Watersheds and Nonpoint Source Pollution

❖

Lower Grand River Watershed Lessons

❖

Unit Two: Managing Excess Sediment

Groundswell

Communities for Clean Water

Groundswell

Written by Janet Vail (Annis Water Resources Institute)
Edited by Joanna Allerhand, Susan Loughrin, Clayton Pelon, and Amanda Syers (Grand Valley State University College of Education)
Reviewed by Michelle Storey and Robert Sweet (Michigan Department of Environmental Quality)

Design and Layout by Clayton Pelon

To learn more about Groundswell, environmental stewardship education, and to view the companion videos, please visit **groundswellmi.org**

This NPS Pollution Control project has been funded wholly or in part through the Michigan Department of Environmental Quality's Nonpoint Source Program by the United States Environmental Protection Agency under assistance agreement C9975474-13 to Grand Valley State University for the Lower Grand River Educational Initiative project. The contents of the document do not necessarily reflect the views and policies of the United States Environmental Protection Agency or the Department of Environmental Quality, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

OVERVIEW & LESSON

STUDENT ACTIVITY

ANSWER KEY

TEACHER RESOURCE

STUDENT READING

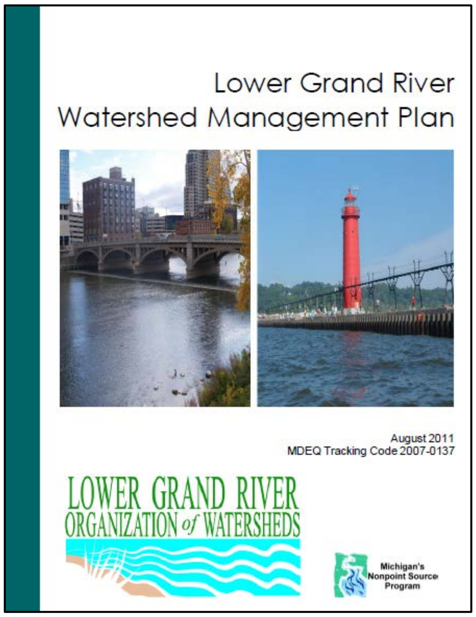
EPA

Grand Valley State University College of Education

DEQ

About the Lessons

The Michigan Department of Environmental Quality's Nonpoint Source Program assists numerous non-profit entities and other local, state, and federal partners to reduce nonpoint source (NPS) pollution statewide. NPS pollution comes from all over the watershed – anywhere rain falls. There is no specific source like a pipe or smoke stack. As such, the basis for this program is watershed management.



The *Lower Grand River Watershed Management Plan* (LGRWMP) is a document developed to provide a description of the watershed, identification of impairments, and goals and objectives for management and improvement of the watershed. The WMP's *Information and Education* (I&E) *Strategy* calls for educating stakeholders about the watershed and the impacts that stakeholders have on the watershed. The strategy has three steps: (1) awareness, (2) education, and (3) action.

With funding from the Michigan Department of Environmental Quality (MDEQ) Nonpoint Source Program, four lessons that draw upon information from the Lower Grand River Watershed Management Plan (WMP) have been developed for teachers. The purpose of these lessons is to further the I&E objectives that reach students as outlined in the WMP.

The three main nonpoint source pollutants of concern in the *Lower Grand River Watershed Management Plan* include sediment, pathogens, and nutrients. The lesson titles, which reflect this, are:

- Watersheds and Nonpoint Source Pollution
- Nonpoint Source Pollution: Managing Excess Sediment
- Nonpoint Source Pollution: Managing Pathogens
- Nonpoint Source Pollution: Managing Excess Nutrients

Videos have been developed to accompany each of the lessons. Lessons and videos are posted at http://groundswellmi.org/resources/educator-resources/. Educators can select the activities about the Lower Grand River Watershed that best fit their classrooms.

About the Lower Grand River Watershed Management Plan

The current Lower Grand River Watershed Management Plan (LGRWMP) was approved by the Michigan Department of Environmental Quality (MDEQ) in 2011. The LGRWMP provides a detailed implementation plan and assigns responsibility to stakeholders to ensure the plan's actions are put into practice. The Lower Grand River Organization of Watersheds (LGROW) was formed in 2009 to provide basin-wide oversight, implement watershed-wide initiatives, and prioritize water quality concerns.

For more information: lgrow.org

The nine key elements of the Lower Grand River Watershed Management Plan include:

1. Understanding watershed characteristics
2. Identifying and involving local agencies and citizens in the watershed planning process
3. Identifying designated and desired uses
4. Defining critical areas which are contributing a majority of the pollutants
5. Identifying and prioritizing pollutants, sources, and causes
6. Determining objectives and tasks for meeting watershed goals
7. Identifying and analyzing existing local projects, programs, and ordinances that impact water quality within the watershed
8. Informing and involving the public
9. Developing an evaluation process

The chapters in the LGRWMP reflect these nine elements.

The LGRWMP also outlines a strategy to identify and restore the state's designated uses of the surface waters in the watershed, which are:

- Agricultural use
- Industrial water supply at the point of intake
- Public water supply at the point of intake
- Navigation
- Warmwater and/or coldwater fishery
- Other indigenous aquatic life and wildlife
- Partial body contact recreation
- Total body contact recreation between May 1 and October 31

Sediment, nutrients, pathogens, temperature, unstable hydrology, chemicals, and habitat fragmentation have an impact on the designated uses of the watershed. Designated uses are considered impaired if the water does not meet Michigan's water quality standards. Total Maximum Daily Loads (TMDLs), which establish the maximum amount of a pollutant allowed in a water body and serves as the starting point or planning tool for restoring water, have been developed for parts of the watershed.

Subjects/Target Grades

Science and Social Studies

Grades 7-12

Duration

Five 50-minute class periods

Classroom and outdoor setting

Materials

Per class

- *Communities for Clean Water: Managing Excess Sediment*
- *15 to the River* (See https://wmeac.org/15totheriver/)
- Jars
- Gravel, sand, silt, clay examples
- Magnifying lenses
- Examples of sediment from the Grand River, Lake Michigan, and its tributaries
- Plastic rectangular box or paint tray
- Stream monitoring equipment (See Appendix B)
- Transparency masters

Per small group

- Egg carton or ice cube tray
- Gravel, sand, silt, clay samples
- Teaspoon
- Jar
- Plastic shoe box or other container
- Sand for stream model
- Gravel for stream model

Per student

- Student activity sheets
- *Grand River's brown color isn't caused by what you think* reading

MI Science Standards

- Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and /or atmosphere interact. 5-ESS2-2
- Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. MS-LS2-4
- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. MS-ESS3-3

Unit Two: Nonpoint Source Pollution: Managing Excess Sediment

Lesson Overview

This lesson focuses on the role of excess sediment as a major type of nonpoint source pollution affecting the Lower Grand River Watershed. Students explore excess sediment as illustrated by the 2013 Grand River flood event. They create a concept map about the effects of excess sediment in streams and rivers. After observing the characteristics of sediment and soils, students create a physical model of a stream noting how sediment moves. They research the sediment patterns in the Lower Grand River Watershed and explore how to reduce excess sediment loads. Outdoor explorations include looking for erosion in their schoolyard and stream monitoring.

Focus Questions

Students answer these essential questions in the context of the Lower Grand River Watershed: What is sediment? What are the sources and effects of excess sediment? What are some methods of monitoring excess sediment and its effects? How can the sediment load in a stream or river be reduced?

Objectives

Students will be able to identify sediment as a major nonpoint source pollutant, predict the movement of sediment based on soil physical characteristics, indicate the relative impact of excess sediment in various parts of the Lower Grand River Watershed, and explore ways to reduce excess sediment loads.

Advance Preparation

- Collect different kinds of sediment (sand, silt, clay).
- Assemble materials for the river model activities.
- Preview the *Communities for Clean Water: Managing Excess Sediment* video before showing it to the class.
- Make copies of the student activity sheets that you plan to use.
- Check the Extensions and Additional Resources sections for other activities on the lesson topics.

Background Information

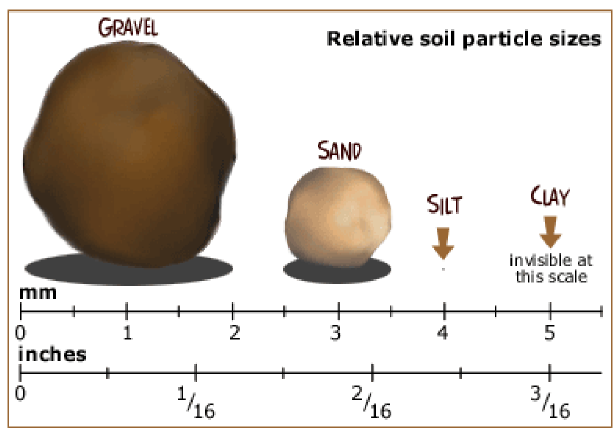
The U.S. Environmental Protection Agency (U.S. EPA) lists **sediment** as the most common pollutant in rivers, streams, lakes, and reservoirs. It also is listed as a major pollutant in the Lower Grand River Watershed Management Plan (LGRWMP), the document used by watershed managers to restore and protect our local water resources.

Sediment refers to the organic and inorganic materials that can be carried away by water, wind, or ice. These materials eventually can be deposited and accumulate on the bed or bottom of a body of water. While the term is often used to indicate mineral-based soil particles (e.g. clay, silt and sand), decomposing organic substances and inorganic material from organisms are also considered sediment. In aquatic environments, sediment can be dissolved, suspended (floating in the water column), or bedded (settled on the bottom of a body of water).

Erosion is the process by which sediments are transported by wind, water, ice, or gravity. Often people mistake erosion for weathering, the process through which rocks are gradually chipped away by abrasion, water, and ice. However, erosion is the active movement of these sediments from one place to another. **Sediments** are carried in rivers – the river's **load** – and **deposited** elsewhere. Erosion is a very natural and essential process upon which many ecosystems depend, including beaches, deltas, and wetlands.[1]

While **natural erosion** produces nearly 30 percent of the total sediment in the United States, **accelerated erosion** from human use of land accounts for the remaining 70 percent. The most concentrated sources of excess sediment come from construction activities, including relatively minor home-building projects such as room additions and swimming pools.[2] Other sources of sediment include cropland, urban landscapes, stream bank erosion, rill and gully erosion, and lakeshore erosion.[2]

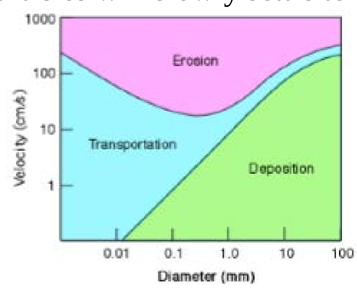
The erodibility of soils is influenced by the texture and particle size. **Silt** (0.004mm – 0.062mm) is most easily eroded. **Clay** (<0.004mm) is cohesive and tends to remain bound together as larger chunks; however, once detached the particles remain in suspension. **Sand** (0.062mm – 2mm) is relatively large and more difficult to move. Sand also promotes **infiltration** (process by which precipitation or water soaks into subsurface soils and moves into rocks through cracks and pore spaces.) **Gravel** (>2mm) is also more difficult to move. **Loam** is a combination of sand, silt, and clay. When soil compaction becomes excessive, there is a greater potential for soil erosion and water runoff. When soil compaction becomes excessive, there is a greater potential for soil erosion and water runoff.



Relative soil particles sizes
http://school.discoveryeducation.com/schooladventures/soil/name_soil.html

Excess sediment in our water bodies can impact the water quality. High levels of total suspended solids can increase water temperatures and decrease dissolved oxygen (DO) levels, which can harm aquatic animals such as fish. The suspended particles absorb more heat from solar radiation than water molecules. This heat is then transferred to the surrounding water by conduction. Warmer water cannot hold as much dissolved oxygen as colder water, so DO levels will drop.

Stream velocity also impacts erosion and sediment load in waterways. "Stream ***velocity*** is the speed of the water in the stream. Units are distance per time (e.g., meters per second or feet per second). Stream velocity is greatest in midstream near the surface and is slowest along the stream bed and banks due to friction. Streams carry dissolved ions as ***dissolved load***, fine clay and silt particles as ***suspended load***, and coarse sands and gravels as ***bed load.*** Fine particles will only remain suspended if flow is turbulent. In laminar flow, suspended particles will slowly settle to the bed. **Hjulstrom's Diagram** plots two curves representing 1) the minimum stream velocity required to erode sediments of varying sizes from the stream bed, and 2) the minimum velocity required to continue to transport sediments of varying sizes. Notice that for coarser sediments (sand and gravel) it takes just a little higher velocity to initially erode particles than it takes to continue to transport them. For small particles (clay and silt) considerably higer velocities are required for erosion than for transportation because these finer particles have cohesion resulting from electrostatic attractions."[3]



Hjulstrom's Diagram
http://www.columbia.edu/~vjd1/streams_basic.htm

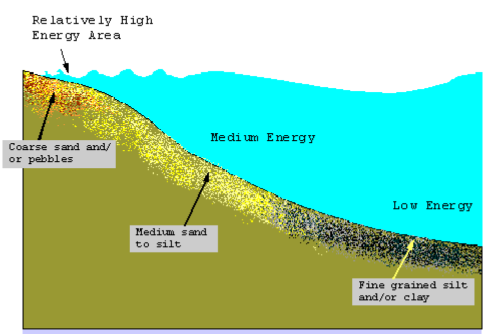


Figure 1 Relationship between energy and grain size.

