



Investigating Local Water

Gr.9 Science: *Biology—Sustainable Ecosystems*

-December 2014-

The Polaris Institute is an Ottawa-based non-governmental organization that has been in existence since 1997. Our main goal is to enable citizen movements to develop new methods, strategies and tools in order to bring about democratic social change. As a result, most of our past educational work has focused on helping students to develop the critical thinking and leadership skills necessary to bring about on-the-ground action.

Full resource accessible online at: www.polarisinstitute.org/education

Other water education resources available at this site:

- Water Use & Availability (*Gr.9 Issues in Canadian Geography*)
- Water Perspectives: Conflict and Action (*Gr.10 Civics and Citizenship*)

These lessons are designed to support high school teachers in integrating water issues into their curriculum. This resource was written by Polaris Institute project staff member, Rebecca McQuaid. Expertise and advice was provided by a local steering committee and volunteer resource reviewers. Special thanks to the following individuals for their support in making this resource possible: Daniel Cayley-Daoust, Gigi Shanks, Michael Faight, Paul Baines, Susan Brandum, Andy Kerr, Lisa Smith, Debra Bellevue, Stana Luxford-Oddie, Sarah O'Grady, and Patricia Larkin (Nature Works Learning). Thanks to everyone else not named here, who have been supportive of this initiative.

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We welcome any and all feedback on this educational resource.

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Section I: Creating a Local Context for Water

Description: *Section I* is meant to highlight the concept of exploring water in your local community. It puts forward a series of optional introductory activities which help to provide a richer context for the water quality explorations in *Section II: Scientific Investigation of Local Water Quality*. This resource also has strong linkages to geography on account of the main activity, which is to create a Community Water Map. This section of the resource has two main goals:

1. Identify and examine ways that water is used in the community
2. Develop an understanding and appreciation for where local water comes from, where it goes & what affects the source(s)

In this section, students examine the following inquiry/critical thinking questions: Where does our water come from? What affects water sources? How do we treat water before and after it's used? Where does water go after we've used it?

IMPORTANT NOTE FOR TEACHERS: This section of the resource also has strong ties to geography (mapping). To enhance the science focus of the activity, plot water quality data on the Community Water Map (upon completion of *Section II*). The main activity is structured as a guideline for teachers in conducting community water mapping with students, as local realities will differ greatly throughout communities across Ontario. We've aimed to provide some starting points, ideas, and resources for gathering information. However, we ultimately hope that you and your students will take this opportunity to make the project your own. Good luck!

Pre-Activity

Option A: Field Trip

Description: An outing for students to get out of the classroom to see first-hand where water comes from in the community. This pre-activity is relevant because it provides a context for the *Community Water Map* activity (p.6), as well as an opportunity for students to ask questions and/or make observations of land use in the community which are relevant to explorations of water quality in *Section II*.

#1: Arrange a field trip to the local water treatment plant. If there is no water treatment plant (or it is not accessible to the public), consider #2.

#2*: Take students on a field trip to examine different water sources in the community.

**Teacher's note:* If you plan to conduct in-the-field water quality testing with your students (see *Section II: Scientific Investigation of Local Water Quality*), sample and data collection should be done during the field trip, unless the water source(s) where you will conduct your water quality testing are easily accessible from the school. *Section II* has further resources for planning field trips, including checklists.

Time required: 1-2 class periods (65-70 min)

- Class 1: Introduce the topic (see **Engagement Strategy**, p.4), discuss the trip with students & come up with a list of questions and/or places to visit during the field trip or guest speaker.
- Class 2 (optional): Discuss water quality testing with students (if you will be conducting this at the same time as the field trip). Refer to *Section II: Scientific Investigation of Local Water Quality*.

Materials & Preparation:

- IN ADVANCE: Follow the appropriate protocol(s) for gaining permission to take students off of school property.
- IF APPLICABLE: Prepare water quality testing materials (refer to *Section II: Scientific Investigation of Local Water Quality*).
- *Research some basic information about the local watershed and water/wastewater distribution systems in your community (refer to *(BLM 1.1/ 1.2) Community Water Map: Individual Student Research*, p.24-27, to help you).

**Teacher's note:* This step is only required if students will not be creating the *Community Water Map* (see p.6).

Option B: Guest Speaker

Description: Students invite an “expert” on water in their community to the classroom and prepare questions for discussion. This pre-activity is relevant because it provides an option for the teacher to help students gather the information they need to create the *Community Water Map* (p.6), without taking students off-site (as in Option A).

#1: Invite an expert from the local water or wastewater treatment plant to talk to the class about treating, testing and protecting local water sources; OR

#2: If private wells are the principal source of water in the community, invite a community expert* (e.g., from a local watershed group or Public Health Unit) to discuss ways to protect and maintain groundwater quality and monitor well water.

**Teacher’s note:* For more information on how to locate water experts or resources in your community, refer to (BLM 1.1/1.2) *Community Water Map: Individual Student Research* (p.24-27).

Time required: 1 class period (65-70 min)

- Introduce the topic (see **Engagement Strategy**, below), and come up with a list of questions to ask the visiting expert.

Materials & Preparation:

- Arrange for a local water ‘expert’ to visit your class

Engagement Strategy (for Option A & B):

- Create a discussion by asking students where their water comes from. If there is a municipal water treatment facility in the community, some students may assume their water comes from there, as opposed to a private well.
- Asking these questions will give an idea of how much prior knowledge students have about water in the community.

Teacher’s note: If students are not creating the *Community Water Map* (p.6), show students on a map (or as part of the field trip outing) where their water comes from—this can be as broad as the surface source from which the water is taken (e.g., Lake Ontario), or as specific as the location of water intake pipe(s). If there is a municipal well, its location can be pointed out to students. If private wells are the main source of water in the community, try to determine where the school well is (and/or assign as homework to have students determine where the well is on their home property).

Teaching Strategy (for Option A & B):

- Have students prepare questions in advance of the presentation or trip (see **Sample Questions**, p.5). If you are going to have students complete the *Community Water Map* activity, you may want to introduce the project to them before the presentation/ trip. This will allow students to develop a list of questions to ask that will help them with their map research.

Sample Questions:

Water treatment plant:

- Where does the water come from? What is important to know about this source?
- How much water do we use from this source (daily/ monthly/ yearly)? Who in the community uses the most? Who else uses this water (*e.g.*, other communities)?
- How does the water get from the source to the treatment plant?
- What happens to the water once it enters the treatment plant? (*process*)
- What problems do we have with the water supply (if any)? *E.g.*, Recurring contaminants
- What water quality tests are carried out on the water supply, and how often?
- Where does your water go after it's used? How is it treated? What is it treated/ not treated for?
- Who ensures the safety of our water supply? What regulations are in place to protect water from contamination?
- Are there water contaminants of potential concern that are not consistently monitored (or for which there are not yet testing methods/ protocols)?

Municipal or private well:

- What do we call water that is found underground? (Answer: groundwater, aquifer)
- Does well depth matter? Why?
- How can water found underground become contaminated?
- How can we protect groundwater?
- Whose responsibility is it to test private wells? What are typical costs?
- How often should we check well water quality?
- What happens to a private well if it becomes contaminated?
- Are there special procedures to close wells and why would this be important?
- Can well water be treated? *E.g.*, For naturally occurring high levels of metals and minerals?

Activity: Community Water Map

Description: Mapping activity and research project to create a picture and understanding of water in the community*. This activity is relevant because it provides a context for the scientific water quality investigation in *Section II*. The main goal of the activity is to:

- To develop an appreciation for where local water comes from, what affects it, how it is distributed & treated, how it is used in the community, and where it goes.

**Teacher's note:* This activity requires some prior knowledge or scaffolding of basic map-reading & map-making skills. Students should be familiar & able to work with: scale, symbols, legend, landmarks, labels, *etc.*

The following web resources provide further information for teaching map-making skills:

- National Geographic Map-Making Guide (Gr.9-12):
<<http://www.nationalgeographic.com/xpeditions/lessons/09/g912/cartographyguidestudent.pdf>>
- Google Maps Education: <<http://maps.google.com/help/maps/education/resources.html>>
- Creating Custom Maps in Google:
<<http://www.google.ca/earth/outreach/tutorials/custommaps.html>>

Time required: Variable, depending on the extent of the activity chosen by the teacher or class

- **At minimum:** 1-2 class periods, 65-70 min (with majority of research/ prep for discussion completed by teacher)
- **At maximum:** 4-5 class periods, 65-70 min (over one month—extra time built in for independent student research)

Materials and Preparation:

- Select and prepare mapping options for students (see *Activity format & Options for mapping*)
- Book time in the computer lab for student research
- Additional materials may be required as the project evolves!

Activity format: Full class, small groups, or individuals

- The advantage of doing the activity collectively, as a class, is that the research can be divided up between students [see (*BLM 1.0*) Community Water Map: Class Division of Research Tasks, p.14-23].
- If done in small groups, compare and contrast the students' maps and discuss any differences. You can also encourage information sharing between groups.
- If done as individuals, the task will need to be scaled back. Refer to (*BLM 1.1/1.2*) for guidance.

Options for mapping:

- Size/Scale:
 - Choose a size for the map based on the activity format, above (*i.e.*, a map used by the entire class or small groups will need to be bigger than one used by an individual student)
 - Consider the level of detail students will want to include on the map (see **Teaching Strategy**, Step 3, Map-making)

- It may not be possible to include all students' homes on a map, particularly in rural areas. An alternative might be to have these students choose a location to research that is on the map (e.g., a public library, or a family member or friend's house). You may also want students to draw a line on the map depicting the limits of municipal water distribution (assuming there is municipal water in your community). Anyone outside these limits would be presumed to be on well water.

Choosing the map format, size and scale may be the most challenging part of scaffolding this activity. There are essentially two options you can choose:

Print map: The advantage of a print map is that the hardest part is over once you have chosen the scale and format. A disadvantage is that it is difficult to fix errors on a print map. Format options include:

- **Hand-drawn map**
 - *Advantage:* You don't need to prepare anything in advance. Students are responsible for creating the map. Recommended if there are students in the class with strong map-making and/or spatial skills.
 - *Disadvantage:* It won't be perfectly to scale; it may also prove difficult to add in more details/ area once the initial map is drawn. Mistakes might also prove difficult to fix.
- **Road map**
 - *Advantage:* It is a pre-existing, to-scale map. All that remains is to find one that is big enough to meet your mapping needs, and that has good resolution (if printing from online).
 - *Disadvantage:* Road maps often provide too much detail, which could make reading the map and working with it more challenging for students.
- **Community map**
 - *Advantage:* Will probably have fewer irrelevant details than a road map. It is also possible that your municipal office could provide you with a map showing existing water distribution and/or treatment infrastructure, thus saving students time and research.
 - *Disadvantage:* May not exist in some communities, and you are at the mercy of others in order to gain access to the map. See **Teacher's note*, below.
- **Aerial photographs**
 - *Advantage:* These can provide a neat way of seeing changes to the community over time, if you obtain the most recent photo in addition to the preceding one. You can compare them and note changes in land-use or water body sizes. Land-use information can also prove useful when interpreting water quality results (*Section II*).
 - *Disadvantage:* Requires some expertise in order to interpret. Recommended that this option is chosen in conjunction with a guest speaker who is brought in and can help point out relevant water-related landmarks and information on the photographs.

**Teacher's note:*

- Contact your municipal office/ planning department; Chamber of Commerce; and/or utilities commission/ agency. They may be able to provide a map with some municipal infrastructure already on it, such as water treatment facilities. Just note in your conversation that you are looking for a resource that will be easy for students with limited mapping experience to work with.

Online map: The advantages of a digital map are that information can be added to it easily, scale can be adjusted as you go along (based on need), and errors are easily fixed. A disadvantage is that creating an online map will require learning how to use an online mapping tool, which can sometimes have a steep learning curve. Some tools available include*:

- **National Geographic Education:** [MapMaker Interactive](#)
- **Googlemaps & Google Earth**
 - **Note:** Students can make a map in google and export the KML file to be used/ layered in any other map
- **[Crowdmap](#)**
- **[OpenStreetMap](#)**
- **[ESRI ArcGIS Online](#)**
- **[Great Lakes Commons map](#)**

**Teacher's note:*

- YouTube tutorials often exist for the more popular online mapping tools, such as Google maps and Google Earth. Many are geared toward educational purposes (*i.e.*, student friendly).
- You can also refer to the following resources for Google: [Google Maps Education](#); [Creating Custom Maps in Google](#)

Engagement Strategy:

- Ask—who knows where the water from their taps comes from (at home, at school)? What about the local outdoor pool? Where do we get this water?
- Engage in a short discussion to help students realize how much (or little) they know about water in their community.

