Science Unit: **Water Around Us**

Lesson 1 ***Moving Water - Land and Ocean***

Summary

The three activities in this lesson will explore how water flows. Students will model water flow on a small scale and then discover large-scale water flow on our planet:

(1) Stream flow and erosion: observe how the water flow shapes sand.

(2) Turbulence patterns: visualization of turbulence patterns in water.

(3) Salty and warm water flow: observe how water mixes and layers.

School Year:	2015/2016
Developed for:	Aboriginal Focus Elementary School (MacDonald Elementary School in the process of renaming), Vancouver School District
Developed by:	Ingrid Sulston (scientist); Fiona LaPorte and Brenda Koch (teachers)
Grade level:	Presented to grades K and 2-5; appropriate for K-7 with age appropriate modifications
Duration of lesson:	1 hour and 20 minutes

Objectives

1. Manipulate the flow of water over sand to understand how rivers flow and shape the landscape.
2. Visualize the movement of water as objects move through it, to discover turbulence patterns.
3. Appreciate how ocean currents arise by observing the flow of water when temperature and salinity varies.

Background Information

The flow of water has profound effects on our world, from the shaping of the landscape to the movement of ocean currents.

Water flowing across the landscape carries away particles of rock, in the process of erosion, to form valleys and leaving mountains and hills on either side. The path that a river makes is dependent on the slope of the surface and the hardness of the underlying rock. Erosion is also caused by wind, snow, ice and gravity.

As water flows in rivers and the ocean, the flow is most commonly not smooth, as objects that the water moves around causes swirls and eddies in the flow - called turbulence. Large objects moving through water also cause turbulence. Air, being a fluid, also can be turbulent.

The flow of water in the ocean is partly dependent on local temperature and salinity differences. Temperature differences are caused by solar energy heating some parts of the ocean more than others. Salinity differences in the ocean are mostly caused by the removal or addition of fresh water (removal by evaporation, ice formation; addition by ice melting, precipitation, and rivers joining the ocean). Cooler water and more salty water are more dense than warmer or less salty water. The sinking of cooler, saltier water and the rising of warmer, less salty water causes ocean currents, both local currents and global currents such as the “ocean conveyer belt”.

Vocabulary

Erosion	The movement of rocks or rock particles due to natural forces (wind, water, gravity).
Turbulence	Movement of a fluid (liquid or gas) that is chaotic, caused by local variation in fluid speed.
Salinity	The amount of salt dissolved in water.
Density	A measure of mass per volume. In a fluid, relatively dense regions will sink and less dense regions will rise.

Materials for Activity 1 - Stream Flow and Erosion:

- large tray (one per group of four students)
- large jug of water (one per tray)
- binder clip, medium or size that will clip on the end of the tray (one per tray)
- sand (enough to pile up at one end of each tray)
- tubing (aquarium; about 70cm) weighted at one end with a ring of modelling clay (one per tray)
- small rocks (several per tray)

Materials for Activity 2 - Turbulence Patterns:

- tray of water (one per student group)
- pearlescent liquid hand soap (contains glycol stearate or glycol distearate) mixed 1:3 with water (enough to half fill the tray)
- food colouring (a few drops per tray)

Materials for Activity 3 - Salty and Warm Water Flow:

- dropper bottles that deliver single drops e.g. purchased Nalgene "drop dispenser bottles", or use rinsed food colouring dispensers (a set of three for each small group of students)
- coloured salt water in a dropper bottle: 1 teaspoon salt in 100ml water, plus 20 drops green food dye (one per group)
- small clear tubes (one per student)
- coloured warm water in a dropper bottle: water plus red food dye, heated in the microwave until very warm (one per group)
- coloured cold water in a dropper bottle: water and blue food dye plus enough ice chips to make very cold (one per group)
- squeeze bottles of water (one per small group of students), for rinsing tubes
- microwave
- small containers of ice, to store coloured cold water bottles on
- waste tub for rinsing tubes into (one per group)

In the Classroom

Introductory Discussion

a. The activities in this lesson will explore how water flows. We will model water flow on a small scale and then discover large-scale water flow on our planet.

b. Brief description of science activities in this lesson:

- Stream flow and erosion: alter the path of water over sand with rocks and observe how the water flow shapes the sand.
- Turbulence patterns: visualization of turbulence patterns in water.
- Salty and warm water flow: use coloured salty and warm water to observe how they flow, mix and layer.

c. **Processes of science** that the students will focus on: exploration, curiosity, mechanical manipulation, close observation, accurate drawing of observations, inferring, hypothesis testing, concluding, predicting.

Activity Detail:

(1) Activity Title: Stream flow and erosion

Purpose of Activity:

To observe how water flow carves out a stream, and how obstacles in its path change the path of the stream.

Methods and Instructions:
Set-up prior to experiment: Pile the sand up at one end of the tray. Set up the siphon system by submerging the weighted end of the tubing in the large jug of water, and placing the jug at one end of the tray. Clip the binder clip to the same end of the tray.
Students will work in groups of three or four around one tray.