Relationship between grain size and energy
http://faculty.gvsu.edu/videticp/grainsize.htm

The Lower Grand River Watershed drains into Lake Michigan. A distinct river plume of sediment is usually evident at the mouth of the Grand River, where it enters Lake Michigan. Gravity moves the water from the headwaters near Jackson, Michigan to the Lake. As it moves, the water mixes with sediment. At the Grand River's headwaters, the smallest sediments (silts and clays) are quickly swept away, leaving behind the sand, gravel, and larger rocks. As the slope of the landscape lessens, the river slows and the energy of the flowing water decreases. The river has less energy to carry the heavier sand, and sandbars can accumulate along the curves and twists of the riverbed. Finally, as the slope becomes nearly flat as it reaches Lake Michigan, the velocity of the current is reduced to a crawl and even the smallest sediments are deposited, which can lead to silt-covered deltas and clay-like mud deposits.

Understanding land use and the effects of urbanization are key to understanding the sediment load in the Grand River. According to a story in MLive, "Grand Rapids – not just downtown, but the entire watershed – is much more developed now than it was a generation ago, much less a century ago. More land development means more asphalt, more roads and more parking lots. This means more water runoff. Instead of being absorbed into the ground, the runoff is funneled to streams and creeks, drainage ditches and smaller rivers. All these eventually feed into the Grand River, where it pushes water volumes higher."[4] Excessive erosion and runoff contribute to increased volumes of runoff and high velocities of flow. This results in more rapid rises and falls in water level, as well as stream bank erosion. When the stream flow returns to its dry weather condition, the water will slow down, have less energy to carry sediment, and the excess sediment from erosion will accumulate in the stream channel and cover desirable habitat.

Sediment patterns in the Lower Grand River, its tributaries, and the mouth of the river can vary substantially. Sediment samples taken from the river and its tributaries can be fine-grained and well sorted (all the grains are about the same size). Other times the samples are much coarser (sand and/or gravel) and may or may not be well sorted. Samples also contain variable amounts of organic material such as leaves, bark, and wood.

Variation among samples from a single river system can illustrate the varying energy levels present at different locations in a stream. Samples taken from Lake Michigan at various water depths and distances from the shore show that the grain size of sediments generally decreases with decreasing energy (increasing water depth and distance offshore). Sediment samples from Spring Lake near the Grand River's mouth are very fine grained (clay with perhaps some silt) and are rich in fine, organic matter. The consistently fine sediment found in this location is representative of the low energy throughout the lake. Fresh samples from Spring Lake can have a rotten egg smell due to organic matter being decayed by bacteria that don't require oxygen for growth. The high organic content of the sediments also provides an indications of the large amount of organic material that accumulates in the lake largely because of algal blooms.[5]

Source:

[1] U. S. Environmental Protection Agency. "Polluted Runoff: Nonpoint Source Pollution". Available online at https://www.epa.gov/nps

[2] Lower Grand River Watershed Management Plan (2011). Available online at: https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm

[3] Stream Processes http://www.columbia.edu/~vjd1/streams_basic.htm

[4] Mlive, *2013 Flood: Experts describe how close Grand Rapids was to crippling floodwall breach,* Matt Vande Bunte

[5] Grand Valley State University Geology Department http://faculty.gvsu.edu/videticp/sediments_lp.htm

Lesson Procedure:

1. What is sediment?

Begin the lesson by showing pictures of the Grand River sediment plume and the 2013 Grand River flood*. Have them provide ideas about the following questions:

- How is our school connected to the Grand River? [the school is in the Grand River Watershed]
- What is causing the plume of brown water in the picture? [Something in the runoff of the river water. See *Grand River's brown color isn't caused by what you think*.]
- What specifically is causing the brown color? [Eroded soil or "**sediment**"]
- Why does the size of the plume change? [Variation in flow and precipitation.]

Follow this up by having students read *Grand River's brown color isn't caused by what you think.*

*Note: there was a good deal of local media coverage of the 2013 Grand River flood resulting in myriad newspaper articles and videos available online, or see the teacher resources *Grand River Plume* and *Grand River Flood, April 2013*.

2. Explore the effect of excess sediment in streams and rivers.

Show the video on *Communities for Clean Water: Managing Excess Sediment*. Follow up with a discussion about the sources of sediment and excess sediment as a nonpoint source pollution concern (see the Background section). Using the *Sediment: What's the Problem?* handout, have students create a concept map of the issues presented in the video and the handout.

Ask the students if they think that their schoolyard might contribute to the excess sediment in the Grand River.

Show students the *Signs of Runoff and Erosion* teacher resources as an illustration of the problem. Using the *Runoff and Erosion at School* activity, take the class outside to the schoolyard and have them draw a map showing places where there are signs of **erosion** (see *Signs of Runoff and Erosion* teacher resource) as well as **impervious surfaces** (sidewalks, parking lots, buildings) where water can easily **run off** the surface instead of soaking into the ground. Ask them where they think the water and eroded soil will go [into storm drains, down a slope, to a body of water, etc.]. Does our schoolyard contribute to excess sediment pollution? [answers vary]

3. Observe characteristics of sediment materials.

Place two samples each of gravel, sand, silt, and clay in an egg carton or ice cube tray. Have students make observations of the dry gravel, sand, silt, and clay noting the size of the particles and other properties. Have them predict what will happen if about one teaspoon (5 mL) of water was poured on each of the samples. Which materials would be **most permeable** to rain (will most easily let water flow through) and **least permeable** to rain? [In order from most to least permeable: gravel, sand, silt, clay] Or, in other words, which would have the highest to lowest **infiltration rates** for water? [In order from highest to lowest infiltration rates: gravel, sand, silt, clay] Which would have the greatest to least **runoff** potential in the first storm after a drought? [In order from greatest to least runoff potential: clay, silt, sand, gravel] Relate these observations to the types of soil that are in the Lower Grand River Watershed as shown in *Size of Soil Particles, Permeability, and Soil*

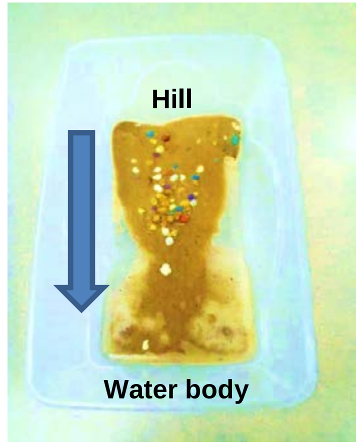
Groups and *Lower Grand River Watershed Soils* transparencies.

Note: The Soil Survey of Kent County has information about where to find clay soils. You could get clay soil from a bank along a road or by digging through the topsoil to get to a clay layer in areas where there is clay as listed in the Soil Survey. Silt often accumulates near the mouth of a stream or sometimes in culverts across roads. You could modify the lesson to use only different types of soil, sand, and gravel if you are unable to obtain clay and silt.

Have students construct a sediment jar by filling a container such as a plastic bottle, baby food jar, or test tube with a stopper with a mixture of gravel, sand, silt, and clay or a mixture of soil types. Add water to the jar until it is about 80% full. Predict what will happen if the jar is shaken. Cap and shake for about 20 seconds and observe what happens over several minutes. Compare this outcome to the prediction. [*The sediments will sort out in layers based on the particle size and the smallest particles will stay suspended in water longer than larger sediments.*]

Ask the students to explain their results.

[*Emphasize the idea that the tiny particles of clay and silt stay suspended in water longer while the largest particles of gravel quickly settle to the bottom. Different sizes of particles move at different speeds. Smaller ones will sink more slowly and end up on top of the larger ones when they both reach the bottom. Even if two particles are made of the same material and are the same shape, the smaller one will sink more slowly and end up on top of the larger one when they both reach the bottom. For advanced classes, a discussion of density and buoyancy would be appropriate.*] Will the clay ever settle? [*Yes the clay will settle, but it will take a while, and the container shouldn't be disturbed during settling.*]



Sample model of a stream (J.Vail)

4. Build a model of sources and movement of sediment.

Ask the students how sediment gets into a stream or river and how it moves. Introduce the terms **erosion** (the movement of sediment from one place to another by water, wind, or other natural forces) and **deposition** (buildup of sediment). Rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

How does sediment move in water? Using what they have observed about the different sizes of particles in sediment, have students predict which type of particles will move the fastest in a flowing stream. To test the prediction, they will create a model of a stream through the guided inquiry activity, *Stream and River Patterns*. This is easily done by placing a mixture of sand and gravel in a container such as a plastic shoe box. Create a hill with the mixture, slightly prop the container up on the hillside, and add water to the top so the water flows downhill.

Students can apply Newton's First Law of Motion (an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force) to their observations as they explore sediment movement, erosion, and deposition. This activity works well in the context of Michigan Science Standards PS2.A.: Forces and motion. A review of forces, push, pull, friction, and gravity might be needed. Also, science and engineering practices can be applied to reducing the sediment load.

Return to the observations of the soil separation test and begin to put the pieces together. Some questions you may want to consider to shape the discussion are:

- Do small particles behave differently in fast-moving water (either the river channel or the sediment jar) than large particles? How? Why?
- Where is the water moving the fastest in their rivers and where is it moving the slowest?
- How does the **velocity** (speed) of the water current affect the sediment load; in particular, the types of sediment that might be suspended?
- How does the **velocity** (speed) of the water current affect deposition; in particular, when different types of sediment might be deposited?
- What would happen if you changed the **slope**?
- How does your model compare to real rivers and streams?

The *Movement of Sediment*, *Sediment in the Stream*, and *Lower Grand River Watershed Topography* teacher resources can be used to illustrate the discussion points.

An alternative to this activity would be the *Rain to Drain - Slow the Flow* activities from Pennsylvania 4H (see the Additional Resources section.)

5. Research the sediment patterns in the Lower Grand River Watershed.

The Lower Grand River Watershed Management Plan (LGRWMP) identifies areas of the watershed (subwatersheds) that are affected by excess sediment pollution. The *Sediment: Where are the problems?* activity pulls information directly from the LGRWMP and challenges students to link subwatershed characteristics with areas that are a high priority for restoration.

The set of subwatershed maps found at the Lower Grand River Organization of Watersheds website can enrich this activity. An example of one of the maps is found in Appendix A.

Other datasets could easily be drawn from the LGRWMP or plans created for subwatersheds, such as the Plaster Creek Watershed Management Plan, for the development of activities and identification of interesting sites to investigate and monitor.

6. Evaluate sediment in streams and rivers.

There are many activities that students can do to evaluate sediment and their effects in streams and rivers, as well as to measure progress of a restoration or remediation project. They include:

- Observations (stream walks, road and stream crossing evaluations)
- Comparisons (wet vs. dry weather stream flow)
- Water quality measurements (turbidity, total suspended solids, flow, temperature)
- Biological assessments (macroinvertebrates)

The Lower Grand River Watershed Management Plan documents water quality monitoring and evaluation efforts throughout the watershed (*Chapter 8 – Methods for Measuring Progress*, Table 8.1.) This includes the parameters measured, types of analysis, protocols, and organizations involved.

Handouts that are useful for student projects have been compiled for each of the activities listed above (see Appendix B).

Website links can be found at:

Groundswellmi.org

More details are available at various sites online, such as the Michigan Clean Water Corps (MiCorps) Volunteer Stream Monitoring Program **Link 2A** and the GLOBE program **Link 2B**, as well as publications such as *The Field Manual for Water Quality Monitoring* and *Steamkeeper's Field Guide*.

Stream habitat assessment

The standardized procedures used by trained volunteers participating in MiCorps include a stream habitat assessment. Physical measurements of streams, substrate types, bank stability and erosion, plant communities, and sources of degradation are some of the parameters evaluated. There is a procedures manual that correlates with the *Stream Habitat Assessment* datasheets found in Appendix B. **Link 2C**

Stream transect

Sediment can settle to the bottom of a stream or river (deposition). **Embeddedness**, the degree to which fine sediments surround coarse substrates on the surface of a streambed, can be used as an indicator of water quality. Although the term and its measurement were initially developed to address habitat space for juvenile steelhead trout, embeddedness measures have been used to assess fish spawning and macroinvertebrate habitat, as well as substrate mobility. The MiCorps *Stream Transect Datasheet* in Appendix B is useful for these measurements.

Measurements

Precipitation- Rainfall amounts can be measured with a rain gauge at your site or data are available online from nearby weather stations. Placement and reading of the rain gauge are critical to accurate measurement of rainfall. Data logs must be kept up-to-date. A reading should be taken every day when there has been any amount of precipitation in the previous 24 hours.