Teaching Strategy:

Step 1: As a class, brainstorm a list of items to identify on the map that will help create a picture of: (1) where water is located in the community; (2) how it moves; (3) what it is used for; (4) what impacts it; *etc.*

- **Some examples include:** school, students' homes, surface water sources, water & wastewater treatment facilities, large-scale water users (*e.g.*, golf courses, factories); potential sources of water pollution (*e.g.*, farms, factories).
- Together, choose the most important items to include on the map*.

**Teacher's note:* If students are completing the mapping exercise as individuals VS. small groups or as a class, you may want to limit the number of items to include on the map to keep the research manageable. Choose those that are the most relevant to students' learning of *water in the community*.

Step 2: Ask students—How easy will this information be to find/ gather? Where can we look, or whom can we contact, for information?

- Brainstorm as a class & have someone take notes
- Alternatively, you can use the pre-assigned research tasks in (*BLM 1.0*), p.14-23 to perform an in-depth class project (read this over prior to the class discussion)

- If you would rather give students a broad overview of potential research questions and resources to refer to for more information, refer to (*BLM 1.1/ 1.2*) Community Water Map: Individual Student Research (p.24-27)

Step 3: Begin the research & map-making process

Example scenario: You have decided to complete this activity as a class, using a print map. You have brainstormed what you want to include on your map, now it is time to divide the research tasks.

Research

- Assign teams of 2-3 to each of the research questions in (*BLM 1.0*), p.14-23, 10 total).
- Choose the questions most relevant to: (1) your community; and (2) the class' goals with respect to creating a *Community Water Map*.
- Using the guidelines provided, teams must research the questions presented under their assigned topic. If they cannot obtain the answer from this source, they must try another. Encourage students to share any relevant information between teams (*e.g.*, Team 1 finds information relevant to Team 2's research questions, so they share this information).
- If students are unable to find an answer to one or more of their questions, they must record the sources they tried and why they were unable to find the answer.
- Teams will then do a short presentation of their research findings for the class (5-7 min)

Map-making

- Each team will identify the relevant items and information they want to include on the map
- As a class, come up with standard symbols (and/or a colour code) for all of the different items to be represented on the map, such as:
 - School (be sure to indicate whether it uses municipal water or a private well)
 - Students' homes*
 - Surface water sources (*e.g.*, lake, river, reservoir). Perhaps include some detail on the map or in the legend about how much water is taken from the source, or how many people rely on it from the community (if this information is available). Also be sure to have students *name* the source.
 - Water treatment facilities**
 - Could also include: (1) Location of water intake pipe(s) and/ or well(s); (2) Site(s) used for monitoring water quality
 - Wastewater treatment facilities
 - Could also include: location of outflow pipes for wastewater
 - Large-scale water users (*e.g.*, industrial operations, institutions, commercial businesses, etc.)
 - Areas at risk for water pollution***

- *If you, or individual students, are uncomfortable with having classmates disclose/ know this information, students may place a sticker/ symbol *near* the correct area on the map. Also, consider using different symbols for homes on private wells & those on municipal water (if relevant).
- **If students in the class receive water from different municipal treatment facilities, you may also want to use distinct markers for each of these facilities
- *** (1) Areas at potential *risk* for water pollution can be added *after* the students complete the pre-activity; OR (2) If undertaking water quality testing with students, you may wish to leave this component until you are ready to interpret and discuss the results (*Section II: Scientific Investigation of Water Quality*).

- ***To avoid creating a finger-pointing activity, discuss with students potential measures that could be undertaken in the community (by water polluters) in order to mitigate impacts to local water sources. Emphasize that water resources need to be managed and protected for a variety of uses. This might be a good opportunity to discuss responsibilities & water management (see *Section II, Appendix C: Water Quality Protection: Whose Responsibility?*)

Multi-media Mapping

- One neat element that would support this activity is having students take **photos** or make **short videos** at the sites visited, which could then be added to the map (particularly if created in a digital media form).
 - *Note:* Some online mapping tools allow for multi-media files to be embedded directly into the software, making it an interactive map that many people can contribute to simultaneously. One example of a user-friendly mapping tool is “Googlemaps,” which many students will already be familiar with. Pictures can be annotated on to these maps. Refer also to the list of online mapping tools listed earlier (p.8).
 - If you are a particularly tech-savvy teacher with a class full of Smartphones, there are also mobile apps for doing this in the field!
- Students might also choose to add written pieces (news articles, letters to the editor, poems, *etc.*) to the map, to further contribute to the visualization of water in the community. One project that does this is the ***Great Lakes Commons Map*** (see below).

Note: Clear guidelines should be provided to students if they’re going to be taking photos or video in the community. For example, students should be cautioned about getting proper permissions for such things as: accessing private property; and taking photos of water around businesses or other industrial operations (particularly at outflows)

One solution would be to **provide students with a short write-up** explaining the purpose of the project and how the information will be used for educational purposes only. That way, if students run into difficulties, you, the teacher, can be listed as the point of contact for the project.

If students are being asked to perform these activities as homework, some school administrators might see this as a “do-it-yourself” field trip; therefore, similar procedures would need to be followed in order to get **permission for students to complete this as part of the class project**

Great Lakes Commons map (<http://www.greatlakescommonsmap.org>):

- This is a locally-spearheaded project
- It is an online map that encourages the public to contribute to a collaborative and growing body of knowledge and awareness around the Great Lakes.
- The map is for observations, curiosities, questioning, education/ awareness, storytelling, and much more!
- At the least, it may give students some ideas!
- If your community relies on the Great Lakes as a water source, you may consider making a contribution to this site an assignment for students (or extension activity for advanced students/ classes).

Assessment:

- **Research Process:** How well did students work together (In their team? With other teams?). Did they contribute in a meaningful way to their team's efforts?
- **Team Research Presentation:** How well is the learned information, communicated?
- **Final map:** How well have the students translated the research about distances, locations and facilities onto their map with appropriate use of scale and layout?
- **Journal Reflection:** Have students research and/or reflect on one or more of the Discussion Questions (below).
 - How well have students integrated the information about how water is connected within their community? (*i.e.*, where the water treatment plant is, what role it plays, *etc.*)

Discussion Questions:

- Did you learn anything that *surprised* you (about water in your community)?
- What concerns might we have around getting water from surface sources? Groundwater sources? (*Hint:* focus on issues of availability & contamination)
- How many people rely on the same source as you, for their water?
- Roughly how far is your home from where your water comes from?
 - Surface water: How far is your home from the plant where it is treated?
 - Groundwater: Where is the well you get your water from?
- What can you conclude about the relationships between different sources of water in the community? What observations have you made?

Differentiated Instruction:

- This will vary a lot depending on the process you choose with your students. There are many options for pairing students up and having them work together throughout the research and map-making.
- If you choose to use (*BLM 1.0*) to scaffold and guide the research process, assign tasks according to student skill level and interest. Some questions will prove more difficult to research than others.
- This activity is meant to be executed on whatever scale you desire. This resource is simply meant as a collection of ideas for exploring the topic of “community water” with students, and you may choose to focus in on specific aspects of study, or a particular section of the community mapping concept.

Extension: Storytelling—gathering & sharing stories

Aside from verifying the information gathered during the map-making process, taking students out into the community has the purpose of **forming personal connections to place**. It is one thing to read about environmental issues in our communities, but quite another to witness them first-hand (especially in places we have formed strong bonds to, whether through memories or other personal connections). The purpose of this activity is to inspire students to share both the information they've learned and stories they've gathered, with others in the community.

Part I: Gathering Stories

Students will be beginning to form a picture of the current ‘story’ of the watershed. You may want to encourage students to investigate the historical perspective of their local water resources, in order to determine how things came to be in their present state. Learning about the history of an area can provide a

rich context for understanding the current situation (for example: recurring contamination problems in the watershed, or the establishment of community groups to deal with particular watershed issues).

The fastest, and most personal way to collect historical information of this nature is through interviewing members of the community. If you are interested in undertaking an interviewing project with your class, there are some great models that already exist.*

The following *Steps to Getting Started* are based off of a more detailed activity of this nature, found in a resource entitled “Ground Truth Studies: Teacher Handbook” 2nd Ed.* The activity is called “Your Watershed’s Story,” p.101 (Aspen Global Change Institute, 2003). Refer to this resource for a more detailed description of conducting an interview project with your students.

Steps to Getting Started:

Step 1: As a class, come up with a list of questions you have about the history of water resources in your area.

Step 2: As a class, identify and discuss people/ organizations in your community who may have answers to your questions about the history of the area. For example: seniors in the community; the person(s) responsible for town planning; a First Nations person living in your area; someone involved in a local environmental committee/ organization/ working group; members of a historical society, *etc.*

Step 3: In small groups, brainstorm a list of interview questions you might ask one of these people. Compile all of the ideas. As a whole class, narrow them down to a list of key questions.

Interview questions might include:

- How long have you lived in the area?
- What was the water in our community like when you were our age?
- What are the different *uses* of the water in the community that you have witnessed?
- How has the *land* in the watershed been used during the years that you have lived here?
- What do you think has caused changes in the watershed?
- How do you feel about the changes that you have witnessed?
- What do you think the local water situation will be like in the next ten to twenty years? In fifty years?

Step 4: Practice interview skills in small groups, including how to prompt interviewees for more specific answers.

Step 5: Discuss methods of identifying, contacting, and questioning the people/ organizations listed.

Step 6: Have students arrange to conduct interviews. Be sure to follow proper protocols and safety procedures. During the interview, students should know what to say about the project and answer any questions the interviewees may have.

Step 7: As a culmination of the research, students could be asked to prepare a written report of the interview findings in the form of a feature article for a newspaper, or a chapter in a biography. Students could also illustrate their report with pictures of the watershed as it appeared in the past, or with a cover map of the watershed in the past.

Part II: Sharing Stories

Students may be encouraged to take their learning of ‘water in the community’ and use it to educate/ inspire others. Students should choose information/ topics that resound with them personally, and may have the choice of several formats for expression. There are many different, creative ways for students to communicate their desired message to the public.

Some examples include:

(1) Becoming a “community reporter”

- *E.g.*, Students write newspaper/ newsletter articles, blog posts, and/or letters to the editor, outlining their learning/ thoughts around water in the community. Tech-savvy students could even be encouraged to create pod-casts or YouTube videos with the same purpose.
- Following up from the interviewing activity outlined above, students could perhaps video or audio record interviews and broadcast them on a YouTube channel or other online medium. Proper permissions would have to be obtained from interviewees, of course!

(2) Becoming a “community supporter”

- *E.g.*, Students engage in public outreach & engagement by volunteering with community groups who are working to improve the health of water in the community. In doing so, students may find that they have ideas for helping to spread the word about the organization’s work and mandate. Students may consider fulfilling school-required volunteer hours through their work with local environmental organizations.
 - As an idea for ‘spreading the word,’ students may want to create an audio or video public service announcement (PSA). It could concentrate on: promoting the work of the local environmental group; communicating a specific message regarding concerns in the local watershed; and/or what people can do to take positive action! The PSA might be directed at students in the school, or to people in the greater community.
- Students could be encouraged to present their findings about water in the community to the local municipal council. For example, students might prepare a 5-10 minute presentation on the major results of their on-the-ground investigation of the local watershed.
- Students could hold an ‘open-house,’ showcasing all of the monitoring and investigative work that the class completed to create a profile of water resources in the community. They might invite a number of people from the community, including city counselors and those from non-governmental or governmental groups they contacted for information during the course of their project.