1. Start the flow of water: suck on the free end of the tubing to get the water flowing (there must be no air in the tube for the flow to continue). Push the tubing through the binder clip arms at the end of the tray so that the water slowly runs down the slope of sand.
2. Allow time for free experimentation, so that students can see how the water flows and moves the sand. They can place the rocks as they wish, to affect the water flow.
3. After about 5 minutes, the teacher will need to raise the siphon system up, e.g. on a book, to keep the flow rate up, then again after another little while.
4. Questions for students that need to focus on the water flow: Can you made the stream split into two? Can you make a waterfall? Can you see where the bank of a stream is being washed away? Can you see separation of the different coloured sand particles?

5. Follow with a group discussion on what students found, with connection to real stream flow and erosion and the shaping of our landscape:
   - Students see channels forming in the sand, through which the water flows. River valleys are formed the same way - the overlying soil, then the underlying rock are worn away by water. Streams and rivers carve out our landscape to make valleys with mountains on either side.
   - Students change the direction of the stream by placing rocks in its path. Similarly, rockslides or human structures, for example dams, change the path and flow rate of rivers.
   - Students may notice that water can move the small sand particles but not the larger rocks. In the same way, gravel, sand and soil particles are washed down rivers whereas large boulders remain. The process of sediment removal is called erosion.
   - Students may notice sand being deposited into the shallow pool at the bottom of the tray. Sediment is moved where water flow is faster, and deposited where the flow is slower, so wide shallow bays are formed at where rivers meet the ocean. Students may notice sand particle colours separating as they are deposited. In the same way, sediments are separated out in the flow of a stream or river.

(2) Activity Title: Turbulence patterns

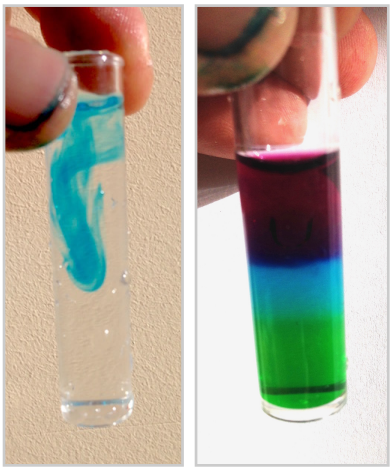
Purpose of Activity:

To visualize turbulence in water

Methods and Instructions:
Set-up prior to experiment: Mix 3:1 water:soap in the tray, gently, to keep bubbles to a minimum. Add a couple of drops of food colouring.
Students will work in groups of three or four.

1. Ask students to move the water around gently with their finger or by blowing on it. The pearlescent particles show the movement of the water. Watch the swirls (turbluence) in the water, and look for unexpected patterns that result from water flow.
2. Ask students to draw the patterns that they see on a worksheet.
3. For discussion on water flow in the ocean:
   - In the ocean, tides and winds push the water around. Obstacles such as land or underwater mountains create turbulence as the water hits them. All this movement of the water, much of it turbulent and moving in complex patterns, both on a large scale (e.g. along a coastline) and small scale (e.g. around a reef) churns and mixes the oceans' water. See Ref. 2.
   - Water movement brings food to animals that can't move, and moves nutrients and heat around.
   - Some tiny animals might have a profound effect on ocean water mixing e.g. krill move en masse to the ocean surface to feed on algae, creating a moving current of water that brings nutrients from the bottom of the ocean to the surface. Phytoplankton (single-celled plants) at the ocean surface can then feed on these nutrients. When they die they sink to the bottom, cycling nutrients back to the deep ocean. See Ref. 3.

(3) Activity Title: Salty and warm water flow



Purpose of Activity: To observe how differences in temperature and salinity affect the flow of water.

Methods and Instructions:
Set-up prior to experiment: Prepare the salty, cold and warm water bottles, as described in the materials table.
Students will work in small groups of four.

1. Show students what to do:

   Half fill a small tube with plain water. Drop in one of the coloured water types (salty/cold/warm). Watch whether the drips sink, float, and flow.
2. Once you have tried them separately, try mixing different combinations to see how they interact and layer.
3. Allow students to freely experiment, while drawing their observations on a worksheet.
4. Make sure that the cold water stays on the ice, and reheat the warm water in a microwave if necessary.
5. Students should find that salty and cold water sink, while warm water stays on top. Different combinations of salt/warm/cold water will result in different flows and layering patterns.
6. Discuss students' results and relate to global ocean currents: The heating of the ocean surface, and freshwater flow into the ocean, locally changes the temperature and salinity of the ocean. Cooler and saltier waters are more dense than warmer water, so sink below warmer water, which rises. This water flow gives rise to global ocean water currents (the "ocean conveyer belt"). See Ref. 4.

References

1. <www.exploratorium.edu/science_explorer/goflow.html> Exploratorium (hands-on science centre) online activities webpage. Accessed May 25, 2016.
2. <http://naturedocumentaries.org/839/perpetual-ocean-nasa/> "Perpetual Ocean from NASA" Video of turbulence in the oceans, posted by Nature Documentaries. Accessed May 25, 2016.
3. <http://www.antarctica.gov.au/magazine/2006-2010/issue-15-2008/science/krill-mix-up-the-ocean> Website summarizing a Science magazine article, that describes how krill can mix up ocean waters. Accessed May 25, 2016.
4. <https://en.wikipedia.org/wiki/Thermohaline_circulation> Wikipedia entry on warm and salty water flow in our oceans. Accessed May 25, 2016.