Students will likely note an increase in sediment in the water and perhaps erosion as well after a large storm. Note that the highest flow after a storm does not happen at the same time as the greatest rainfall – there is a lag period. Another type of study would be to make observations about sediment in the stream/river and monitor flow as the snow is melting in spring. A *Precipitation* datasheet is in Appendix B.

Flow- Making observations (turbidity) and measurements (flow) of a stream or river before and after a storm can help students conceptualize sediment loads. Flow is the volume of water that passes a point in a stream in a unit of time (flow = volume/time). Stream studies in the United States generally calculate flow in cubic feet per second. See the USGS website for current streamflow data. **Link 2D**

Volume is difficult to measure directly. It can be estimated by calculating velocity and area. Measure the average velocity by timing how long it takes an object (such as an orange) to travel a set distance downstream and measure the average cross sectional area (depth x width). The equation for flow by this method is: flow = velocity x cross sectional area. See the three *Flow* datasheets in Appendix B.

Turbidity- Although **turbidity** (cloudiness) is a measure of the clarity of water, turbidity is caused by a variety of suspended materials, not just sediment. The material can be both organic (e.g., plankton) and inorganic (e.g., silt, clay). The suspended material will scatter and absorb light passing through the water. The light scattered back to the observer can make the water appear different colors, depending on the type and amount of suspended material. Rainfall and runoff can increase the suspended solid load in a river and make the river appear cloudy or muddy.

Turbidity can be used to evaluate water quality and the health of aquatic ecosystems. High turbidity (low clarity) can indicate erosion and excess sediment. One of the ways to measure turbidity is to use a turbidity tube. This tube can easily be constructed from relatively inexpensive materials. Directions on how to use and make a turbidity tube are found in Appendix B. Schools in the GLOBE program could post their results on the GLOBE data entry site. **Link 2B**

Total suspended solids (TSS)- The majority of a stream's sediment load is carried in solution (**dissolved load**) or in suspension (**suspended load**). The remainder is called the **bed load**. Suspended load is composed of fine sediment particles suspended in the water column and transported by the stream. These materials are too large to be dissolved, but too small to stay deposited on the bed of the stream. Sophisticated computer models are used to estimate sediment loads in watersheds using a variety of parameters such as erosion based on soil types, slopes, proximity to water, management practices, land use/cover, and 30-year average annual precipitation. The suspended sediment concentration (SSC) in mg/L can be determined by filtering and drying an entire water sample as show in the *Total Suspended Solids* handout in Appendix B.

Temperature- Sediments can absorb heat resulting in an increase in water temperature. Water temperature is important because warm water can be fatal for sensitive species, such as trout or salmon, which require cold, oxygen-rich conditions. Warmer water also can hold less dissolved oxygen, which can make the water body inhospitable for species that need higher oxygen levels.

Water temperature is important for understanding local and global weather patterns. Water temperatures change differently than air temperatures because water has a higher specific heat capacity than air. (It takes more heat to raise the temperature of water by one degree than it takes to raise the temperature or air one degree.) Water also helps to change air temperature through the processes of evaporation and condensation.

Have your students test the effects of sediment on temperature by putting samples of pure water and cloudy water with sediment in a sunny place for an hour. Then compare the water temperatures. This activity could be expanded by using samples with different sediment loads (add different known amounts of sediment to the water). Basic equipment for measuring water temperature includes a calibrated thermometer and a bucket for water collection (see Appendix B. *Water Temperature*). Water temperatures can be taken directly in streams as well.

Road-Stream Crossings

According to Michigan Department of Natural Resources (MDNR), thousands of road-stream crossings exist throughout the State of Michigan but most have not been assessed for effects on stream health and stability, aquatic organism passage, erosion related issues, or water quality. Poorly maintained or poorly constructed road-stream crossings can result in increased sediment loads in streams and rivers. Both the stream crossing structure as well as the road and its surroundings need to be evaluated.

Using the *Stream Crossing Data Sheet* in Appendix B, students can help inventory road-stream crossings. A supporting document for the *Stream Crossing Data Sheet* is available at the MiCorps website. Results of previous inventories are shown in a map at **Link 2E**. Additional examples are available at **Link 2F** and **Link 2G**.

Macroinvertebrates

Macroinvertebrates are animals without backbones that are large enough to see with the naked eye. Examples include insect larvae, flatworms, crayfish, snails, and clams. Aquatic macroinvertebrates live on, under, and around rocks and sediment on the bottoms of lakes, rivers, and streams.

Macroinvertebrates have long been used as indicators to evaluate water quality. A biotic index, which is simple measure of pollution tolerance, can be calculated from the macroinvertebrates present at a site. Partners such as local offices of Trout Unlimited, West Michigan Environmental Action Council, or MiCorps could serve as resources for getting started with assessing macroinvertebrates. Basic *Stream Macroinvertebrate Data Sheets* are in Appendix B.

7. Reduce sediment loads.

Where does water go when it rains? Show the video *15 to the River* at **Link 2H** or **Link 2I**. Use the *Urban Wet Water Flows* diagram to review the flow of water in an urban system emphasizing **combined sewer systems** (sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe system) and **separate sewer systems** (two different sets of sewer pipes for sanitary sewage and rainwater runoff). If possible, determine if the area around your school has combined or separate sewer systems and where the sewer systems take their contents.

Emphasize the role of **catch basins**, which are storm sewer inlets that filter out debris such as leaves and litter. Catch basins typically are located next to street curbs or in the rear yards of residential areas. Grand Rapids students can adopt a catch basin as shown in the *Be a Basin Buddy* teacher resource and students in other areas could do similar "adoptions."

Now that students have a basic understanding of how water flows, use the *Charity Car Wash* worksheet as a practical example. Have students decide on where to have their car wash and the advantages/disadvantages of the locations selected. Engage them in discussion based on the *Example Charity Car Wash Locations* teacher resource.

Introduce the terms best management practices (BMPs) and green infrastructure as a way to manage erosion and stormwater runoff. **Best management practices** are physical or cultural controls working individually or as a group, appropriate to the source, location, and area climate for the pollutant to be controlled. **Green infrastructure** includes a range of soil-water-plant systems that intercept stormwater, infiltrate a portion of it into the ground, evaporate a portion of it into the air, and in some cases release a portion of it slowly back into the sewer system. Show pictures of BMPs and green infrastructure as found online in the Great Lakes Commission's Nonpoint Source Pollution Educational Primers. **Link 2J**

The *MDEQ Nonpoint Source Best Management Practices (BMP) Manual* has numerous examples of best management practices and green infrastructure. **Link2K**

Another BMP resource is the Michigan Low Impact Development Manual. **Link 2L**

Using the *Sediment: What can you do?* worksheet, have student teams select an example BMP and create posters to illustrate their BMP. After a gallery walk where students view each other's posters, engage them in a discussion of what ideas arise for reducing excess sediment loads from the schoolyard or other location.

Follow this up with a discussion of *Sediment Goals and Objectives* from the Lower Grand River Watershed Management Plan and how this might relate to a school project. The Lower Grand River Organization of Watersheds (LGROW) website is another source of project ideas and it lists the groups that are working on a specific subwatershed. **Link 2M** Nonpoint Source Project Fact Sheets about nonpoint source projects can be found by following the link at the MDEQ's Nonpoint Source Pollution website. **Link 2N**

Optional online activity:

Have students choose a site and run the National Stormwater Calculator. **Link 2O** They can enter any U.S. location and select different scenarios to learn how specific green infrastructure installations, including affordable changes like rain barrels and rain gardens, can prevent pollution. This information helps users determine how adding green infrastructure can be one of the most cost-effective ways to reduce stormwater runoff. The *National Stormwater Calculator* activity sheet leads students through the process.

Extensions

1. Divide the class into teams and have each team create a physical model of land near a stream. Test the model by running a known volume of water on it, measuring the percent runoff by collecting the volume of runoff, and presenting the results to the class. Each box should be constructed differently. Examples are a lawn, farm with row crops, contour planting, dirt road, diversion ditch, gravel road, asphalt road, construction by a road, and construction with a best management practice.

2. Research the Grand River flooding event that happened in April 2013. Why did it happen? What were the effects of the flooding? What was the condition of the river's sediment load during the flooding?

3. Collect sediment samples to compare from various parts of the Grand River and Lake Michigan. Contact the GVSU Annis Water Resources Institute for Lake Michigan samples that are collected offshore where the Grand River meets Lake Michigan.

4. As an online exercise, run Model My Watershed to learn how changes in rainfall amounts, the surfaces on which the rain falls, and soil texture change where the water goes. **Link 2P**

5. Using GIS to download a property map, students can design a stormwater management plan for a specific site.

Embedded videos guide this process. **Link 2Q**

6. An Introduction to Stream Ecology **Link 2R**, Understanding Macroinvertebrates **Link 2S**, and Biotic Index **Link 2T** provide background information for this lesson. The videos are produced by the University of Wisconsin Extension.

7. Even though you might not have a stream near your school, there might be drain systems to investigate. Go online to the Kent County Drain Commissioner's office to access drain maps. **Link 2U** Have students select the map where their school is located. Along the location of streams, the map might show culverts (drain or pipe that allows water to flow under a road, railroad, etc.), flood routes, open channels, storm mains, and detention basin culverts.

8. Use the Michigan Surface Water Information Management (MiSWIM) System to view monitoring sites and associated data. **Link 2V**

Assessment

1. Have students, either individually or in teams, propose answers to these questions: "How does the speed of the current affect the types of sediments that are carried and deposited by a river? When water moves quickly, what happens? When water moves slowly, what happens? Why?"

2. As an application of their learning, have students design a project for their schoolyard that will help minimize erosion and runoff.

3. Have students play Stormwater Jeopardy at the Michigan Department of Environmental Quality Stormwater website. **Link 2X**

Additional Resources

Website links can be found at:

Groundswellmi.org

After the Storm

This 22-minute video and accompanying brochure introduces the public to stormwater runoff using a variety of case studies. The video can be viewed at **Link 2X**. It includes tips for preventing runoff and was co-produced by the U.S. Environmental Protection Agency and The Weather Channel. The brochure is available at **Link 2Y**. Another useful brochure from the EPA is available here **Link 2Z**.

City of Grand Rapids - Basin Buddy

The City of Grand Rapids has a program called Basin Buddy where people can "adopt" a catch basin to make sure it is well maintained. **Link 2AA**

Conservation Districts

Counties in Michigan have local Conservation District offices that can offer assistance for projects and educational resources. The Kent Conservation District website is useful for finding out information about soil types and their erosion potential. **Link 2BB**

Drain Commissioners

By state law, drain commissioners are elected to oversee administration of the State Drain Code. This involves overseeing the Code as it applies to more than 536 miles of County Drain and 356 storm water detention ponds in Kent County. There is a GIS program for the drains in the county, which generates maps of city and county drains. **Link 2U**

Exploring Streams: Stream Monitoring Curriculum Guide for Middle and High School Teachers and Students

Middle and high school students can learn about at least six aspects of stream health when educators guide them through this Water Action Volunteers (WAV) stream monitoring curriculum. The activity guide is divided into six sections. You can download the entire curriculum or specific components of it. Note that the version posted online does not contain answers. An educators' version is available in print. There are links to PowerPoint slides at this site. **Link 2CC**

Field Manual for Water Quality Monitoring

Mark Mitchell's and Dr. William Stapp's *Field Manual for Water Quality Monitoring, an Environmental Education Program for Schools* is a classic guide for K-12 educators. Originally developed at the University of Michigan, the manual includes detailed information about setting up a water monitoring site, determining what data to collect, and what to do with the data once they are collected. Mitchell, M. and W. Stapp. (2000). Dubuque, IA. Kendall/Hunt ISBN-10: 0757555462

Lower Grand River Organization of Watersheds (LGROW)

LGROW brings together local municipalities and community stakeholders in a unique format to address watershed issues facing the Lower Grand River and its subwatersheds. LGROW promotes community education and sustainable use of our river resource. This website has numerous maps relating to the Lower Grand River Watershed. **Link 2M**

MiCorps

The Michigan Clean Water Corps (MiCorps) is a network of volunteer water quality monitoring programs in Michigan. It was created to assist the Michigan Department of Environmental Quality (MDEQ) in collecting and sharing water quality data for use in water resources management and protection programs. MiCorps water monitoring procedures and forms for lake and stream monitoring are at this site. **Link 2A**

Michigan Dept. of Environmental Quality

The MDEQ maintains an online database of water quality monitoring information. The data are available through their Assessment of Michigan Waters page. **Link 2DD**

Michigan Environmental Education Curriculum Support (MEECS)

The MEECS Water Quality Unit is part of a series of lesson units specifically developed for teachers in Michigan. Several lessons and parts of lessons are applicable for teaching about nonpoint source pollution. Specifically, Lesson 4: *How do land uses affect water quality?* and *How healthy is this stream*? complement this lesson. **Link 2EE**