(BLM 1.0) Community Water Map – Class Division of Research Tasks

Research Team #1: _____

Q: What watershed(s) is our community located in?	Research Strategies
<ul style="list-style-type: none"> What is a watershed (define)? What is the main watershed in our community (name)?* How big is it (e.g., km²)? <ul style="list-style-type: none"> Find a map showing the watershed & its borders (be sure to record where it came from!) Name any sub-watersheds, if relevant <u>Who</u> is responsible for maintaining the health of our watershed? <p><i>*If simpler, choose the watershed in which our school is located.</i></p>	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Is there an <u>Ontario Conservation Authority</u> in your region? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Ontario Ministry of the Environment, <u>Great Lakes Watershed Locator</u> <ul style="list-style-type: none"> Search: “Ontario Ministry of Environment Great Lakes Watershed Locator” Find out the name of the watershed you live in, as well as neighbouring watersheds Variety of Canada-wide maps showing distribution (e.g., watersheds, hydrogeological regions) Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) 	

Research Team #2: _____

Q: Are there historical problems with water in our area (surface and/or groundwater)?	Research Strategies
<p>Surface water</p> <ul style="list-style-type: none"> Are there concerns for protecting surface water quality in our area? (<i>i.e.</i>, <i>what can negatively affect it?</i>) Can you place any of these “areas of concerns” on the map? <ul style="list-style-type: none"> <i>E.g.</i>, Are there any areas prone to closures (such as beaches in the summertime)? <p>Groundwater</p> <ul style="list-style-type: none"> Is there any concern related to <i>natural</i> contaminants in the groundwater (<i>e.g.</i>, arsenic or other metals) Is there any concern for <i>unnatural</i> contamination of groundwater sources (<i>e.g.</i>, from farming, industry, <i>etc.</i>). 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Try contacting a local environmental organization in your area for information/ data on historical sources of water pollution. <ul style="list-style-type: none"> If you don't know of any, start with your Conservation Authority. Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) Is there an <u>Ontario Conservation Authority</u> in your region or local not-for-profit environmental group? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Your CA should also know of any not-for-profit groups in the area with expertise. <u>Provincial Groundwater Monitoring Network (ON)</u> <ul style="list-style-type: none"> Search: “Ontario Provincial Groundwater Monitoring Network:” Interactive map where you can search and view groundwater levels and water chemistry (from monitoring wells across the province) <u>Groundwater Information Network (Canada)</u> <ul style="list-style-type: none"> Search: “Canada Groundwater Information Network:” Shows water wells, monitoring sites and aquifers in Canada 	

Research Team #3: _____

Q: Where does our drinking water come from?	Research Strategies
<ul style="list-style-type: none"> How many <u>sources</u> are there for drinking water in the community? <ul style="list-style-type: none"> Where are they? (record for mapping purposes) Are they surface or groundwater sources? Name them (<i>e.g.</i>, Lake Ontario, Oak Ridges Moraine Aquifer) How much water do we <u>use</u> from these sources? <ul style="list-style-type: none"> Record any water use stats you can find—such as how much is used by industry VS. households 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
Where to start? <ul style="list-style-type: none"> Is there a local agency/ commission/ utility responsible for water/ wastewater management? Start here. Is there an <u>Ontario Conservation Authority</u> in your region or local not-for-profit environmental group? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Your CA should also know of any not-for-profit groups in the area with expertise. <u>Drinking Water Ontario</u> <ul style="list-style-type: none"> Search: “Municipal Drinking Water Treatment Facilities in Ontario” Access info about local municipal drinking water systems, including: water source; population served; listing of water treatments; water quality report; facility’s contact information; <i>etc.</i> Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) 	

Research Team #4: _____

Q: Where & how is our drinking water treated?	Research Strategies
<p>Water treatment plants</p> <ul style="list-style-type: none"> Are there any drinking water treatment plants? If so, how many? <ul style="list-style-type: none"> Name them and record their location (address or coordinates) Record any relevant, extra details you find about the water treatment plants (<i>e.g.</i>, type of treatment used, amount of water treated each year, location of intake pipes, <i>etc.</i>) <p>(or, for well water...)</p> <ul style="list-style-type: none"> What can you find out about wells in your community? (<i>e.g.</i>, typical depth, common problems with well water, <i>etc.</i>) Who is responsible for monitoring and treating well water? How often should monitoring take place? 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Is there a local agency/ commission/ utility responsible for water/ wastewater management? If yes, start here. <ul style="list-style-type: none"> Work with team #5 to ask about existing maps that show water infrastructure; some utilities may be able to tailor-make a map for the class already showing the location of water treatment facilities and intake/ outflow pipes, for example <u>Drinking Water Ontario</u> <ul style="list-style-type: none"> In an internet search engine, type in: “Municipal Drinking Water Treatment Facilities in Ontario” Access info about local municipal drinking water systems, including: water source; population served; listing of water treatments; water quality report; facility’s contact information; <i>etc.</i> Is there an <u>Ontario Conservation Authority</u> in your region or local not-for-profit environmental group? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Your CA should also know of any not-for-profit groups in the area with expertise. <u>Public Health Ontario</u>: Go to the heading “<u>Water Testing</u>”—it provides information for well owners related to testing water quality and well/ groundwater protection 	

Research Team #5: _____

Q: Where & how is our wastewater treated?	Research Strategies
<p>Wastewater treatment plants</p> <ul style="list-style-type: none"> Are there any wastewater treatment plants? If so, how many? <ul style="list-style-type: none"> Name them and record their location (address or coordinates) Record any relevant, extra details you find about the wastewater treatment plants <ul style="list-style-type: none"> <i>E.g.</i>, Type of treatment used: What is the purification process? What pollutants do they take out/ treat? Which are difficult (or impossible) to remove entirely? <i>E.g.</i>, Amount of water treated each year, where water goes after it is treated, <i>etc.</i> <p>(or, for other waste management systems...)</p> <ul style="list-style-type: none"> What is the main type of waste management system in our community (<i>e.g.</i>, septic systems) Who is responsible for ensuring proper maintenance? 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Is there a local agency/ commission/ utility responsible for water/ wastewater management? <ul style="list-style-type: none"> Work with team #4 to ask about existing maps that show water infrastructure; some utilities may be able to tailor-make a map for the class already showing the location of water treatment facilities and intake/ outflow pipes, for example <u>Safe Drinking Water Foundation</u> <ul style="list-style-type: none"> Search: “Safe Drinking Water Foundation” <u>Factsheets</u>—on aquifers, groundwater, conventional water treatment, source water protection, treating rural water, wastewater treatment, water pollution, <i>etc.</i> Is there an <u>Ontario Conservation Authority</u> in your region or local not-for-profit environmental group? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Your CA should also know of any not-for-profit groups in the area with expertise. 	

Research Team #6: _____

Q: How is drinking water quality monitored?	Research Strategies
<ul style="list-style-type: none"> How is drinking water quality monitored? Describe the system in place for ensuring safety (<i>e.g.</i>, how often, what water quality parameters are tested, <i>etc.</i>). <ul style="list-style-type: none"> Who is responsible? (Water treatment facilities? Well water?) 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Is there a local agency/ commission/ utility responsible for water/ wastewater management? If yes, start here. Is there an <u>Ontario Conservation Authority</u> in your region or local not-for-profit environmental group? <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any). Your CA should also know of any not-for-profit groups in the area with expertise. Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) <u>Drinking Water Ontario</u> <ul style="list-style-type: none"> In an internet search engine, type in: “Municipal Drinking Water Treatment Facilities in Ontario” Access info about local municipal drinking water systems, including: water source; population served; listing of water treatments; water quality report; facility’s contact information; <i>etc.</i> <u>Public Health Ontario</u> <ul style="list-style-type: none"> Go to the heading “<u>Water Testing</u>”—it provides information for well owners related to testing water quality and well/ groundwater protection <u>Safe Drinking Water Foundation</u> <ul style="list-style-type: none"> <u>Factsheets</u>—on aquifers, groundwater, conventional water treatment, source water protection, treating rural water, wastewater treatment, water pollution, <i>etc.</i> 	

Research Team #7: _____

Q: How is surface water quality monitored?	Research Strategies
<ul style="list-style-type: none"> How is surface water quality monitored (<i>e.g.</i>, for fishing, swimming)? <ul style="list-style-type: none"> Who is responsible? Where does sampling take place? (record the address or coordinates if possible) 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> Is there an <u>Ontario Conservation Authority</u> in your region? Start here. <ul style="list-style-type: none"> Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any) You may find information under “source water protection” strategies/ plans/ maps If no Conservation Authority, contact your regional Ministry of <u>Environment & Climate Change</u> and/or <u>Natural Resources & Forestry</u> office (Government of Ontario) Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) <u>Provincial Water Quality Monitoring Network</u> (Ontario-wide stream monitoring database) <u>Safe Drinking Water Foundation</u> <ul style="list-style-type: none"> <u>Factsheets</u>—on aquifers, groundwater, conventional water treatment, source water protection, treating rural water, wastewater treatment, water pollution, <i>etc.</i> 	

Research Team #8: _____

Q: How are drinking water sources protected?	Research Strategies
<ul style="list-style-type: none"> • What is “source water protection”? (define) <ul style="list-style-type: none"> ◦ Who is responsible (in our community)? • What are the major focuses of source water protection plans in our region? • Find a map of the source water protection area for our drinking water source(s) 	<ol style="list-style-type: none"> 1. Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). 2. For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. 3. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> • Is there an <u>Ontario Conservation Authority</u> in your region? Start here. <ul style="list-style-type: none"> ◦ Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any) ◦ You may find information under “source water protection” strategies/ plans/ maps • If no Conservation Authority, contact your regional Ministry of <u>Environment & Climate Change</u> and/or <u>Natural Resources & Forestry</u> office (Government of Ontario) • Consult the <u>Community Water Profiles</u> (by County), compiled by the Polaris Institute (<www.polarisinstitute.org/education>) • <u>Safe Drinking Water Foundation</u> <ul style="list-style-type: none"> ◦ <u>Factsheets</u>—on aquifers, groundwater, conventional water treatment, source water protection, treating rural water, wastewater treatment, water pollution, <i>etc.</i> 	

Research Team #9: _____

Q: How is storm water collected and where does it go?	Research Strategies
<ul style="list-style-type: none"> • What is stormwater? (define) <ul style="list-style-type: none"> ◦ Why does it cause pollution? • Who is responsible for managing storm water runoff in our community? (department or agency) • Where does the run-off go? Is it treated? • Are there any problems during high rainfall events or snowmelt in spring? If yes, how do water managers prepare for these issues? • What are some examples of how communities and individuals can prevent stormwater runoff? Briefly describe. 	<ol style="list-style-type: none"> 1. Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). 2. For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. 3. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
<p>Where to start?</p> <ul style="list-style-type: none"> • Contact your municipal town/ city office to see if they have a department that manages stormwater • Is there a local agency/ commission/ utility responsible for water/ wastewater management? If yes, contact someone who works on sanitary sewers • Is there an Ontario Conservation Authority in your region? <ul style="list-style-type: none"> ◦ Search: “Ontario Conservation Authority map.” Based on where you are located, figure out who your local Conservation Authority is (if any) • RAIN program (Green Communities Canada): <http://greencommunitiescanada.org/programs/rain/> <ul style="list-style-type: none"> ◦ Learn about strategies for preventing stormwater runoff 	

Research Team #10: _____

Q: Who uses the <i>most</i> water in our area & how might they impact water quality?	Research Strategies
<ul style="list-style-type: none"> In our community, are there: golf courses, industrial/ manufacturing plants, large companies/ office buildings, agricultural operations (farms), mining/ quarry projects, and/or hydroelectric generating stations (dams)? <ul style="list-style-type: none"> Do they have permits to withdraw water? <ul style="list-style-type: none"> If yes, how much water are they permitted to take? Where are they located on the map? Which might also have an impact on water quality? <ul style="list-style-type: none"> <i>E.g.</i>, How close are these to local waterways? What type(s) of pollution might be of concern? 	<ol style="list-style-type: none"> Consult the websites & record useful information. Be sure to note the page and/or URL where the info was found (you must be able to later cite your source!). For more detailed inquiries, contact the person responsible for education/ outreach/ communications (by phone or email). Introduce yourself and explain the project. Be sure to record the name of the person, their position/ place of work, the date of your communication, and their contact information. If you hit a “dead end,” contact your municipal town/ city office to see where you can get the information you require.
Where to start? <ul style="list-style-type: none"> Try the <u>Ontario Ministry of the Environment interactive map</u> where you can search permits to take water in your local area. The <u>Ontario Environmental Registry</u> lists permits issued for taking 50,000 (or more) litres of water per day <ul style="list-style-type: none"> <www.ebr.gov.on.ca/ERS-WEB-External/> Enter site, then hit “search” (not “basic search”); in the section labeled “with all the words,” type in <i>water permit</i>. Scroll down to “Geographic Location Filters” and under “Location name,” enter your community (<i>e.g.</i> Kingston). <u>Note</u>: You don’t need to add the province, as this database is Ontario-specific! <i>Be sure to click on the circle beside this label to activate the search parameter.</i> Consult the Community Water Profiles, compiled by the Polaris Institute (<www.polarisinstitute.org/education>) <ul style="list-style-type: none"> Lists major water takers in the County; source of information for assessing contributors to water pollution Lists local environmental groups* with an interest in water protection (*many of these groups are a wealth of knowledge) Type the name of the large water users into “Google.” Find their address & plot accordingly on your map (if you are able). 	

