relates to sediments being carried by the water.
<p>ESS2.E: Biogeology</p> <p>Living things affect the physical characteristics of their regions. (4-ESS2-1)</p>	<ul style="list-style-type: none"> At the hill, we talk about how the roots of plants help keep soil from being washed away. At the wetland, plants are helping filter the water and make it cleaner. This idea can also be applied to humans and our effects on increasing and decreasing stormwater problems.

Engineering Design

The Engineering Design Process is the focus of the **Disciplinary Core Ideas that focus on engineering (ETS1.A-C)**. It overlaps with specific Engineering Practices designed to reflect the skills engineers use as a part of engineering.

The Engineering Design Process is integral to this unit as students **define** the stormwater runoff problem they are trying to solve, look at examples around the Brightwater Campus to research possible solutions, model and **develop their solutions** as they explore their options, and then have a conversation at the end on how they might **optimize** a final solution.



From: <http://nqss.nsta.org/3-5-engineering-design.aspx>

In K–2, students learn that situations people wish to change can be defined as problems that can be solved or goals that can be achieved through engineering design. 3rd-5th graders are expected to engage in engineering in ways that are both more systematic and creative. The rest of this section describes the expectations of what 3-5 graders do with Engineering Design.

Engineering design can be thought of as three phases. It is important to keep in mind, however, that the process of design does not necessarily follow in that order, as students might think of a new solution during the testing phase, or even re-define the problem to better meet the original need. Nonetheless, they should develop their capabilities in all three phases of the engineering design process.

Defining the problem in this grade range involves the additional step of specifying criteria and constraints. Criteria are requirements for a successful solution and usually specify the function that a design is expected to perform and qualities that would make it possible to choose one design over another. Constraints are the limitations that must be taken into account when creating the designed solution. In the classroom constraints are often the materials that are available and the amount of time students have to work.

Developing possible solutions at this level involves the discipline of generating several alternative solutions and comparing them systematically to see which best meet the criteria and constraints of the problem.

Improving designs involves building and testing models or prototypes using controlled experiments or “fair tests” in which only one variable is changed from trial to trial while all other variables are kept the same. This is the same practice as in science inquiry, except the goal is to achieve the best possible design rather than to answer a question about the natural world. The broader message is that “failure” is an essential and even desirable part of the design process, as it points the way to better solutions.

Engineering Design Vocabulary

- **Constraint:** a limitation to a possible solution, often related to materials and resources

- **Criteria for success:** desired features of a solution
- **Engineering (design process):** engagement in a systematic practice of design to achieve solutions to particular human problems
- **Optimize:** test solutions in order to determine which of them best solves the problem, given the criteria and the constraints
- **Solution:** a way (object, tool, process, or system) to address or solve a problem; in engineering, solutions take into account constraints and criteria for success

* Definition based on NGSS – 3-5 ETS-1 Engineering Design, *NGSS APPENDIX G – Crosscutting Concepts*, or *NGSS APPENDIX I – Engineering Design in the NGSS*.

Engineering Design “Talk Moves”

These questions may be used to guide students’ thinking as they work through different aspects of the Engineering Design Process. *Adapted from Kirk Robbins,*

<https://teachscience4all.org/2014/11/05/engineering-design-talk-moves/>.

Goal	Talk Moves
Initiating Engineering Talk	<i>Can you tell me about your design? What are you working on? Do you think this will solve the problem? How did you arrive at this design?</i>
Maintaining focus on the Problem	<i>What is the problem we are trying to solve? What are the criteria (goals)? What are our constraints (limits)?</i>
Examining Materials and Tools	<i>What will you use for _____? What materials did you pick? Why?</i>
Maintaining Stamina & Sticking with an Idea	<i>How could you make this even better? If you kept working, what would you do next? What might you change about this design? Did you fail or did the design fail?</i>
Uncovering Scientific Thinking	<i>Why do you think that might work? What science ideas did you use to figure that out? How are you using science to solve this problem?</i>
Increasing Effective Collaboration	<i>How did your group decide on this? Have you heard from everyone in your group? What could you do to work together more successfully? Does everyone agree with this idea?</i>
Making Sense of Testing	<i>What did you notice when you tested this? What happened when you tested your design? What did you do to make sure it was a fair test? What specifically didn’t work?</i>
Considering Trade Offs	<i>What do you think is the most important criteria? What tradeoffs might you need to make?</i>
Pushing for Optimization	<i>How could you make this even better? What do you need in order to improve your design? What ideas could you borrow to make your design even better?</i>

NGSS Performance Expectations

The following Next Generation Science Standards are supported by this lesson. This lesson reinforces the material in these standards but does not replace the need for them to be learned and practiced more deeply in a larger curriculum.

Students who demonstrate understanding can...

- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.**
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.**
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**
- 4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.** *[Clarification Statement: Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.] [Assessment Boundary: Assessment is limited to earthquakes, floods, tsunamis, and volcanic eruptions.]*
- 4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.** *[Clarification Statement: Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.] [Assessment Boundary: Assessment is limited to a single form of weathering or erosion.]*

Program Materials and Equipment

Instructor backpack with the following:

- Soil Corer x 3
- First aid kit
- Clinometer x 1
- Pencil box with extra pencils

Setup in classroom:

- Landforms student journals x 15
- Clipboards x 15
- Pencils x 15
- Stream tables x 3
- Nalgene bottles x 4

For the field:

- Detention pond kit
- Stream velocity kit
- Wetland sponge demo kit