Michigan Surface Water Information Management (MiSWIM) System

The Michigan Surface Water Information Management (MiSWIM) System is an interactive map-based system that allows users to view information about Michigan's surface water. Users are able to view and download data collected by the MDEQ and DNR from surface water monitoring sites throughout Michigan. They can pinpoint the creeks, streams, and rivers in their area. **Link 2FF**

National Low Impact Development Atlas

This online resource has a map of the United States with low impact development (LID) projects highlighted. This LID Atlas was created for the National Nonpoint Education for Municipal Officials (NEMO) Network. **Link 2GG**

National Stormwater Calculator

EPA's National Stormwater Calculator (SWC) is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site anywhere in the United States. Estimates are based on local soil conditions, land cover, and historic rainfall records. The Calculator accesses several national databases that provide soil, topography, rainfall, and evaporation information for the chosen site. The user supplies information about the site's land cover and selects the types of low impact development (LID) controls they would like to use. **Link 2HH**

Networked Neighborhoods

This Great Lakes-focused resource includes information about low impact development (LID) projects. It's available at: **Link 2II**

Rain to Drain –Slow the Flow

Rain to Drain – Slow the Flow is a creative, hands-on stormwater education curriculum available from Penn State Extension and Pennsylvania 4-H. This experiment-style series of activities leads youth and adults to a better understanding of the movement of stormwater in natural and developed communities. It's also a great introduction to green infrastructure and stormwater best management practices. **Link 2JJ**

River Cutters

River Cutters is a classic Great Explorations in Math and Science (GEMS) publication. Creating river models using a dripper system and diatomaceous earth, students acquire geological terminology and begin to understand rivers as dynamic, ever-changing systems. They investigate the concepts of erosion, pollution, toxic waste, and human manipulation of rivers, and help students gain understanding of controlled experimentation. **Link 2KK**

Soils Surveys

Soil survey information is regularly updated and posted to the Web Soil Survey, which is the official source for current information. The Web Soil Survey provides both tabular and spatial data and allows you to create a custom soil resource report for your specific area of interest. Electronic pdf files are available for older soil surveys. **Link 2LL**

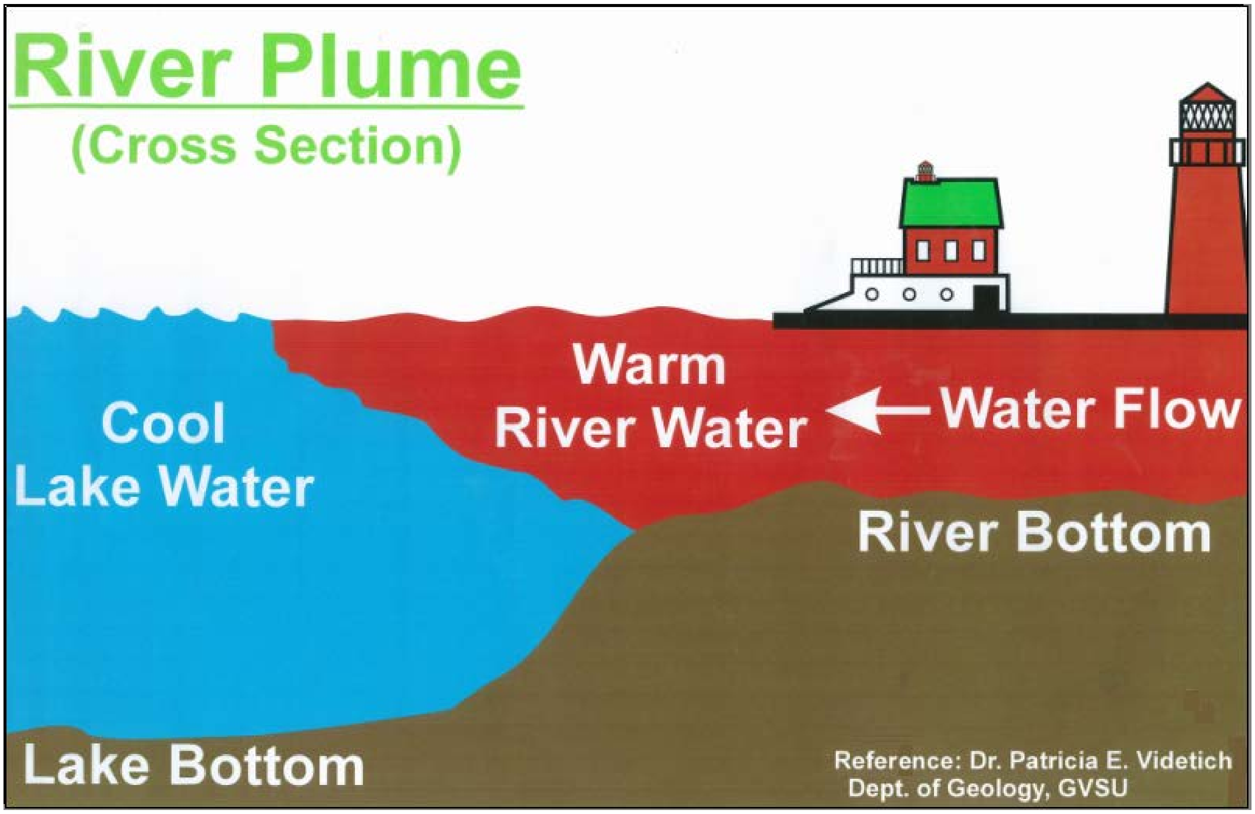
Streamkeepers Field Guide

The Adopt-A-Stream Foundation's *Streamkeepers Field Guide* has background information about understanding watersheds, stream reach surveys, monitoring parameters and procedures, data management, data display, and putting data to use. Data sheets and directions for making homemade sampling equipment are found in the appendix.

Murdoch, T., M. Cheo, and K. O'Laughlin. (1996). Everett, WA: Adopt-a-Stream Foundation ISBN: 0965210901

Grand River Plume into Lake Michigan at Grand Haven

Image by Marge Beaver



Grand River Flood, April 2013

Fifth Third Ballpark

Grand Rapids Water Resource Recovery Facility

Riverfront Plaza Building

Source for photos: http://photos.mlive.com/mlivecom_photo_essays/2013/04/20_most_dramatic_images_from_h.html

Grand River Flood, April 2013, Ada, MI

Images by J. Vail

Grand River Flood, April 2013, Ada, MI

Images by J. Vail

Grand River's brown color isn't caused by what you think

Jeff Alexander, Muskegon Chronicle, July 12, 2010

Heavy rains routinely turn the Grand River the color of cappuccino in Grand Haven, where the river sends a large plume of light brown filth into the clear blue water of Lake Michigan.

The conventional wisdom in Grand Haven holds that sewage discharges in Lansing and Grand Rapids discolor Michigan's longest river following heavy rains. But that theory doesn't hold water, experts said.

"A lot of people continue to focus on combined sewer overflows as the major source of pollution in the river, but that's really not the case anymore," said Rick Rediske, a professor of water resources at Grand Valley State University. "The issues facing the Grand River have changed."

It turns out that tiny particles of light brown clay, not sewer overflows, change the river's hue when it rains. The Grand River drains a 5,572-square-mile basin laden with clay soils, Rediske said.

The river's periodic chameleon act illustrates what experts said is the most serious problem facing the Grand — polluted stormwater runoff from farms and urban areas. Large livestock farms, failing septic tanks and dirty runoff from streets and parking lots are feeding the Grand River and many of its tributaries a heavy dose of sediment and pathogens that hurt water quality, jeopardize fish and wildlife and threaten human health, Rediske said.

The magnitude of the stormwater problem — also known as nonpoint source pollution — was illustrated in 2006. Manure from an unidentified farm drained into Tyler Creek that year, killing hundreds of trout in a 4.5-mile stretch of the scenic stream in southeast Kent County.

The Grand River's problem with excessive stormwater runoff dates to the early 1800s, according to a U.S. Army Corps of Engineers study. Before European settlers arrived, the river's 5,572-square mile drainage basin was dominated by forests, meadows and wetlands, according to the Corps report.

"This type of land use/cover would have resulted in very little sediment delivered to the river and harbor area (in Grand Haven)," the Corps report said.

The logging of Michigan's forests in the 1800s denuded the landscape. The subsequent growth of farming and urban areas destroyed about half of all wetlands in the basin, according to the scientific studies.

The result: Abnormally large amounts of stormwater and sediment now wash off the landscape and into the river during rain showers and when snow melts.

Each year, the Grand River pumps 167,160 tons of sediment into Lake Michigan, nearly 14,000 tons per day on average, according to the Corps study.

Rivers are designed to move sediment. The problem is the Grand carries 10 times more sediment to Lake Michigan than the Saginaw River pumps into Lake Huron, even though the Saginaw drains a much larger landscape.

Rita Chapman, clean water program director for the Sierra Club, said the battle to improve water quality in the river would be won or lost on land. "When you think about restoring a river, you'd better think about what's happening on the land around it," Chapman said, "because 95 percent of a watershed is land."

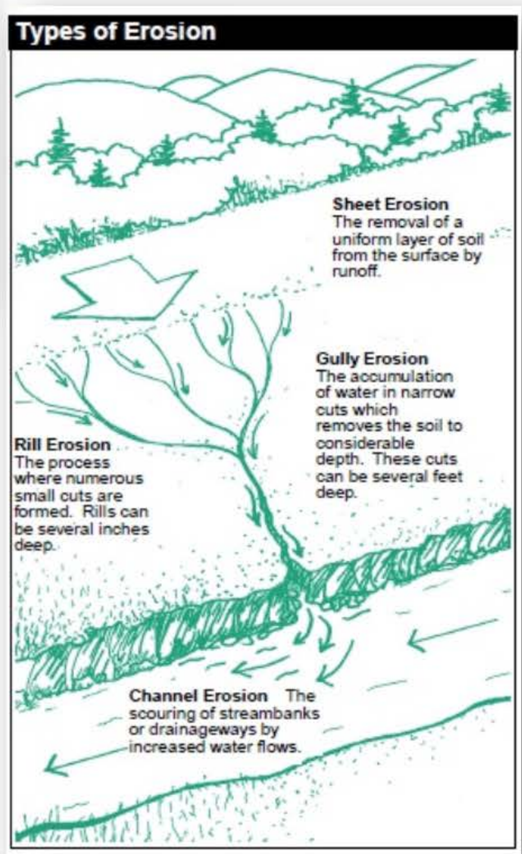
Signs of Soil Erosion

- Small rills or gullies beginning to show
- Buildup of silt in certain areas
- Bare spots on lawns or property
- Exposed roots of trees and vegetation
- Small stones or rocks becoming evident
- Soil splashed on windows and exterior walls
- Undercut and fallen trees in stream channels
- Widening and deepening of stream channels

Macatawa River
M. Oudsema, AWRI

Unnamed ditch near 43rd street (Macatawa Watershed)
M. Oudsema, AWRI

Peter's Creek (Macatawa Watershed)
M. Oudsema, AWRI



Types of Erosion
http://www.fairfaxcounty.gov/nvswcd/youyourland/soil.htm

Excess Sediment: What's the Problem?

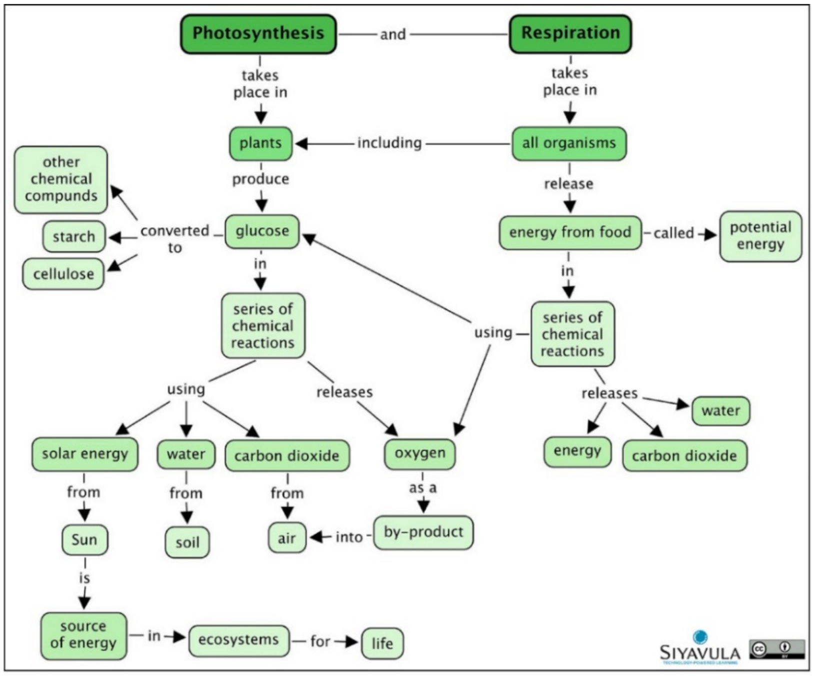
Your challenge: Draw a concept map that links these ideas together. The main topic of your concept map should be "sediment". Feel free to add illustrations to your thoughts.