(BLM 1.1) Community Water Map – Individual Student Research (p. 1 of 2)

Surface water

Where does your drinking water come from?	Where to start?
<p>1. Ask at home: does our water come from a local treatment plant or a private well?</p> <p>*If private well, go to (BLM 1.1)</p> <p>2. If water treatment plant, find out where the water comes from (groundwater or surface water?)</p> <p>3. If surface water, what is the <i>name</i> of the source? (e.g., Lake Ontario)</p>	<p>For questions 2 & 3, try the following resources for information:</p> <ul style="list-style-type: none"> • Local utilities agency or commission • Ontario Conservation Authority (which one is responsible for your region?) • Drinking Water Ontario (<i>for information on municipal drinking water treatment facilities</i>) • Community Water Profiles (by County), compiled by the Polaris Institute
Where is your water treated?	Where to start?
<p>4. Where is the facility where your drinking water is treated—at home? At school?</p> <p>5. How many water treatment plans are there in your town/ city? Where are they located?</p>	<ul style="list-style-type: none"> • Local utilities agency or commission • Drinking Water Ontario (<i>for information on municipal drinking water treatment facilities</i>) • Ontario Conservation Authority (which one is responsible for your region?)
Where is surface water quality monitored?	Where to start?
<p>6a. For drinking water ?</p> <p>6b. For fishing?</p> <p>6c. For swimming?</p>	<p>For these more detailed questions, try:</p> <ul style="list-style-type: none"> • Local utilities agency or commission • Ontario Conservation Authority <p>*One of these places should be able to point you in the right direction!</p>
Where is your wastewater treated?	Where to start?
<p>7. Ask at home: do we have a septic system, or are we hooked up to the town/ city sewer?</p> <p><i>*If on the city sewer, continue with #8 & 9. If on a septic system, continue to #10.</i></p> <p>8. Where is the facility where your wastewater is treated—at home? At school?</p> <p>9. How many wastewater treatment plants are there in your town/ city? Where are they located?</p>	<p>For questions 8 & 9:</p> <ul style="list-style-type: none"> • Call or email your municipal town/ city office to see where you can get this information

(BLM 1.1) Community Water Map – Individual Student Research p. 2 of 2

****Surface water****

Who uses the <i>most</i> water in your area?	Where to start?
<p>10a. Are there golf courses, industrial/ manufacturing plants, large companies or agricultural operations (farms), mining/ quarry projects, hydroelectric generating stations (dams), <i>etc.</i>?</p> <p>10b. Where are these located on the map? Can you assign an area to them, or do they take water from all over?</p>	<p>For question 10a:</p> <p>1) Try the Ontario Ministry of the Environment interactive map (link) where you can search permits to take water in your local area.</p> <p>2) The Ontario Environmental Registry* (link) lists permits issued for taking 50,000 (or more) litres of water per day</p> <p>*Instructions: Enter site, then hit “search” (not “basic search”); in the section labeled “with all the words,” type in <i>water permit</i>. Scroll down to “Geographic Location Filters” and under “Location name,” enter your community (<i>e.g.</i> Kingston). <u>Note:</u> You don’t need to add the province, as this database is Ontario-specific! <i>Be sure to click on the circle beside this label to activate the search parameter.</i></p> <p>For question 10b:</p> <p>Type in the name of the large water users into “Google.” Find their address & plot accordingly on your map (if you are able).</p>
Which areas of the community are at <i>higher risk</i> for water pollution?	Where to start?
<p>11. Consider the large water users in your area. How is their wastewater dealt with?</p> <p>12. What are common causes of “non-point*” source water pollution in your community?</p> <p>*Non-point source pollution: Pollution is contributed to the water source from a wide variety of places in the watershed. This can happen when water running over non-permeable surfaces such as pavement and concrete picks up pollutants along the way (<i>e.g.</i> oil/gas, dog poop, litter, chemicals, <i>etc.</i>)</p>	<p>For question 11:</p> <p>The Polaris Institute's Community Water Profiles (www.polarisinstitute.org/education) provide a source of information for assessing contributors to water pollution.</p> <p>For question 12:</p> <p>Try contacting a local environmental organization in your area for information/ data on historical sources of water pollution. If you don't know of any of these organizations, start with your Conservation Authority.</p>

(BLM 1.2) Community Water Map – Individual Student Research p. 1 of 2

Groundwater

Where does your drinking water come from?	Where to start?
<p>1. Ask at home: does our water come from a local treatment plant or a private well?</p> <p>*If water treatment plant, go to (BLM 1.0)</p>	<ul style="list-style-type: none"> • If desired, you could try to find out more about your local aquifer. Start with your Conservation Authority or a local environmental group that works on watershed issues • Another resource is the Groundwater Information Network (link)
How is your water treated (if at all)?	Where to start?
<p>2. Ask at home: do we treat our tap water with anything before we drink it?</p>	<ul style="list-style-type: none"> • Sometimes well-water is found to be 'hard' or 'soft,' and people will treat their water for this in different ways • Other filtration or bacterial protection measures may also be necessary • The Provincial Groundwater Monitoring Network (link) may be able to provide more information on groundwater quality in your area
How is your groundwater quality monitored? Who is responsible?	Where to start?
<p>3. Ask at home: how often do we test our well water quality?</p>	<ul style="list-style-type: none"> • Consult Public Health Ontario (link) for information on testing your well water quality and groundwater protection
Where is your wastewater treated?	Where to start?
<p>4. Ask at home: do we have a septic system, or are we hooked up to the town/ city sewer?</p> <p><i>*If on the city sewer, continue with #5 & 6. If on a septic system, continue to #7.</i></p> <p>5. Where is the facility where your wastewater is treated—at home? At school?</p> <p>6. How many wastewater treatment plants are there in your town/ city? Where are they located?</p>	<p>For questions 5 & 6:</p> <ul style="list-style-type: none"> • Call or email your municipal town/ city office to see where you can get this information

(BLM 1.2) Community Water Map – Individual Student Research p. 2 of 2

Groundwater

Who uses the <i>most</i> water in your area?	Where to start?
<p>7a. Are there golf courses, industrial/ manufacturing plants, large companies or agricultural operations (farms), mining/ quarry projects, hydroelectric generating stations (dams), <i>etc.</i>?</p> <p>7b. Where are these located on the map? Can you assign an area to them, or do they take water from all over?</p> <p>Are they likely to rely on the same groundwater source you do?</p>	<p>For question 7a:</p> <p>1) Try the <u>Ontario Ministry of the Environment interactive map</u> (link) where you can search permits to take water in your local area.</p> <p>2) The <u>Ontario Environmental Registry*</u> (link) lists permits issues for taking 50,000 (or more) litres of water per day</p> <p>*Instructions: Enter site, then hit “search” (not “basic search”); in the section labeled “with all the words,” type in <i>water permit</i>. Scroll down to “Geographic Location Filters” and under “Location name,” enter your community (<i>e.g. Kingston</i>). <u>Note:</u> You don’t need to add the province, as this database is Ontario-specific! <i>Be sure to click on the circle beside this label to activate the search parameter.</i></p> <p>For question 7b:</p> <p>Type in the name of the large water users into “Google.” Find their address & plot accordingly on your map (if you are able).</p>
Which areas of the community are at <i>higher risk</i> for water pollution?	Where to start?
<p>8. Consider the large water users in your area. How is their wastewater dealt with?</p> <p>9. What are common causes of “non-point*” source water pollution in your community?</p> <p>*Non-point source pollution: Pollution is contributed to the water source from a wide variety of places in the watershed. This can happen when water running over non-permeable surfaces such as pavement and concrete picks up pollutants along the way (<i>e.g. oil/gas, dog poop, litter, chemicals, etc.</i>)</p>	<p>For question 8:</p> <p>The Polaris Institute's Community Water Profiles (<u>www.polarisinstitute.org/education</u>) provide a source of information for assessing contributors to water pollution.</p> <p>For question 9:</p> <p>Try contacting a local environmental organization in your area for information/ data on historical sources of water pollution. If you don't know of any, start with your Conservation Authority.</p>



Section II: Scientific Investigation of Local Water Quality

Description: In *Section I: Creating a Local Context for Water*, students created a picture of water in the community through a research and mapping activity. *Section II* provides the next step for looking at water resources—students are provided with the background knowledge and tools necessary to test and evaluate water quality. This section of the resource has three main goals:

1. Identify and understand commonly tested water quality parameters
2. Conduct water quality testing & interpret the results
3. Propose ways to: (a) protect and/or (b) restore, water quality

In this section, students examine the following inquiry/critical thinking questions: What do we test for (and why)? How do we test for it? What do the results tell us? What are the tools/ measures available: (1) To protect against impacts?; (2) To restore water quality?

IMPORTANT NOTE FOR TEACHERS: This section of the resource involves water quality testing, which requires the use of pre-ordered testing kits. You may want to skip ahead to p.55-56 for more information regarding the materials needed for this activity. We also encourage you to have students plot the data from your water quality findings on the Community Water Map from *Section I: Creating a Local Context for Water* (if you have completed this project). Finally, refer to Appendix C: Teacher Background Information for further resources to help guide your students through these activities (see descriptions in Table of Contents).

Pre-Activity: Water We Looking For?

In this activity, we want to provide students with a sense for the different water quality parameters we will be testing for (in “*What’s in the Water?*”), as well as why we test for these parameters (*i.e.*, what they tell us).

Part I: Introduction to Water Quality*

**The following was modified from an activity created by Patricia Larkin (Nature Works Learning)*

Learning Goal: To understand the importance of scientific sampling & water quality analysis.

Description: Students make visual observations of several water samples (up to 6 in 1- or 2-L clear bottles). This activity helps students think about different ways to determine water quality.

Time required: 20-min

Materials & Preparation:

- 6 clear, 1- or 2-L plastic bottles with lids
- Masking or electrical tape
- (BLM 2.0) Water Quality Worksheet (1 per student or group)

Fill and label 6 clear containers with water as follows. Use the tape to seal the lids onto the bottles.

Sample #1: Add enough coffee grounds and cocoa powder until the water has a "dirty" look

Sample #2: Add food coloring so that the water appears clear purple

Sample #3: Add vinegar - ½ vinegar and ½ water

Sample #4: Add a few tablespoons of table salt to warm water (so that salt dissolves)

Sample #5: Local surface water sample (*e.g.*, from stream, pond, wetland, river, lake, *etc.*)

Sample #6: School water

Engagement Strategy:

- Ask who is thirsty. Offer 1 or 2 students who have raised their hands a drink of water from sample #2... gage their reaction. Ask them to share why they would or would not drink the water. What sense(s) are they relying on to make this assessment?
- Show these same students the other prepared water samples. Ask them to pick out which of the bottles they *would* drink from (if not sample #2). If students seem cautious to choose, ask them what is the matter (*students should reply that even though the water looks clean & clear, they can't make this assessment on sight alone*).
- Inform the class that for this activity, we will be using our sense of *sight only* to make estimations of water quality. Students should make note of any further ways they might assess water quality (beyond sight), even though they *cannot* do it in this activity.
CAUTION students that *no one should open the bottles*, and that they should **never drink something where the contents are unknown**.

Teaching Strategy:

- In groups, have students examine two water samples only. Students should record their individual observations on (BLM 2.0) Water Quality Worksheet (p.31). Take ~4 minutes/jar – total 10 min.
- Then ask the students, in groups, to determine which of the water samples they would be willing to use for such things as fishing, swimming, boating or drinking. Which do they think other species could use? Students should jot down notes on their worksheet.
- After students have ‘analysed’ their samples, have them share their consensus and rationale for their decisions regarding water use – 1 sample/group. Record class results. Prompt students to provide evidence for their decisions.
- Reveal the contents of those bottles that appear ‘clean.’ Discuss whether their methods now, in light of this information, seem adequate. How else could/should water quality be measured?

Assessment:

- Observation of group work
- Collect and review student Water Quality Worksheets (BLM 2.0)

Differentiated Instruction:

- For students needing literacy support, you can also verbally assess their understanding of the activity using the Water Quality Worksheet (BLM 2.0) questions as a guideline.

Extension:

- Have students research instances where problems with water quality went undetected and caused health issues for people or ecosystems.
- One good example to give is the incident in Walkerton (ON) in 2000
- You can also refer students to news articles on the state of drinking water supplies for indigenous people in Canada, and have them explore this issue.