Sediment entering local waterbodies through stormwater runoff degrades the quality of water for drinking, wildlife, and the land surrounding lakes and streams in the following ways:

- Sediment fills up storm drains and catch basins, potentially clogging them and impairing their ability to carry water away from roads and homes. This increases the potential for flooding.
- Water polluted with excess sediment becomes cloudy, making it more difficult for animals to see their food in the water.
- Murky water limits the ability for natural vegetation to grow in the water if it can't get enough sunlight.
- Excess sediment in stream beds disrupts the natural food chain by destroying the habitat where the smallest stream organisms live and causing massive declines in fish populations.
- Excess sediment increases the cost of treating drinking water and can result in odor and taste problems.
- Excess sediment can clog fish gills, reducing resistance to disease, lowering growth rates, and affecting fish egg and larvae development.
- Nutrients transported by sediment can activate large algae blooms, including cyanobacteria (blue-green algae) that release toxins and can make swimmers sick.
- Sediment deposits in rivers can alter the flow of water and reduce water depth, making navigation and recreational use more difficult.
- Pollutants such as dissolved metals and pathogens can attach to sediment and enter the water.

Source: What is Sediment Pollution, https://cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf

This is an example of a concept map:



Chapter 1: Photosynthesis and Respiration
http://www.mstworkbooks.co.za/downloads/Science-Grade-8A-English-Learners.pdf

Signs of Runoff and Erosion at School

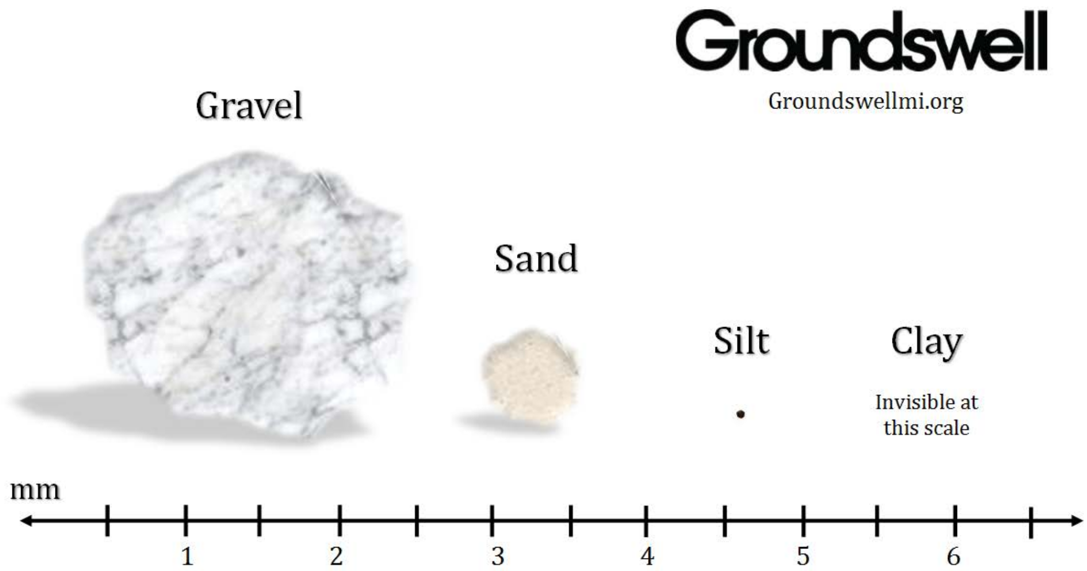
1. Make and label a map of your schoolyard showing the school building, parking lots, sidewalks, grass, trees, drains, ditches, etc. You might want to use an online aerial map of your schoolyard to help with this.

2. Go outside and look for areas where water runs off the surface instead of being absorbed into the ground. These would be impervious surfaces. Label these areas with an “**R**”.

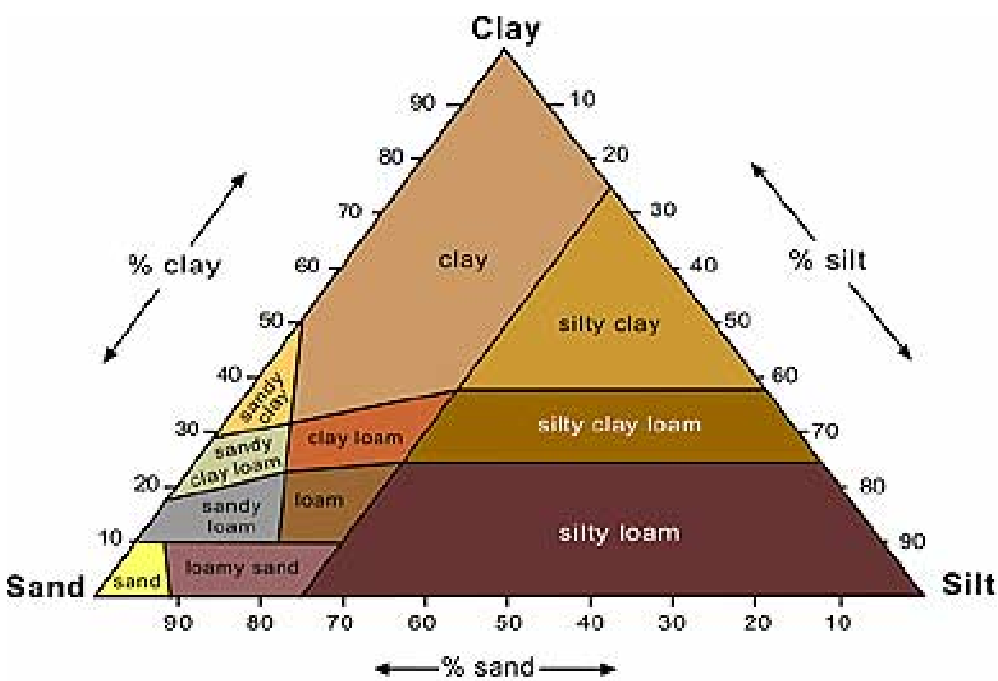
3. Look for signs of erosion and label them with an “**E**”.

4. Use arrows to show where you think the water would flow in a rainstorm.

Size of Soil Particles

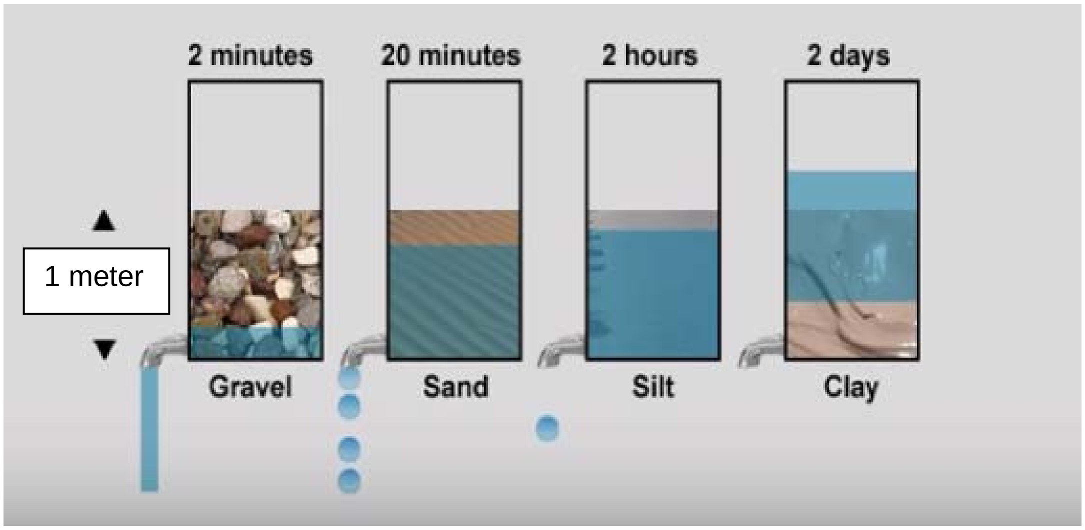


Groundswell, Groundswellmi.org



Texture Triangle
http://lrrpublic.cli.det.nsw.edu.au/lrrSecure/Sites/Web/5222/SoilTexture_04.htm

Permeability and Soil Groups



Source: https://www.youtube.com/watch?v=QcgTZxi1ajk

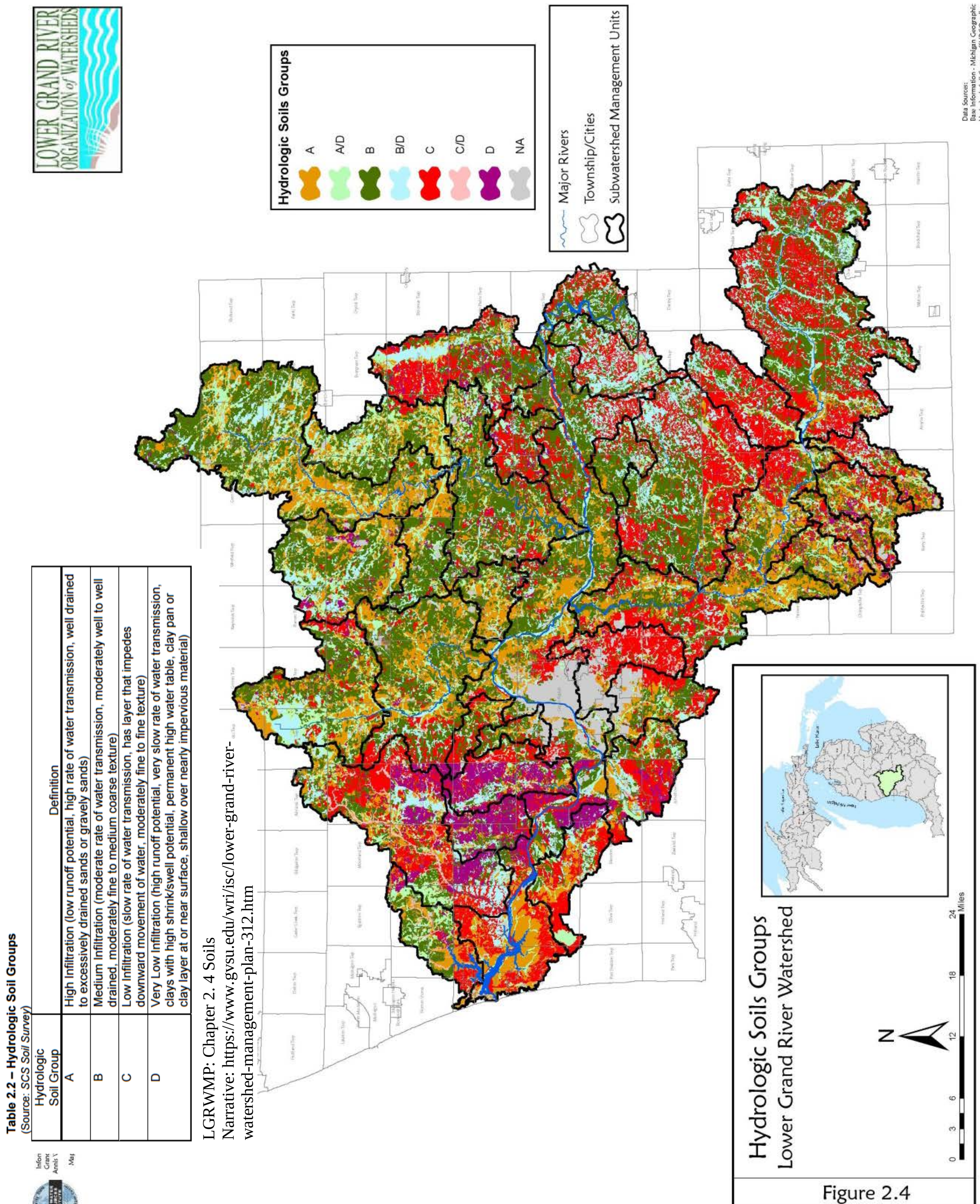
Table 1. Definitions of Hydrologic Soil Groups (USDA, 2010).

Group	Meaning	Saturated Hydraulic Conductivity (in/hr)
A	Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels.	≥ 0.45
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with moderately fine to moderately coarse textures. E.g., shallow loess, sandy loam.	0.30 - 0.15
C	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine textures. E.g., clay loams, shallow sandy loam.	0.15 - 0.05
D	High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay-pan or clay layer at or near the surface, and shallow soils over nearly impervious material.	0.05 - 0.00

Saturated hydraulic conductivity is how fast standing water drains into the soil.

Loam is a combination of sand, silt, and clay.