(BLM 2.0) Water Quality Worksheet

Group/ Name: _____

Observations and Impressions:

Look at 2 water samples only. Would you use the water in each of these to fish? Swim? Boat? Drink? Record your answers. Provide reasons for your answers.

Description	Sample # _____	Sample # _____
Would you	Yes/ No/ Why	Yes/ No/ Why
Fish?		
Swim?		
Boat?		
Drink?		
Good for other species?		

Part II: “So-What?” Scenarios

Learning Goal: Identify and understand commonly tested water quality parameters.

Description: Students are presented with a scenario of an activity or event that has an impact on local water quality.

Time required: 1 class period (65-70 min)

Materials & Preparation:

- (BLM 2.1) Example Mind Map - “Sustainable” (for **Engagement Strategy**, below)
- (BLM 2.2) Student Guide: Water Quality Parameters (~2 per group)
- (BLM 2.3) “So-What” Scenarios worksheet (1 scenario per group)
- (BLM 2.4) Water Quality Results (1 per group or put on board/overhead)
- (BLM 2.5) Water Quality Learning Chart (1 per student)

Engagement Strategy:

- Ask the class if they’ve heard the word ‘sustainable’ used before. In what context? Create a word association or “mind map” for the word. You can do this in a large group or in smaller groups.
 - *What do you think of when you hear the word “sustainable”?*
 - *What other words come to mind?*
 - See (BLM 2.1) Example Mind Map for guidance (p.34)
- Ask students if they think the word can be applied to ecosystems. If so, what kinds of things do they think make an ecosystem *sustainable*?
- Brainstorm further how sustainability might “look” in an ecosystem setting (*e.g.*, good habitat for living things, food sources, good reproduction rates, *etc.*). Refer to Mind Map for more ideas.
- What kinds of things might negatively *influence* these factors that make an ecosystem sustainable (refer back to the list generated)? Are these impacts naturally occurring, or is human activity involved?
- Explain that you’re going to be looking at ecosystem sustainability in more detail in this activity, where we look at scenarios affecting water quality.

Teaching Strategy:

- Split students into groups of 2-4. Give each group a copy of (BLM 2.2) Student Guide: Water Quality Parameters (3 pages) and assign them one of the “So-What” Scenario Student Worksheets (BLM 2.3). The same scenario may be given to more than one group*.
 - There are currently only 4 scenarios, so duplicates of the same scenario will be necessary in order to keep class groups small.
- Ask students to read through both the descriptions of the water quality parameters, and the scenario. Have the group identify which **water quality parameters might be affected** in the scenario.

- Using (*BLM 2.2*) Student Guide: Water Quality Parameters, have each group record potential ecosystem & health impacts that may result from the scenario [there is a place to write this on the student worksheet, (*BLM 2.3*)].
- Next, distribute (or display on the board/ overhead) the four different, hypothetical water quality test results provided (*BLM 2.4*). Each set of results corresponds to one of the scenarios. Students must use the information they've learned from (*BLM 2.2*) Student Guide: Water Quality Parameters, and choose which water quality test result best reflects their scenario. There is a space to record this information on their worksheet (*BLM 2.3*)

Assessment:

- Have each group prepare a short presentation for the class, summarizing: (1) the scenario; (2) expected impacts to water quality (water quality parameters affected/ test results); (3) possible ecosystem/ human health impacts. You may want to provide (*BLM 2.5*) Water Quality Learning Chart as a graphic organizer for students in creating their presentations.

Mark presentations using a rubric (*Note: Not provided*, as it is probably easiest to best gage what you'd like to evaluate in your students, yourself. Suggested assessment of teamwork and individuals' group contributions).

Have students complete a self-assessment on their contribution to the group's work (again, not provided)

- During the presentations, have students fill out (*BLM 2.5*) Water Quality Learning Chart. Each student should record information on 3-4 water quality parameters & their impacts, based on the other group presentations. Collect these to check for understanding/ engagement.
- After all the presentations have been made, take-up the activity together as a class. Did everyone agree with the other groups' assessments of water quality impacts? Did any groups choose the same water quality results? If so, which scenario do the results make the most sense, for?
- Ask students to consider how far-reaching & long-standing some of these impacts might be in the watershed (*i.e.*, what is the scope of the impact?). How might surface and/or groundwater be affected?

Differentiated Instruction:

- For applied science, you may want to go through the information as a class, first (*especially* water quality parameters). Do 1 or 2 example scenarios and then have students try one on their own. Pair students who may have difficulty with this activity in groups with students who can help out.

Extension:

- Have students come up with their own water quality "so-what" scenarios, or have them research a real-life event which had an impact on water quality. Have them complete the activity using these new scenarios.

(BLM 2.1) Example Mind Map - “Sustainable”

Engagement Strategy (“So What?” Scenarios Activity)

1. **Ask the class if they’ve heard the word ‘sustainable’ used before. In what context? Create a word association or “mind map” for the word. You can do this in a large group or in smaller groups.**

Q: What do you think of when you hear the word “sustainable”? What other words come to mind?

- Energy (*i.e.*, renewable)
- Forestry
- Fisheries
- Agriculture/ farming
- Food systems (*e.g.*, buying local)
- Transportation (*e.g.*, walking, biking, carpooling)
- Living (*i.e.*, lifestyle choices)
- Building/ design (*e.g.*, strawbale homes)
- Sustainability OR sustainable development (can they define?)
 - Common definition: “Meeting the needs of today without compromising the ability of future generations to meet their needs.”
 - “Pillars” of sustainability: environmental, economic, cultural, social
- 2. **Ask students if they think the word can be applied to ecosystems. If so, what kinds of things do they think makes an ecosystem *sustainable*? Note: It may help to place this in the context of specific ecosystem examples, such as: forests, lakes, oceans, *etc.***
- Characteristics of a 'sustainable ecosystem': many different species co-exist (both animal & vegetable); healthy balance of populations (*e.g.*, predator-prey relationships); terrestrial environment undergoes changes/ renewals (growth/death, disturbances), *etc.*

Teacher Information:

- ***Sustainable ecosystem***: a system that survives, functions, and is renewed over time without outside (human) influence or assistance.
- A balance between **4 main elements** maintain ecosystem stability: **(1) productivity** (growth rates of organisms in the ecosystem); **(2) diversity** (variation *within* & *between* living things); **(3) disturbance** (that changes the environment, such as a forest fire or mud slide)-- some is good, too much is bad; **(4) resilience** (ability of ecosystem to resist or recover from disturbances)
- 3. **Brainstorm further how sustainability might “look” in an ecosystem setting.**
E.g., healthy habitats: clean water, shelter, plenty of food sources, good reproduction rates, *etc.*
- 4. **What kinds of things might negatively *influence* these factors that make an ecosystem sustainable (refer back to the list generated)? Are these impacts naturally occurring, or is human activity involved?**

Generally, changes in land characteristics & use (*e.g.*, clearing land for development):

- Impacts: removing vegetation that adds stability to soil and filters surface water runoff before it enters waterways; decreasing shelter and food sources available; fragmenting habitat (so species can't move between sources of food and water safely/ easily).

(BLM 2.2) Student Guide: Water Quality Parameters (1 of 3)

Physical	
Colour	<ul style="list-style-type: none">• Can indicate there is dissolved organic (living) matter in the water, or metals such as iron, copper, or manganese
Odor	<ul style="list-style-type: none">• Caused by dissolved organic matter, biological activity (such as bacteria helping in decomposition), or pollution from industry
Taste	<ul style="list-style-type: none">• Can indicate the presence of such things as: magnesium, calcium, sodium, copper, iron, or zinc
Temperature	<ul style="list-style-type: none">• <u>Causes</u> for temperature change (in surface water): dramatic changes in air temperature; changes to shape or flow of waterway; reduced shade; cloudiness; warm-water discharge from processing plants• <u>Impacts</u> of higher temperatures: lower dissolved oxygen levels (see “dissolved oxygen”); physical stress to aquatic organisms (such as insects and cold-water fish)
Suspended Sediment	<ul style="list-style-type: none">• When soils are exposed they can wash into nearby waterways and make the water cloudy (‘turbid’)• <u>Impacts</u>: small particles (like silt and clay) can clog or damage fish gills, suffocate bottom-living aquatic insects and fish eggs, and destroy habitat by filling in the spaces between gravel where fish lay eggs; can cause higher temperatures because more sunlight is absorbed; may interfere with photosynthesis & aquatic plant growth (because sunlight does not reach bottom); will carry nutrients or other chemicals into water (such as heavy metals which attach to soil particles)
Turbidity	<ul style="list-style-type: none">• Closely related to suspended sediment, turbidity refers to the clarity/ cloudiness of the water• It is the result of particles (such as clay, silt, plankton, or microscopic organisms) suspended in water• Can be an indication of surface runoff or erosion• <u>Impacts</u>: Same as for suspended sediment; also, if turbidity is largely caused by microorganisms, their decomposition can lead to lower dissolved oxygen in the water

(BLM 2.2) Student Guide: Water Quality Parameters (2 of 3)

Chemical	
pH	<ul style="list-style-type: none"> • Measure of the amount of hydrogen present in water • Certain organisms can tolerate only specific levels of pH; it can have a wide range of impacts on aquatic wildlife, as it affects the solubility and availability of nutrients in an ecosystem
Hardness	<ul style="list-style-type: none"> • Determined by the amount of dissolved calcium and magnesium in the water. Higher concentrations = “harder” water • Source: Often dissolved out of soil/ rock
Dissolved oxygen (DO)	<ul style="list-style-type: none"> • A basic requirement for a healthy aquatic ecosystem, because certain species are sensitive to specific levels of dissolved oxygen • Water temperature affects dissolved oxygen (colder water can hold more oxygen) • Bacteria that help in the decomposition process use up dissolved oxygen in the water • Impacts: suffocation of adult cold-water fish or egg/juveniles; reduced health/ populations of insects & microorganisms; foul odor (when low dissolved oxygen is associated with the decomposition process)
Nutrients Often, farmers and gardeners will add manure or fertilizers to the soil, which will provide more nutrients for the plants. But sometimes, too much fertilizer and manure is used and the plants cannot use up what is in the soil. The extra nutrients are washed into water sources and become pollution. Untreated sewage is also a source of nutrient contamination in many waterways.	
Nitrates & phosphates	<ul style="list-style-type: none"> • When nitrates and phosphates enter the water source, a type of water plant called algae grows very quickly • Eventually that water can become green or blue, or red and cloudy from all the algae in it; it feels slimy and smells bad! We call this ecosystem impact “eutrophication” • As more algae grow, some of it dies to make room for newer algae • The dead algae decompose and are eaten by bacteria that use up the oxygen in the water (this is what causes the smell) • Other aquatic species, such as fish and insects, rely on certain levels of oxygen in the water to survive • High levels of nitrate in drinking water also negatively affect human health (particularly pregnant women & bottle-fed infants)

(BLM 2.2) Student Guide: Water Quality Parameters (3 of 3)

Biological	
Microorganisms <ul style="list-style-type: none">• Sources: untreated sewage (septic tanks, sewage treatment plant overflow); stormwater (including runoff from manure-fertilized land or manure piles); animal processing plants; wildlife (living in and around water)• Impacts: human illnesses (ranging from gastro-intestinal disease to minor respiratory and skin diseases)• Both groundwater and surface water can become contaminated. The most common causes of groundwater contamination are poorly maintained or operating septic systems, unprotected wellheads, leaky sewer pipes, <i>etc.</i>• Cannot test for <i>every</i> disease-causing organism in water, so usually test for indicator bacteria (those found in high numbers in the stomachs and intestines of warm-blooded animals, including humans)	
Coliforms	<ul style="list-style-type: none">• Bacteria associated with environmental sources such as plants, insect infestation and soil, or possibly animal ‘feces’ (i.e., poop!)• Even a low count can indicate the presence of other more harmful bacteria (see <i>E. coli</i>)
<i>E. coli</i>	<ul style="list-style-type: none">• The most common indicator bacteria we test for is <i>E. coli</i> (<i>Escherichia coli</i>), which is associated with human and animal feces• When found in drinking water, it is a strong indication of sewage or animal waste contamination (and water is considered unsafe to drink due to serious health risks)• As an ‘indicator bacteria,’ <i>E. coli</i> can also point to the presence of other microorganisms in the drinking supply (many of which have health concerns)

Group members:

(BLM 2.3) Student Worksheet: “So What” Scenario #1

You are walking along a path by a large stream that feeds into a local river, when you notice that a large section of land next to the stream has recently been disturbed. All the vegetation (trees, plants) has been removed and the soil is completely exposed. It is calling for heavy rains all week.