Lower Grand River Watershed Soils



Lower Grand River Watershed Management Plan. Image from the Figures Volume: https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm

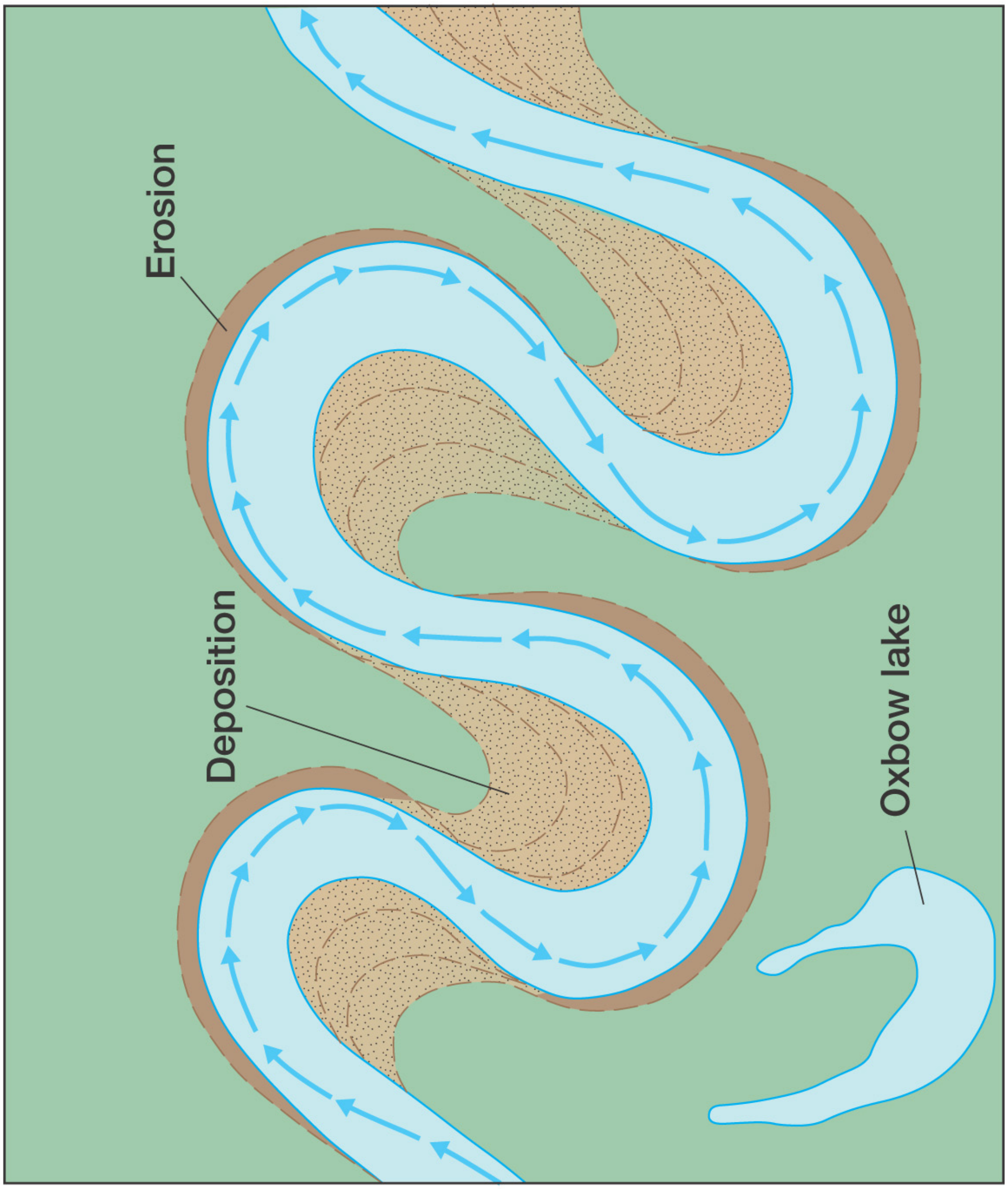
Stream and River Patterns

You and your team will be creating a model of a stream or river to show sediment movement. Put a book or other item underneath one end of a plastic container to create a slope. Make a hill with a mixture of sand, gravel, and clay at the elevated end of a plastic container. Perform the actions, create labeled drawings, and make observations. Use the terms **erosion**, **deposition, runoff, infiltration,** and **slope** in your drawings and observations and indicate how the each of the different types of earth materials moved.

Action	Drawing of the Model	Observations
1. Sediment movement – low flow - slowly add water to the hill		
2. Sediment movement – high flow - rapidly add water to the hill		
3. Sediment load reduction - create and test a design that will slow down the movement of sediment off of the hill		

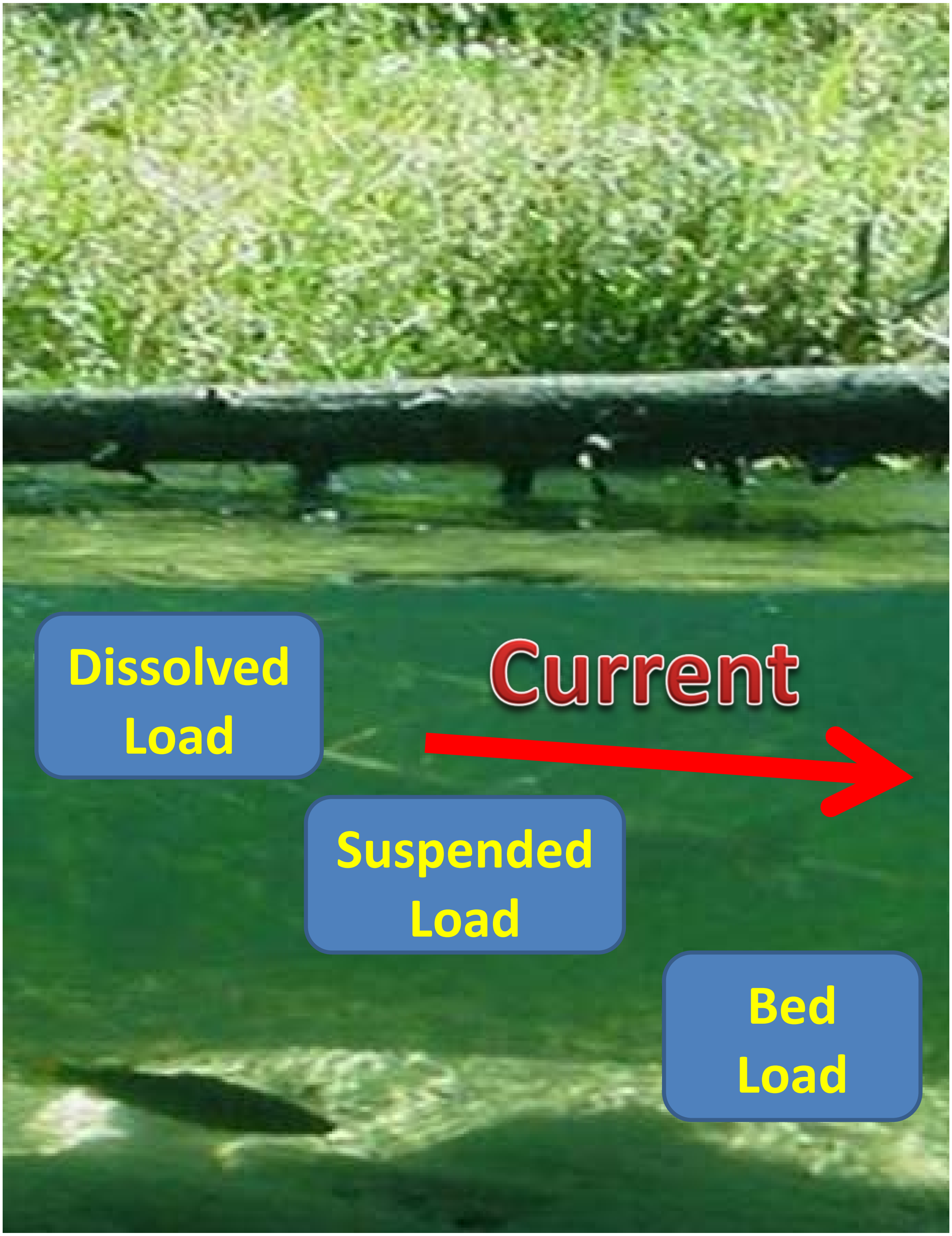
1. According to Newton's First Law of motion, an object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force. What forces (push and pull) were involved in your model?
2. What patterns of sediment movement did you observe during low flow?
3. What patterns of sediment movement did you observe during high flow?

Movement of Sediment

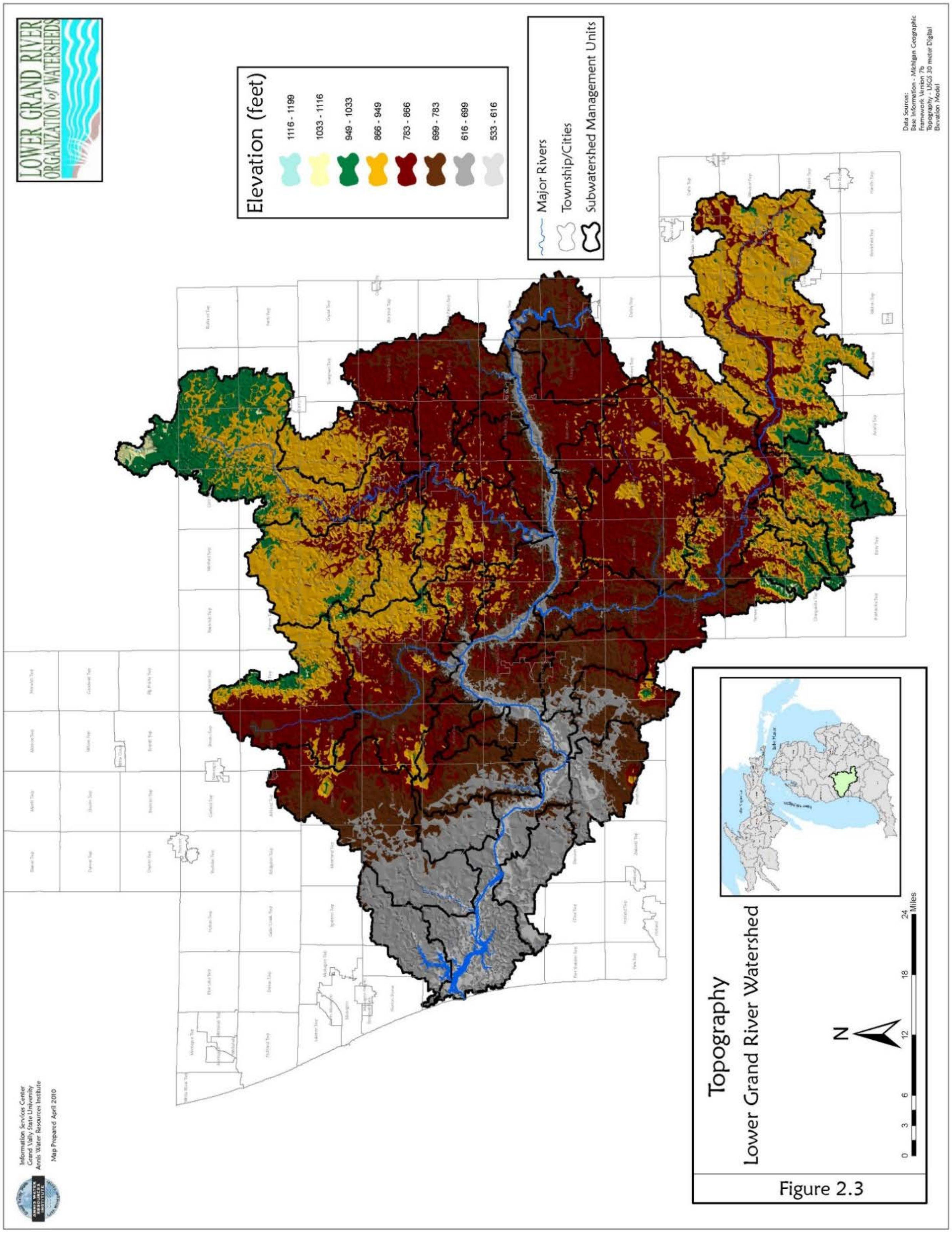


Erosion and Deposition
http://web.gccaz.edu/~lnewman/gph111/topic_units/fluvial/fluvial2.html

Sediment in a Stream



Lower Grand River Watershed Topography



Lower Grand River Watershed Management Plan. Image from the Figures Volume:
https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm

Excess Sediment: Where are the Problems?

Background:

Did you know that there is a *Lower Grand River Watershed Management Plan*? The purpose of a Watershed Management Plan (WMP) is to document the sources and causes of water pollution and outline a strategy to address the activities that harm our local water quality.

Within the Lower Grand River WMP, Chapter 4 identifies the types and sources of pollutants, the quantity of each pollutant, and high-priority areas where action is needed.

Key Elements of a Watershed Management Plan:

1. Understanding Watershed characteristics
2. Identifying and involving local agencies and citizens in the Watershed planning process
3. Identifying designated and desired uses
4. Defining critical areas which are contributing a majority of the pollutants
5. Identifying and prioritizing pollutants, sources, and causes
6. Determining objectives and tasks for meeting Watershed goals
7. Identifying and analyzing existing local projects, programs, and ordinances that impact water quality within the Watershed
8. Informing and involving the public
9. Developing an evaluation process

Your Challenge:

Sediment loading has been calculated for subwatersheds in the Lower Grand River. But is the area with the highest total sediment load also the top priority area?

1. Rank the following by top priority to lower priority (1-6) for reducing sediment.

Subwatershed	Subwatershed, Acres	Sediment Load, Tons/year	Rank
Buck Creek	32,392	1,025	
Indian Mill Creek	10,979	395	
Wabasis and Beaver Dam Creek	30.124	294	
Plaster Creek	36,448	1,347	
Bear Creek	20,332	209	
Direct Drainage to the Grand River	275,237	4,676	

2. Calculate the sediment load per acre and rank top priority to lower priority (1-6).

Subwatershed	Sediment Load/acre	Rank
Buck Creek		
Indian Mill Creek		
Wabasis and Beaver Dam Creek		
Plaster Creek		
Bear Creek		
Direct Drainage to the Grand River		

3. The WMP's relative rankings of these areas were Plaster Creek (1), Buck Creek (2), Indian Mill Creek (5), Direct Drainage (9), Bear Creek (17), and Cedar Creek (28). What likely played a larger role in the WMP ranking - sediment load or sediment load per acre?

4. Use the information below from *Chapter 2 Watershed Characteristics* from the Lower Grand River Watershed Management Plan to explain the difference in sediment load per acre in Bear Creek and Indian Mill Creek.

Land Use, acres	**Bear Creek**	**Indian Mill Creek**
Agriculture	33.4%	38.7%
Forest	35.9%	12.3%
Lakes	2.3%	0.1%
Open land	3.4%	2.5%
Urban	12.2%	43.0%
Wetland	12.8%	3.6%
Soil Type	**Bear Creek**	**Indian Mill Creek**
High infiltration (A)	42%	13%
Medium infiltration (B)	37%	42%
Low infiltration (C)	3%	14%
Very low infiltration (D)	1%	0

5. An inventory of nonpoint sources revealed the following:

Identified Nonpoint Source Pollution Sites	**Bear Creek, Number of sites**	**Indiana Mill Creek, Number of sites**
Nonpoint agricultural source	0	9
Streambank erosion	0	16
Tile outlet	0	5
Livestock access	0	1
Debris/Trash/Obstructions	0	37
Urban/residential	0	59
Construction	0	1
Gully erosion	0	1
Rill erosion	0	3
Total NPS Sites	0	132

If you were to design an outreach program using limited resources for Indian Mill Creek regarding nonpoint source pollution, what would be the message, target audience, and overall plan?

Excess Sediment: Where are the Problems?

Source: Chapters 2 and 3, Lower Grand River Watershed Management Plan
(source: *https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm*)

Teacher's Note: The watershed maps in Appendix B would be valuable additions to this lesson. Refer to the *Lower Grand River Watershed Management Plan* for more details about the subwatersheds.

Your Challenge: Sediment loading has been calculated for each subwatershed in the Lower Grand River. But is the area with the highest total sediment loading also the top priority area?

1. Rank the following by top priority to lower priority (1-6) for reducing sediment.

Subwatershed	Subwatershed, Acres	Sediment Load, Tons/year	Rank
Buck Creek	32,392	1,025	3
Indian Mill Creek	10,979	395	4
Wabasis and Beaver Dam Creek	29,624	238	5
Plaster Creek	36,448	1,347	2
Bear Creek	20,332	209	6
Direct Drainage to the Grand River	275,237	4,676	1

2. Calculate the sediment load per acre and rank top priority to lower priority (1-6).

Subwatershed	Sediment Load/acre	Rank
Buck Creek	0.0326	3
Indian Mill Creek	0.0360	2
Wabasis and Beaver Dam Creek	0.0098	6
Plaster Creek	0.0370	1
Bear Creek	0.0103	5
Direct Drainage to the Grand River	0.0170	4

3. The WMP's relative rankings of these areas were Plaster Creek (1), Buck Creek (2), Indian Mill Creek (5), Direct Drainage (9), Bear Creek (17), and Cedar Creek (28). What likely played a larger role in the WMP ranking - sediment load or sediment load per acre? *Sediment load per acre*

Subwatershed	Sediment Load, Tons/year	Sediment Load/acre	Adjusted Rank
Buck Creek	3	3	2
Indian Mill Creek	4	2	3
Wabasis and Beaver Dam Creek	5	6	6
Plaster Creek	2	1	1
Bear Creek	6	5	5
Direct Drainage to the Grand River	1	4	4

4. Use the information below from *Chapter 2 Watershed Characteristics* from the Lower Grand River Management Plan to explain the difference in sediment load per acre in Bear Creek and Indian Mill Creek.

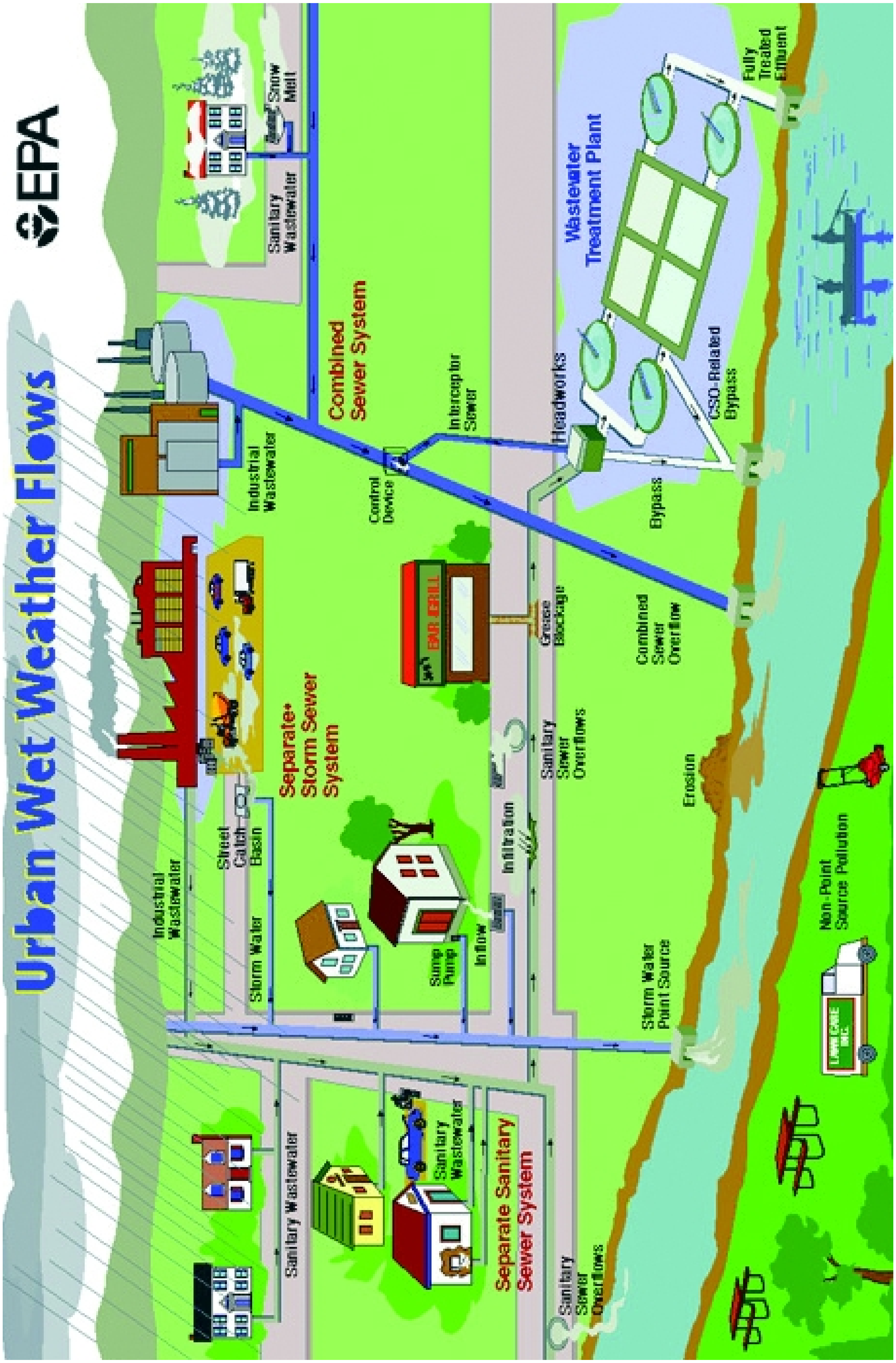
Land Use, acres	**Bear Creek**	**Indian Mill Creek**
Agriculture	33.4%	38.7%
Forest	35.9%	12.3%
Lakes	2.3%	0.1%
Open land	3.4%	2.5%
Urban	12.2%	43.0%
Wetland	12.8%	3.6%
Soil Type	**Bear Creek**	**Indian Mill Creek**
High infiltration (A)	42%	13%
Medium infiltration (B)	37%	42%
Low infiltration (C)	3%	14%
Very low infiltration (D)	1%	0

The sediment load per acre for Indian Mill Creek is greater than that of Bear Creek. Indian Mill Creek has a higher percentage of land uses that can contribute to sediment loads (agriculture, urban). Bear Creek's higher percentage of forests, wetlands, and lakes contribute lower sediment loads. The distribution of soil types in Indian Mill Creek has lower infiltration potential than in Bear Creek. This would imply more runoff and erosion resulting in increased sediment loads.

5. An inventory of nonpoint sources revealed the following:

Identified Nonpoint Source Pollution Sites	**Bear Creek, Number of sites**	**Indiana Mill Creek, Number of sites**
Nonpoint agricultural source	0	9
Streambank erosion	0	16
Tile outlet	0	5
Livestock access	0	1
Debris/Trash/Obstructions	0	37
Urban/residential	0	59
Construction	0	1
Gully erosion	0	1
Rill erosion	0	3
Total NPS Sites	0	132

If you were to design an outreach program using limited resources for Indian Mill Creek regarding nonpoint source pollution, what would be the message, target audience, and overall plan?

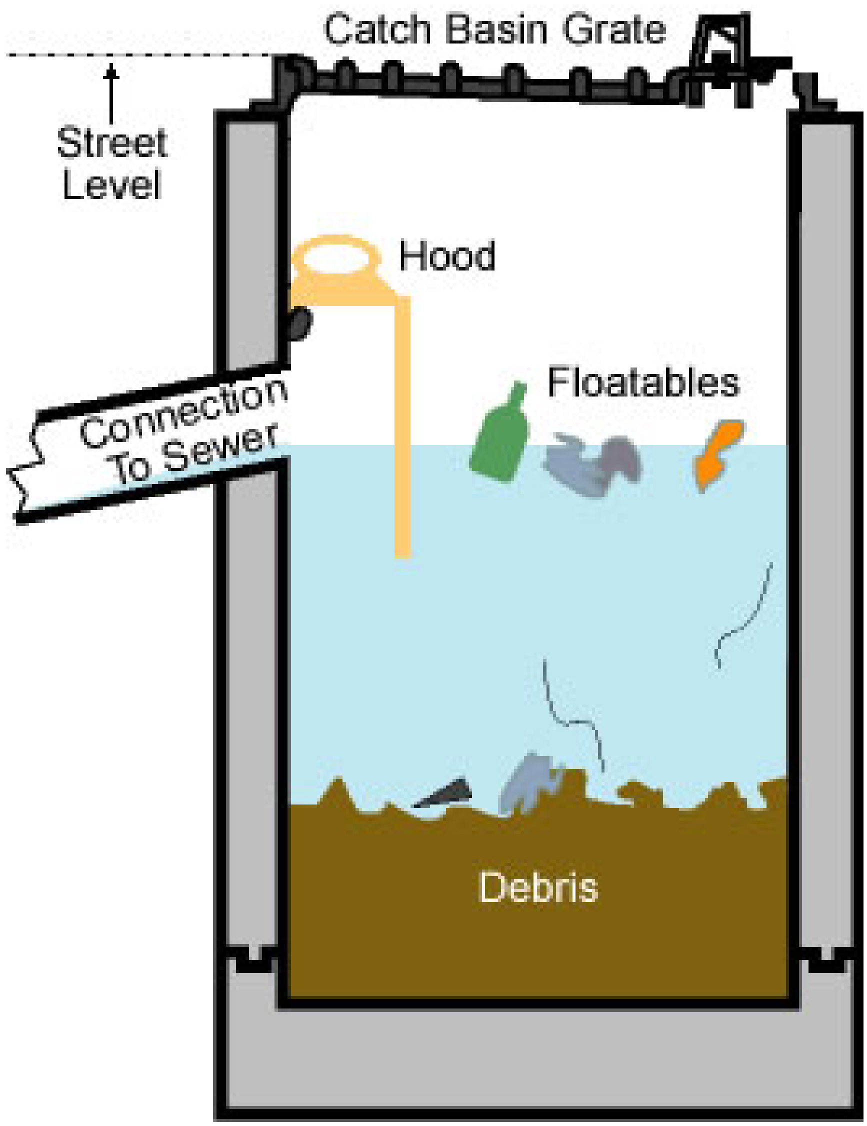


Source: National Academies Press, page 109. https://www.nap.edu/read/11196/chapter/6#108

Be a Basin Buddy

The Basin Buddy Program was created to educate and involve City of Grand Rapids residents in the care, maintenance, and complexity of the storm water infrastructure. City residents can adopt a catch basin. Below is a cross section of a catch basin. The debris in the bottom portion (sump) should be no more than half of the total volume of the sump. If you notice that your Basin Buddy ate too much (more than half full) contact the City!