In the space provided below, answer the following questions in your group:

What water quality parameters will be affected?

*Refer to *(BLM 2.2)* Student Guide: Water Quality Parameters

Looking at the *Water Quality Test Results (BLM 2.4)*...

Which do you think best reflects your scenario?

What will be the impacts?

To the ecosystem? To human health?

Group members:

(BLM 2.3) Student Worksheet: “So What” Scenario #2

It is mid-summer, and you are visiting a friend’s cottage on a small, shallow lake. You notice that it doesn’t smell great, or look nice for swimming—it’s covered in green algae! Your friend explains that it has only become like this since more cottages have been built along the lake. Looking around, you notice very large summer homes and well-kept lawns extending down to the water’s edge.

In the space provided below, answer the following questions in your group:

What water quality parameters will be affected?

*Refer to *(BLM 2.2)* Student Guide: Water Quality Parameters

Looking at the *Water Quality Test Results (BLM 2.4)*...

Which do you think best reflects your scenario?

What will be the impacts?

To the ecosystem? To human health?

Group members:

(BLM 2.3) Student Worksheet: “So What” Scenario #3

Someone from a local community water group recently stopped by your house to drop off a pamphlet for a program called “Well Aware.” You get your drinking water from a well, so decide to read through it. In it, you learn about things like contamination from bad septic systems (gross!) and underground tanks that were used many years ago to store things like oil for heating your house. You also read about the importance of making sure your well is in working order so it doesn’t get contaminated from surface sources, either. You start to think about the two big cattle farms in the area, as well as a half-dozen or so hobby farms...

Based on the above concerns, imagine a “worst case scenario” for impacts to your water quality...

In the space provided below, answer the following questions in your group:

What water quality parameters will be affected?

*Refer to *(BLM 2.2)* Student Guide: Water Quality Parameters

Looking at the *Water Quality Test Results (BLM 2.4)*...

Which do you think best reflects your scenario?

What will be the impacts? To the ecosystem? To human health?

Group members:

(BLM 2.3) Student Worksheet: “So What” Scenario #4

Your class goes on a field trip to the local wastewater treatment plant. There, you discover that one of the biggest problems they deal with is “stormwater run-off”--this is when rainwater and melted snow flows along the roads and eventually ends up in the sewers. When there is a lot of rain that falls over a few days (or a sudden snowmelt), the plant can't handle treating all of this extra water. This means that the wastewater flows into the lake without being treated...the same lake you get your drinking water from!

The water manager tells your class stormwater run-off often carries gas and oil from the roads, fertilizers and pesticides from farms and gardens, and a surprising amount of animal poop—ew! What is more, because of the way the pipes are set up to deal with wastewater, this untreated water also contains human sewage (from the homes in your community).

Over time, if these flooding events became more frequent, what water quality problems could arise?

What water quality parameters will be affected?

*Refer to *(BLM 2.2)* Student Guide: Water Quality Parameters

Looking at the *Water Quality Test Results (BLM 2.4)*...

Which do you think best reflects your scenario?

What will be the impacts?
To the ecosystem? To human health?

(BLM 2.3) “So What” Scenario #1 (Teacher Key)

You are walking along a path by a stream that feeds into the local river, when you notice that a large section of land next to the stream has recently been disturbed. All the vegetation (trees, plants, *etc.*) has been removed and the soil is completely exposed. It is calling for heavy rains all week.

Student Questions:

1. What water quality parameters will be affected?

**Refer students to hand-out (BLM 2.2) Student Guide: Water Quality Parameters*

2. What will be the impacts to the ecosystem (both immediate and longer-term)?

3. Looking at (BLM 2.4) Water Quality Test Results, which do you think best reflects your scenario?

Water quality parameters affected:

- **Suspended sediment** (exposed soil will enter stream during rainfall)
- **Turbidity** (at least temporarily, due to higher suspended sediment levels)
- **Temperature** (no shade due to removed vegetation)
- **Dissolved oxygen** (see #2, 3)
- **Nutrients** (see #3)
- **Toxic chemicals, heavy metals** (see #2, 3)

Water Quality Test Results (expected):

- High suspended sediment
- High turbidity
- High temperature
- Low dissolved oxygen
- Possibility of high nutrient (nitrate/ phosphate) levels
- Possibility of toxic metals or chemicals attached to sediment settling out on bottom

What impacts?

- High suspended sediment can cause: fish kills (clogs gills), decrease plant growth (by blocking sunlight needed for photosynthesis)
- Higher temperatures mean the water can hold less dissolved oxygen (needed by aquatic fish & insects to live)
- When sediment settles out of water to bottom, it will destroy egg-laying habitat for fish and living environment for bottom-dwelling aquatic insects
- Sediment can carry nutrients into the water (nitrogen, phosphorus), which can lead to *eutrophication* (a sudden increase in plant/ bacteria growth)
- When these plants/bacteria die, their break down will use up the dissolved oxygen
- Low dissolved oxygen levels can cause fish kills; fish kills further aggravate the demand for oxygen in the water to break down the dead organisms
- Low dissolved oxygen levels can decrease populations of insects that are sensitive to specific levels of oxygen
- Sediment can carry toxic chemicals (such as pesticides) or heavy metals into the water
 - o Note: Heavy metals and toxic chemicals are further discussed under **Other Water Quality Concerns** on p.77. Although students may come up with this impact on their own from reading the scenario, it could be brought up as a discussion point because it is not outlined in (BLM 2.2) “Student Guide: Water Quality Parameters.”

(BLM 2.3) “So What” Scenario #2 (Teacher Key)

It is mid-summer, and you are visiting a friend’s cottage on a small, shallow lake. You notice that it doesn’t smell great, or look nice for swimming—it’s covered in green algae! Your friend explains that it has only become like this since more cottages have been built along the lake. Looking around, you notice very large summer homes and well-kept lawns extending down to the water’s edge.

Student Questions:

1. What water quality parameters will be affected?

**Refer students to hand-out (BLM 2.2) Student Guide: Water Quality Parameters*

2. What will be the impacts to the ecosystem (both immediate and longer-term)?

3. Looking at (BLM 2.4) *Water Quality Test Results*, which do you think best reflects your scenario?

Water quality parameters affected:

- **Odor** (from anaerobic bacteria*)
- **Temperature** (mid-summer, shallow lake)
- **Nutrients** (nitrogen, phosphorus), most likely entering lake from (a) improperly installed or ill-maintained septic systems (*i.e.*, sewage); and/or (b) lawn fertilizers
- **Microorganisms** (*e.g.*, bacteria, parasites, *etc.*) from untreated sewage
- **Toxic chemicals** (pesticides)

**Most anaerobic bacteria do not use oxygen, and can survive without it being present. If there is low dissolved oxygen in water, these bacteria can still be active.*

Water quality test results (expected):

- Bad odor
- High temperatures
- Low dissolved oxygen
- High nutrient levels (nitrate, phosphate)
- Possibility of high microorganism levels (*e.g.*, bacteria, parasites, *etc.*)
- Possibility of pesticides

What impacts?

- Higher temperatures mean the water holds less dissolved oxygen (needed by aquatic life)
- Excess nutrients in the water can lead to *eutrophication*—a sudden increase in plant/ bacteria growth (this is where the algae came from)
- When the plants/bacteria later die, their decomposition will use up dissolved oxygen
- Low dissolved oxygen levels can cause fish kills and the disappearance of insect populations that are sensitive to particular oxygen levels
- The presence of anaerobic bacteria in the lake (which can reproduce without oxygen) may be causing the bad odor
- Untreated sewage entering the waterway may cause elevated bacteria levels (*e.g.*, *E. coli*), which would make the water unsafe for swimming and drinking
- Pesticides** may cause problems to life within the aquatic ecosystem, or to human health if they enter the groundwater supply

***This can be an added discussion point; students may come up with it on their own from the scenario, but it is not discussed on (BLM 2.2) Student Guide: Water Quality Parameters.*

(BLM 2.3) “So What” Scenario #3 (Teacher Key)

Someone from a local community water group recently stopped by your house to drop off a pamphlet for a program called “Well Aware.” You get your drinking water from a well, so decide to read through it. In it, you learn about things like contamination from bad septic systems (gross!) and underground tanks that were used many years ago to store things like oil for heating your house. You also read about the importance of making sure your well is in working order so it doesn’t get contaminated from surface sources, either. You start to think about the two big cattle farms in the area, as well as a half-dozen or so hobby farms...

Based on the above concerns, imagine a “worst case scenario” for impacts to your water quality...

Student Questions:

1. What water quality parameters will be affected?

**Refer students to hand-out (BLM 2.2) Student Guide: Water Quality Parameters*

2. What will be the impacts to the ecosystem (both immediate and longer-term)?

3. Looking at (BLM 2.4) Water Quality Test Results, which do you think best reflects your scenario?

1) Water quality parameters affected:

- **Nutrients** (nitrate): from septic systems, manure piles, and fertilizers
- **Microorganisms** (e.g., bacteria, parasites, etc.): from septic systems and manure
- **Toxic chemicals** (hydrocarbons from old, leaky underground fuel storage tanks)

3) Water quality test results (expected):

- Unacceptable levels of coliform bacteria
- Likely presence of other, harmful microorganisms
- High nitrate levels
- Possible toxic levels of hydrocarbons*

**Ingesting hydrocarbons through a water source can lead to a variety of short or long-term adverse health effects, dependent on exposure.*

2) What impacts?

- Leaking septic systems—either yours, or your neighbours’, can contaminate the groundwater supply with nitrates and/or coliform bacteria
- Fertilizers applied to farmland (or for domestic use) also contain nitrates, which can enter the groundwater supply through the soil or a poorly maintained well
- High nitrate levels in water can lead to negative health affects, particularly for pregnant women and bottle-fed infants under 6 months
- Cattle farms have lots of manure! Living near so many farms could lead to nitrates and/or coliform bacteria entering your drinking water supply through a similar means to the fertilizer.
- *E. coli* contamination of a water supply can cause serious health issues (*refer students to Walkerton tragedy*).
- As an ‘indicator bacteria,’ *E. coli* can also point to the presence of other microorganisms in the drinking supply (many of which have associated health concerns, such as parasites).
- The water supply is at risk of hydrocarbon contamination**, particularly if storage tanks are >15 years old or lack corrosion protection

***This can be an added discussion point; students may come up with it on their own from the scenario, but it is not discussed in (BLM 2.2) Student Guide: Water Quality Parameters*

(BLM 2.3) “So What” Scenario #4 (Teacher Key)

Your class goes on a field trip to the local wastewater treatment plant. There, you discover that one of the biggest problems they deal with is “stormwater run-off”--this is when rainwater and melted snow flows along the roads and eventually ends up in the sewers. When there is a lot of rain that falls over a few days (or a sudden snowmelt), the plant can't handle treating all of this extra water. This means that the wastewater flows into the lake without being treated...the same lake you get your drinking water from!

The water manager tells your class stormwater run-off often carries gas and oil from the roads, fertilizers and pesticides from farms and gardens, and a surprising amount of animal poop—ew! What is more, because of the way the pipes are set up to deal with wastewater, this untreated water also contains human sewage (from the homes in your community).

Over time, if these flooding events became more frequent, what water quality problems could arise?

Student Questions:

1. What water quality parameters will be affected?

**Refer students to hand-out (BLM 2.2) Student Guide: Water Quality Parameters*

2. What will be the impacts to the ecosystem (both immediate and longer-term)?

3. Looking at (BLM 2.4) Water Quality Test Results, which do you think best reflects your scenario?

1) Water quality parameters affected:

- **Dissolved oxygen**
- **Nutrients** (nitrate): from animal & human waste, fertilizers
- **Microorganisms (e.g., *E. coli* bacteria, parasites, etc.):** from animal & human waste
- **Hydrocarbons**
- **Toxic chemicals, heavy metals**
- **Odor**

3) Water quality test results (expected):

- Low dissolved oxygen (see #2)
- High nitrate levels (see #2)
- Unacceptable levels of coliform bacteria (e.g., *E. coli*)
- Likely presence of other, harmful microorganisms (parasites/ pathogens)
- Likely hydrocarbon contamination (due to oil and gas spills on roadways)
- Likely presence of toxic chemicals (such as pesticides) and heavy metals (from industry)
- Possibility of odor (due to raw sewage)

2) What impacts?