Source: City of Grand Rapids. http://grcity.us/enterprise-services/Environment-Services/basin/Pages/Basin%20Buddy%20Program.aspx



Charity Car Wash

A group at your school wants to have a car wash to raise money. Draw a map of the area around your school to identify three potential car wash locations that offer the greatest opportunity for environmental controls and for preventing the pollutants from leaving the site.

After selecting a location for a proposed car wash, determine where any wash water would drain and determine the drainage path, especially for any locations on or adjacent to pavement. You will need to determine what type of sewer (**separate** or **combined**) drains the proposed car wash location, because there's no way of determining the storm sewer type just from outward appearances (i.e., just by looking at the inlets).

Map of Car Wash Locations

1. Advantage of Location 1:

2. Advantage of Location 2:

3. Advantage of Location 3:

Example Charity Car Wash Locations

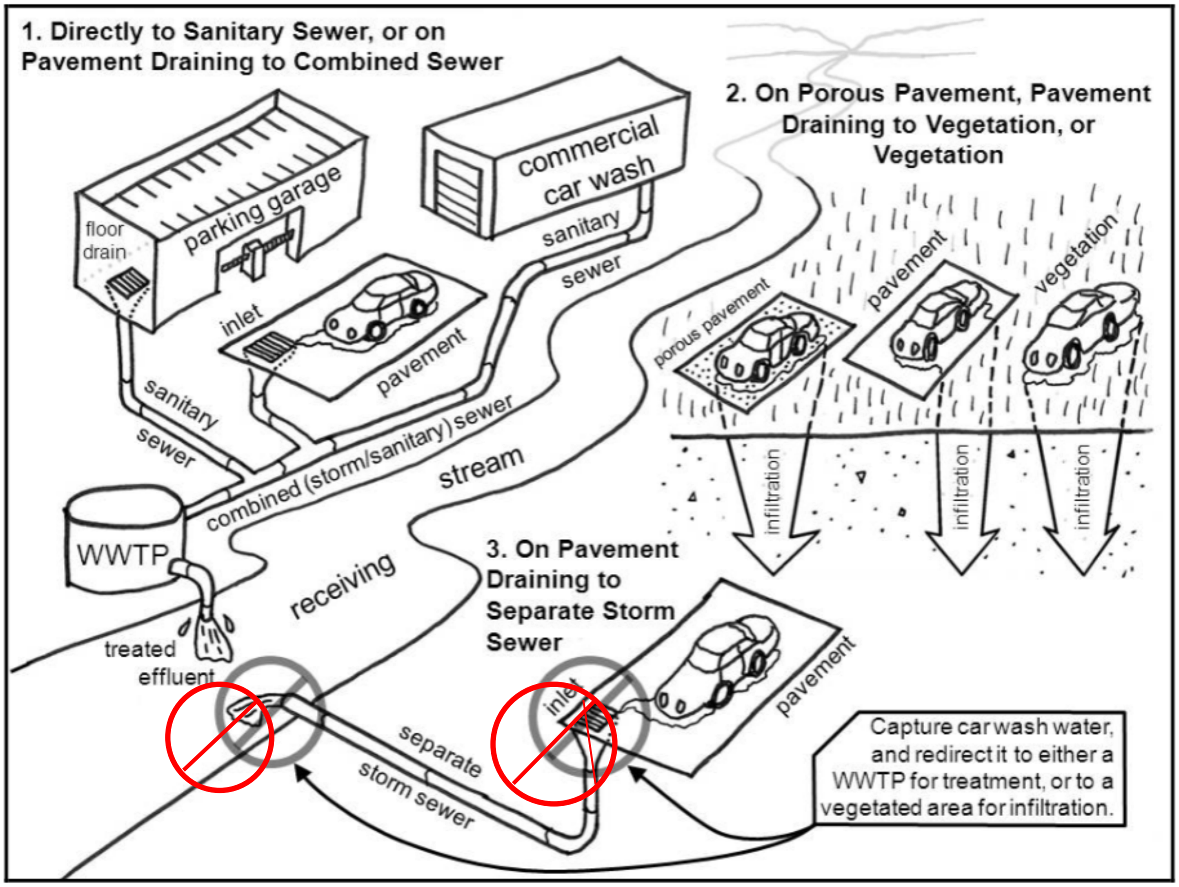


Figure 1. Scenarios for Charity Car Wash Locations

1. **Car Washes on Pavement Draining to Combined Sewer**

Combined (sanitary/storm) sewers carry both storm water and sanitary wastewater to the wastewater treatment plant (WWTP). Any car wash water that enters a combined sewer will eventually be carried to the WWTP where it will be treated, which is the preferred option.

2. **Car Washes on Vegetation, Porous Pavement, or Pavement Draining to Vegetation**

(i.e., Water infiltrates into the ground only, and doesn't run off). If the car wash is to be held on grass or other vegetation, there can be no runoff; all car wash water must infiltrate into the ground. Make sure that the car wash location is far enough away from any drinking water wells. To ensure that car wash water does not cause erosion, select areas with stable vegetation.

3. **Car Washes on Pavement Draining to Separate Storm Sewers**

Separate storm sewers carry storm water only, and drain directly to the nearest receiving waters. Thus, if any car wash water were to enter this type of sewer, it would be carried to and discharged directly into the nearest lake, stream, or wetland. Proper controls must be in place prior to conducting a car wash to prevent the release of pollutants to a separate storm sewer.

* Check with your municipality to make sure your location can be used.

Source: MDEQ: http://www.michigan.gov/documents/deq/wrd-nps-charity-car-washes_459714_7.pdf

Lower Grand River Watershed Restoration Projects

Source: Nonpoint Source Project Fact Sheets, MDEQ
(http://www.michigan.gov/deq/0,4561,7-135-3313_71618_3682_3714-101788--,00.html)

Pratt Lake Creek, tributary to Tyler Creek Before

The site is located in Bowne Twp, Kent County, MI. The land was farmed and manure was spread adjacent to the banks of the creek, where pathogens such as *E. coli* directly entered the water.

Pratt Lake Creek, tributary to Tyler Creek After

The switch grass filter strip was well established by June 2007: the grasses were planted in April.

Stream Bank Before

Stream Bank After

Description: Before and after photos above of a streambank that is heavily used by fisherman along the Rogue River in Kent County. As a consequence, seven hundred feet of streambank were eroding and contributing sediment into this section of the river, which is prime spawning area for fish. To control the sediment input, the bank was graded and stabilized with riprap and vegetation. Partners on this project were the Schrems West Michigan Trout Unlimited.

Excess Sediment: What can you do?

Your challenge: Develop a poster using some of the ideas below that could be used for informing people about what they can do to reduce excess sediment.

- Sweep sidewalks and driveways instead of hosing them off. Washing these areas results in sediment and other pollutants running off the surface, down storm drains, and into streams, rivers, and lakes.
- Use weed-free mulch when reseeding bare spots on your lawn and use a straw erosion control blanket if restarting or tilling a lawn.
- Think about notifying local government officials when you see sediment entering streets or streams near a construction site.
- Put compost or weed-free mulch on your garden to help keep soil from washing away.
- Avoid mowing within 10 to 25 feet from the edge of a stream or creek. This will create a safe buffer zone that will help minimize erosion and naturally filter stormwater runoff that might contain sediment.
- Either wash your car at a commercial car wash or on a surface that absorbs water, such as grass or gravel.
- To decrease polluted runoff from paved surfaces, households can develop alternatives to areas traditionally covered by impervious surfaces. Porous pavement materials are available for driveways and sidewalks.
- In areas subjected to strong winds, such as along the Great Lake shorelines, soil should never be placed in piles and left unvegetated or otherwise unprotected.
- An effective way to control runoff and erosion and controlling sediment, is to keep the soil covered with vegetation, which:
  - Shields soil from the impact of raindrops, the force of the wind, and the energy of runoff
  - Creates structure in the soil with its roots and rhizomes, which both resists the erosive forces of runoff and increases soil permeability and infiltration
  - Provides a continuing supply of organic matter, which improves fertility and infiltration
  - Slows runoff to non-erosive velocities
  - Filters sediment

Source: U.S. EPA, https://cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf

Samples of urban stormwater runoff.

Sediment Goals and Objectives

Lower Grand River Watershed Management Plan

Narrative Volume: https://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm

(note: k means known)

Sources (by priority)	Causes (by priority)	Prioritized Objectives
1. Cropland (k)	1. Tillage practices (k)	Implement cropland management practices.
	2. Lack of buffers (k)	Implement vegetative buffering practices.
	3. Dense drainage network (k)	Implement watershed focused land-use planning.
2. Urban landscapes (k)	1. Impervious surfaces (k)	Implement Low Impact Development practices to reduce imperviousness and increase infiltration
	2. Dense drainage network (k)	Implement watershed focused land-use planning.
	3. Construction sites (k)	Implement proper soil erosion and sedimentation control techniques.
3. Streambanks (k)	1. Altered morphology and hydrology (k)	Implement watershed focused land-use planning. Implement channel stabilization and erosion control techniques.
	2. Uncontrolled livestock access (k)	Implement livestock management practices at access sites.
	3. Removal of vegetation (k)	Implement streambank stabilization, bio-engineering, and erosion control techniques.
4. Rill and gully erosion (k)	1. Agriculture practices (k).	Reduce and control gully erosion.
	2. Concentrated flow from roadside ditch (k)	Implement streambank stabilization and erosion control techniques.
5. Lakeshore erosion (k)	1. Boat traffic/seawalls/wave action (k)	Reduce and control lakeshore erosion.

National Stormwater Calculator

In this activity, you will estimate the annual amount of rainwater and frequency of runoff from a specific site then apply different scenarios to learn how specific green infrastructure changes can prevent sediment pollution.

Go to the National Stormwater calculator website at http://www.epa.gov/water-research/national-stormwater-calculator and follow the directions for downloading the application. A user's manual for the calculator is available at this site.

Follow the instructions in the program to define the:

1. Location – establishes the site's location

2. Soil Type – identifies the site's soil type

3. Soil Drainage – specifies how quickly the site's soil drains

4. Topography - characterizes the site's surface topography

5. Precipitation - selects a nearby rain gage to supply hourly rainfall data

6. Evaporation - selects a nearby weather station to supply evaporation rates

7. Climate Change – selects a climate change scenario to apply

8. Land Cover – specifies the site's land cover for the scenario being analyzed

9. Low Impact Development (LID) Controls - selects a set of LID control options, along with their design features, to deploy within the site
   - Create a baseline scenario in the results section first by not applying any LID controls. Then return to this section to add the controls.

10. Results - runs a long term hydrologic analysis and displays the results

There are also three command options shown along the bottom status bar that can be selected at any time:

1. **Analyze a New Site**: This command will discard all previously entered data and take you to the Location page where you can begin selecting a new site to analyze. You will first be prompted to save the data you entered for the current site.

2. **Save Current Site**: This command is used to save the information you have entered for the current site to a disk file. This file can then be re-opened in a future session of the calculator by selecting the Open a previously saved site command on the Location page.

3. **Exit**: This command closes down the calculator. You will be prompted to save the data you entered for the current site.

Results of a National Stormwater Calculator Run

Parameter	Information/Results	
1. Location		
2. Soil Type		
3. Soil Drainage		
4. Topography		
5. Precipitation		
6. Evaporation		
7. Climate Change Scenario		
8. Land Cover		
9. Low Impact Development Controls		
10. Results	Scenario: Current Runoff: Infiltration: Evaporation:	Scenario: Baseline Runoff: Infiltration: Evaporation:

ANSWER KEY

Example Results of a National Stormwater Calculator Run

Parameter	Information/Results
1. Location	Kent ISD East Beltline, Grand Rapids, Michigan Site area: 100 acres
2. Soil Type	C moderately high runoff with some D
3. Soil Drainage	>0.1 to 1.0 inches per hour
4. Topography	Moderately flat (5% slope)
5. Precipitation	Source: Grand Rapids International Airport
6. Evaporation	Source: Grand Rapids International Airport
7. Climate Change Scenario	None
8. Land Cover	Estimated: 3% forest, 15% meadow, 60% lawn, 22% impervious (includes buildings, sidewalks, roads)
9. Low Impact Development Controls	Green roofs: 10% Permeable pavement: 10%