- When human or animal waste decomposes, it uses up dissolved oxygen in the water
- Low dissolved oxygen levels can cause fish kills; fish kills further aggravate the demand for oxygen in the water to break down the dead organisms. Low DO can also decrease populations of insects that are sensitive to specific levels of oxygen
- High nitrate & bacteria (coliform) levels from animal and human waste are both harmful to human health (*refer students to Walkerton tragedy of *E. coli* contamination*)
- As an ‘indicator bacteria,’ *E. coli* can also point to the presence of **other microorganisms** in the drinking supply (many of which have associated health concerns, such as parasites & other pathogens).
- The water supply is at risk of hydrocarbon contamination, as well as toxic chemicals and heavy metals (due to runoff from roadways)*

**This can be an added discussion point; students may come up with it on their own from the scenario, but it is not discussed in (BLM 2.2) Student Guide: Water Quality Parameters*

(BLM 2.4) “So What” Scenarios – Water Quality Test Results

Teacher Copy

*These are the (hypothetical) expected water quality test results from the water-based scenarios the students are working with. Provide student groups with p.47-48 (**BLM 2.4, Student Copy**) so they can refer to it during the presentations of their classmates.*

Scenario	Expected Water Quality
#1	<ul style="list-style-type: none"> - High suspended sediment - High turbidity - High temperature - Low dissolved oxygen - Possibility of high nutrient (nitrate/ phosphate) levels - Possibility of toxic metals or chemicals attached to sediment settling out on bottom
#4	<ul style="list-style-type: none"> - Low dissolved oxygen - High nitrate levels - Unacceptable levels of coliform bacteria - Likely presence of other, harmful microorganisms - Likely toxic chemical & heavy metal contamination (e.g., pesticides) - Hydrocarbon contamination - Possibility of bad odor
#3	<ul style="list-style-type: none"> - Unacceptable levels of coliform bacteria - Likely presence of other, harmful microorganisms - High nitrate levels - Possible toxic levels of hydrocarbons
#2	<ul style="list-style-type: none"> - Bad odor - High temperatures - Low dissolved oxygen - High nutrient levels (nitrate, phosphate) - Possibility of high microorganism levels (e.g., bacteria, parasites, etc.) - Possibility of pesticides

(BLM 2.4) “So What” Scenarios – Water Quality Test Results

Student Copy (p.1 of 2)

- *There were 4 scenarios that your class worked with during this activity*
- *On the back page, there are 4 different sets of hypothetical water quality test results*
- *Each result matches with one of the scenarios below*
- *While listening to the presentations of your classmates, try to match the results with the correct scenario*

Scenario 1: You are walking along a path by a stream that feeds into the local river, when you notice that a large section of land next to the stream has recently been disturbed. All the vegetation (trees, plants, etc.) has been removed and the soil is completely exposed. It is calling for heavy rains all week.

Scenario 2: It is mid-summer, and you are visiting a friend’s cottage on a small, shallow lake. You notice that it doesn’t smell great, or look nice for swimming—it’s covered in green algae! Your friend explains that it has only become like this since more cottages have been built along the lake. Looking around, you notice very large summer homes and well-kept lawns extending down to the water’s edge.

Scenario 3: Someone from a local community water group recently stopped by your house to drop off a pamphlet for a program called “Well Aware.” You get your drinking water from a well, so decide to read through it. In it, you learn about things like contamination from bad septic systems (gross!) and underground tanks that were used many years ago to store things like oil for heating your house. You also read about the importance of making sure your well is in working order so it doesn’t get contaminated from surface sources, either. You start to think about the two big cattle farms in the area, as well as a half-dozen or so hobby farms...

Based on the above concerns, imagine a “worst case scenario” for impacts to your water quality...

Scenario 4: Your class goes on a field trip to the local wastewater treatment plant. There, you discover that one of the biggest problems they deal with is “stormwater run-off”—this is when rainwater and melted snow flows along the roads and eventually ends up in the sewers. When there is a lot of rain that falls over a few days (or a sudden snowmelt), the plant can’t handle treating all of this extra water. This means that the wastewater flows into the lake without being treated...the same lake you get your drinking water from!

The water manager tells your class stormwater run-off often carries gas and oil from the roads, fertilizers and pesticides from farms and gardens, and a surprising amount of animal poop—ew! What is more, because of the way the pipes are set up to deal with wastewater, this untreated water also contains human sewage (from the homes in your community).

Over time, if these flooding events became more frequent, what water quality problems could arise?

(BLM 2.4) “So What” Scenarios – Water Quality Test Results

Student Copy (p.2 of 2)

Scenario	Expected Water Quality
_____	<ul style="list-style-type: none"> - High suspended sediment - High turbidity - High temperature - Low dissolved oxygen - Possibility of high nutrient (nitrate/ phosphate) levels - Possibility of toxic metals or chemicals attached to sediment settling out on bottom
_____	<ul style="list-style-type: none"> - Low dissolved oxygen - High nitrate levels - Unacceptable levels of coliform bacteria - Likely presence of other, harmful microorganisms - Likely toxic chemical & heavy metal contamination (e.g., pesticides) - Hydrocarbon contamination - Possibility of bad odor
_____	<ul style="list-style-type: none"> - Unacceptable levels of coliform bacteria - Likely presence of other, harmful microorganisms - High nitrate levels - Possible toxic levels of hydrocarbons
_____	<ul style="list-style-type: none"> - Bad odor - High temperatures - Low dissolved oxygen - High nutrient levels (nitrate, phosphate) - Possibility of high microorganism levels (e.g., bacteria, parasites, etc.) - Possibility of pesticides

(BLM 2.5) Water Quality Learning Chart

Name: _____

Scenario	Water Quality Parameter	Impact
<i>Provide a brief description of the scenario presented by your classmates</i>	<i>Name one WQ parameter that will be affected in the scenario (e.g., temperature, dissolved oxygen, nitrates, etc.).</i>	<i>What are the possible effects on: (1) Health of the ecosystem? (2) Human health?</i>

Activity: What's in the Water?

Now that students have had a chance to explore the location and uses of water within the community, as well as learn about factors affecting water quality, it's time to explore what is actually *in* your local water.

Note: *Before undertaking this activity with students, you must choose and order a water quality testing kit (if you don't already have access to testing materials within your school or board). Refer to **Resources:** "Choosing a Test Kit" (p.55-56) for more information.*

Part I: Testing for Water Quality

Learning Goal: Conduct water quality testing toward the purpose of applying knowledge and understanding of water quality parameters and what they may indicate about ecosystem health.

Description: Scientific investigation skills and critical thinking form the basis for this inquiry-based learning activity. Students will plan and carry out water quality sampling in the local community. They will then conduct water quality tests on the samples, using their previous learning to choose which parameters to test for*.

**Teacher's note: Parameter selection may be somewhat limited due to the water quality tests available. See the "Choosing a Test Kit" section for further information (p.55-56).*

Time required: 2-3 class periods* (65-70 min)

- Period 1: Planning sampling locations & procedure
- Period 2: Field trip to conduct water sampling **and/or** water quality testing**
- Period 3: Water quality testing

**Number of classes required depends on whether sampling will be done during class time, or if students will bring in the water samples on the day-of.*

***Some parameters will need to be tested in the field, while for others, water samples can be collected and then refrigerated until further testing can be completed (ideally, the next day).*

Materials & Preparation:

- Choose which water quality parameters you will test with your class. If necessary, order a water quality testing kit (for ideas, refer to **Resources:** "Choosing a Test Kit" (p.55-56)
- Community Water Map (if completed) OR small-scale map of community
- (BLM 2.6) Conducting Water Quality Sampling (1 per pair, double-sided)
- Removable sticky notes
- (BLM 2.7) What's in the Water? Student Recording Sheet (1 per pair)
- (BLM 2.8) Teacher Backgrounder: What's in the Water? (1 for teacher)

- (BLM 2.9) Student Field Trip Checklist (1 per student, or place list on overhead/ board for students to copy down)
- **Sampling equipment:** non-latex medical gloves (1 pair per student); small, empty plastic water bottles (~4 per pair, to collect samples if bringing back from the field); clipboard + pencil (1 per pair) + (BLM 2.7) recording sheets; water sampling device (ideas: yardstick with large plastic cup taped to bottom; bucket with rope that students can work in pairs to lower into the water); 1-L plastic bottle with tight-fitting lid for collecting water tested in the field, labeled ‘Waste’
 - Note: Water you have added chemicals to for testing should not be put back into the environment!
- **Safety equipment:** emergency contact numbers for students, first aid kit, sunscreen, bug spray, cell phone, hand sanitizer, garbage bag (for used gloves, test strips, etc.)
- **Lab safety equipment** (lab coats, goggles): enough for all students, especially if using water quality testing materials that require use of chemical reagents*
 - Note: You should review with students the concept of ‘whiff’ testing when working with chemicals and reactions.

Engagement Strategy:

- Explain to students that the next ‘*piece of the puzzle*’ is to actually find out about water quality in the local community using scientific sampling and testing procedures
- Distribute (BLM 2.6) Conducting Water Quality Sampling (1 per pair)
- In pairs, have students brainstorm ideas for where to collect their water samples:

<u>Procedure:</u> If completed “Community Water Map”	<u>Procedure:</u> If <u>not</u> completed “Community Water Map”
<ul style="list-style-type: none"> • Referring back to the mapping activity, where would students choose to take water samples? • <i>Hint: Any concerns related to land uses/ practices in the immediate area?</i> • Have students plot out potential sample locations on the map using removable sticky notes 	<ul style="list-style-type: none"> • If possible, do a walk-around the community. As a class, discuss potential impacts to water quality in different locations • <i>Hint: Any concerns related to land uses/ practices in the immediate area?</i> • If not possible to do a walk-around, for homework, have students brainstorm 2-3 places in the community where water sampling could be conducted • Mark locations on small-scale map of community

- Have students justify their sample location suggestions by **making predictions** about what water quality concerns there might be in these areas. As a follow-up to this, have students refer back to (BLM 2.2) Student Guide: Water Quality Parameters, and choose which parameters are most important to test the water sample for. Have students record all of this information on (BLM 2.6) Conducting Water Quality Sampling
 - **Note:** Prior to this, consider the water quality test kit students will be working with, and inform them of any limitations with respect to parameters they might be able to test.
- By this point, students should have completed filling in (BLM 2.6), questions 1-3.

- As a class:
 - Put together the list of locations in the community you *could* sample in (mark these on a map, or your Community Water Map, if applicable).
 - Discuss the logistics of sampling some of these locations. If going out as a class (as opposed to having students conduct the sampling themselves, as pairs, for homework), it may only be possible to test in one location in the community. Discuss the pros and cons of this. Come to a consensus on *where* to conduct the sampling as a large group.*
 - Prepare yourself (*BLM 2.8*) and students (*BLM 2.9*) for the field trip.

**Teacher's note:* One alternative to a field trip would be to assign students to work in pairs to collect water quality samples in several of the locations identified. This would involve taking the same precautions with students as if you were taking them on a field trip, including proper parental permissions. You would also want to take students out somewhere locally to model exactly what it is they would be doing on their own in the field.

Teaching Strategy:

- Return students to (*BLM 2.6*) Conducting Water Quality Sampling, question 4
- Have students go through a brainstorming process for *how* they're going to collect the water samples (*i.e.*, procedure).
 - What materials might you need to complete water sampling in the field? Make a list.
 - Decide on an appropriate number of water samples to collect. Discuss why it might be important to collect more than one sample:
 - (1) to make sure you get a fair representation of the quality of water at that location; (2) to check water quality testing accuracy (since water samples from the same locations should show similar results)
 - You may also want to discuss the concept of a "control" sample with students (*i.e.*, a sample of known composition that ensures WQ testing is accurate)
 - Encourage students to think about *other* parameters that might influence water quality results, such as: amount of recent rainfall, cleanliness of sampling materials, *etc.*
 - Are there any special considerations for water sampling at particular sites? (*e.g.*, Is the water fast-moving? Does special permission need to be obtained to access private property?)

Sampling:

- Before handing out the testing equipment, and working in pairs, have students fill out (*BLM 2.7*) What's in the Water? Student Recording Sheet (p.1)
- Model the proper procedure for water sampling with students (this will depend a little on your sampling site and the materials you are using). Refer to the **Materials & Preparation** section for information on equipment and options for sampling.
- Have students conduct water quality sampling in pairs. Results from any water tests done in the field should be recorded on (*BLM 2.7*) What's in the Water? Student Recording

Sheet (p.2). Students should not return any water to the site if they have had to add anything to it to test for a water quality parameter. Show students how to dispose of this water in another container.

- **Note:* Some water quality tests will need to be conducted in the field or back in the lab. Refer to the resource material that came with your testing kit. Check to see which parameters can be tested the day after sampling, and refrigerate.

Testing:

- Explain testing procedures to students as per the kit (or your own), instructions.* Some educational kits will provide you with a structure for how to go about splitting up the test procedures amongst groups of students. They will also indicate how long each test takes, as well as any special considerations with chemical reagents that are to be used.

** Many water quality test kits, especially those ordered from educational institutions/ companies, will come with their own lesson plans. Non-educational kits will have a manual of instructions for conducting the tests, which may or may not be user-friendly for students.*

- Have students record their test data on (BLM 2.7), p.2
- ***Note 1:*** Students may need to research “acceptable standards” for some of the parameters they are testing for. Have students consider what the standards indicate (e.g., Is it a standard for maintaining ecosystem health? Being able to swim in the water? Being able to *drink* the water?)
- ***Note 2:*** It cannot be overstated how important it is to be clean and careful while doing all of these tests. Although the educational water quality test kits are designed to be safe for students to use, whenever working with any amount of chemicals, lab safety precautions must be practiced. Please ensure that students wear lab coats, goggles and gloves when handling kit materials and samples.
- After students have carried out the testing and recorded the data, have them review their results. Do they make sense (knowing what they do about standards)? Did the results match up with their predictions? Refer them back to (BLM 2.6) Conducting Water Quality Sampling.
- Have student groups compare their results with that of their classmates. Were there any discrepancies? What might have happened? Have students problem-solve any issues that came up during the sampling and/or testing (i.e., What happened? What could have been done differently?)

Assessment:

- Collect (BLM 2.6) Conducting Water Quality Sampling for marking (does it show critical thinking skills/ well thought-out responses?)
- Collect (BLM 2.7) What’s in the Water? Student Recording Sheet (Is it complete? Does it show attention to detail?)
- Have students self-assess their contribution to group procedures during field testing
- Assess students’ behaviour and attention to the task during field testing

Differentiated Instruction:

- This whole activity (water quality sampling) relies a lot on worksheets to record data and information, which is an important scientific research skill. However, it may prove difficult for some learners. There is the option to complete most worksheets with the whole class or in small groups/ pairs (in order to support these learners). It is a lot of new information to synthesize for any student!
- Consider how best to provide instruction on water quality sampling procedures for exceptional learners (e.g., one-on-one, before going out into the field)

Extension: Macroinvertebrate Sampling

“Macroinvertebrates can be used to assess the health of aquatic ecosystems by looking at populations and biodiversity”

It is sometimes possible to assess relative water quality by sight or smell, but as we now know, not all pollutants can be seen. Macroinvertebrates (organisms that lack an internal skeleton and which are large enough to be seen with the naked eye) can be used to assess the health of aquatic ecosystems by looking at populations and biodiversity. Various landuse activities can affect macroinvertebrate populations, particularly things like sewage and fertilizers that deplete oxygen in water bodies. Increased erosion (due to removal of vegetation) can also create sedimentation that destroys rocky habitat for macroinvertebrates. In addition, alteration of stream habitats can influence water velocity, which in turn can have an affect on temperature. Some organisms rely on specific temperatures to regulate their life cycles.

There are macroinvertebrate species that are intolerant of pollutants in an aquatic ecosystem (e.g., mayfly, caddisfly larvae, and midge larvae). Still others are considered “tolerant” species, a higher presence of which, relative to the intolerant species, may indicate poor water quality.

If you are interested in pursuing this type of water quality evaluation with your students, refer to the following resources for more information:

- Streamside Science <<http://www.uen.org/Lessonplan/preview.cgi?LPid=28883>>
- Changing Currents (EcoSpark) <<http://www.ecospark.ca/changingcurrents>>

Resources: “Choosing a Test Kit”

Questions to consider when choosing a kit for water quality testing with your students:

- How much does the kit cost*? Where does it ship from? Is there a hazardous materials shipping fee?
- How many students can complete the testing?
- How long do the contents last (*i.e.*, If you buy 100 tests for each parameter, will you be able to use these over multiple years?)
- What testing method** does the kit use? Is it what you want? What skills are involved? Do your students have these skills? Do you want to teach them?
- Which parameters do the kits test for? Does this cover your learning objectives for students with this activity?
- Do the tests come with accompanying educational lesson plans? A student-friendly manual of instructions for completing the tests?

**Cost is sometimes a large barrier for completing water quality testing with students. If you are new to trying this out with your class, consult with other teachers in your school who may have already gone through the process of ordering materials. They may already have some you can use, or can point you in the direction of a cost-effective and comprehensive kit.*

***There are different testing methods offered in different kits (*e.g.*, titrations VS. test strips). Consider carefully the skill level and maturity of your group before undertaking water testing, as well as the desired learning and time available.*

There are many programs and companies out there that sell “educational kits” for measuring water quality. Many of these kits are tailored toward specific types of sampling—*e.g.*, surface water, drinking water, water ecology, stream survey, *etc.* Some kits have been reviewed, below, and a matrix has been created indicating *which* parameters they test for. Recommended kits (to review in more detail) are indicated as well. Cost comparisons have not been done.

Water Test Kits: Matrix Key *Recommended kits

1. Lamotte: Water Quality Educator and Monitoring Outfit*
2. Lamotte: Water Pollution Introductory Kit (+ chromium, cyanide, salinity, sulfide)
3. Lamotte: Water Pollution 1 – Water Monitoring Kit*
4. Lamotte: Water Pollution 2 (Supplement to #1)
5. Lamotte: GREEN Advanced Water Monitoring Kit*
6. Lamotte: GREEN Low-Cost/ Standard Water Monitoring Kit
7. Lamotte: Urban Water Test Kit
8. Lamotte: Teach Water Test Strip Kit (+ nitrite)
9. Safe Drinking Water Foundation: Operation Water Drop (high school kit)* (+ arsenic, manganese, sulphate)
10. Safe Drinking Water Foundation: Operation Water Drop (high school kit) (+ sulphate)
11. HACH: Education Test Kit, Water Ecology
12. HACH: Just Add Water Education Kit, Pond & Stream
13. HACH: Just Add Water Education Kit, Drinking Water
14. HACH: Stream Survey Test Kit
15. HACH: Surface Water Test Kit*

Water Test Kits (Matrix)

**Parameters that are known to correlate directly with the health of a river, stream, or creek*

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Colour				X					X	X					
Temperature*	X		X		X	X	X							X	X
Turbidity	X			X	X	X									
Dissolved solids		X													
pH*	X	X	X		X	X	X	X	X		X	X	X	X	X
Ammonia*		X	X						X	X				X	X
Nitrogen/ nitrate*	X	X	X		X	X	X	X	X			X		X	X
Phosphate*	X	X	X		X	X	X					X		X	X
Dissolved oxygen*	X		X		X	X					X			X	X
Biological oxygen demand						X									
Carbon dioxide		X		X							X				
Alkalinity	X	X		X				X	X	X	X	X			
Hardness		X		X			X	X	X	X	X		X		
Coliform bacteria						X			X						
Chlorine		X	X				X	X	X	X			X		X
Chloride		X		X											
Copper		X					X	X	X	X			X		
Iron		X					X	X	X						

Note: HACH educational test kits tend to be more technical (using titrations and colorimetry), but not beyond students' abilities. They also include materials to complete the tests multiple times. One downside is that there doesn't appear to be lesson plans, only manuals on how to complete the analyses.

Other places to try for water testing materials: [HANNA Instruments](#), [Ben Meadows](#)

Also check out: www.worldwatermonitoringday.org

For more information on water quality testing, try the following resources in your community:

- Is there an **Ontario Conservation Authority** in your region?
 - Search: "Ontario Conservation Authority map."
 - Based on where you are located, figure out who your local Conservation Authority is (if any).
- Are there any **local not-for-profit environmental groups** in your area?
 - They may be able to provide you with equipment, expertise, and/or a sampling location
 - Some run school-based programs designed to introduce students to water quality sampling
 - E.g., Changing Currents: www.ecospark.ca/changingcurrents

(BLM 2.6) Conducting Water Quality Sampling (p. 1 of 2)

Group: _____

1. Where do you think we should collect water samples in our community?

- List general places—such as: puddles, lakes, *etc.*

- List specific places—such as: the creek behind our school

(1)
(2)
(3)

2. What types of water quality results might we expect in these locations?

Location (describe)	<u>Prediction of Result</u> (i.e., What WQ problems might we expect to see, if any? Why?)
(1)	
(2)	
(3)	

(BLM 2.6) Conducting Water Quality Sampling (p. 2 of 2)

3. Considering your answers above, refer back to *(BLM 2.2) Student Guide—Water Quality Parameters*. Which parameters will you want to test the sample for?

Location (as described above)	Parameters to test:
(1)	
(2)	
(3)	

4. Sampling Procedure

Materials needed:

How many samples at each location? _____ ***Why?*** _____

Considerations? (i.e., list special sampling instructions for any site)

(BLM 2.7) – What’s in the Water? Student Recording Sheet (p. 1 of 2)

Name(s): _____

Date: _____

Location of water sample: _____

Site Observations:

1. Type of water sample (*e.g.*, stream, lake, wetland, drainage collector/ ditch, puddle, *etc.*):

2a. Weather today (*e.g.*, sunny/cloudy/rainy): _____

2b. Weather yesterday: _____

3. Air temperature (°C): _____

4. Is the water source shaded (yes/ no/ partially)? _____

5. Water appearance (*e.g.*, clear, blue-green, foamy, oily, weedy, *etc.*):

6. What type of land uses are in the immediate area (right next to the water source)? Upstream?
E.g., urban (city/ streets), industrial (factory), residential (houses), agricultural (farm),
woodlands, swamp, *etc.*

(a) *Right beside:* _____

(b) *Upstream:* _____

7. Did you make any other observations that might be important to interpreting water quality
(*e.g.*, Are there any unusual smells? Are there any other, noticeable human activities that may be
positively or negatively affecting the waterway? Describe.). If none, write “N/A” below.

8. Were there any changes to the sampling procedure? Describe. Why were changes made?

(BLM 2.7) – What’s in the Water? Student Recording Sheet (p. 2 of 2)

**Note:* This BLM provides an example of what a field recording sheet *could* look like. Students would fill in the columns according to the parameters the class is testing. You may wish to make your own recording sheet for students which reflects these parameters. You can have students research the “standard” or provide this yourself.

There is always natural variability in ecosystems. When we take measurements, we also introduce some variability due to differences in observers (eye sight, experience) and limitations of the equipment. Therefore, we will also include a class average for the data collected (when possible).

RESULTS:

Water Quality Parameter	My group’s measurement	Unit	Class average (if applicable)	Standard*
Temperature		°C		<18 °C (optimal range for most aquatic life in streams) 12-14 °C (optimal range for salmon)
Turbidity		NTU		5 NTU is best, higher number reflects higher than average turbidity
pH				6.0 - 8.5
Dissolved oxygen		mg/L		8.0 mg/L

(BLM 2.8) Teacher Backgrounder: What's in the Water? (p.1 of 2)

Pre-Field Trip Preparation Checklist*

**Taken with permission from "Testing Water Quality: Teacher Guide" prepared by the Ontario Society for Environmental Educators (with support from the Ontario Teachers Federation)
Gr.7/8 cross-curricular resource "Water, Water Everywhere"*

- Choose a site within walking distance. Book transportation if walking is not possible.
- Try to recruit a colleague to join you and bring their class on the field trip.
- Complete the required field trip forms. Some school boards have a special form for "high risk" field trips and being near water is a risk factor.
- Remember, there are often students who cannot afford a field trip, so ensure you have a way to cover their field trip costs without embarrassment.
- Be sure to include the following items on the parent permission form: hat, gloves, raingear, camera, mitts, long warm pants, coat, sunscreen, bug repellent, pencil.
- Recruit parents or other responsible adults like a pre-service teacher. Try to have them join you when visiting the site.
- Visit the stream, river or lake ahead of time and assess the site for safety. Water samples can be scooped out with a bucket on a rope or plastic cups duct taped to a meter stick. This keeps students back from the edge and protects the shoreline.
- Perform all the tests yourself onsite. Often it is best to carry the water sample away from the edge of the water to do the tests. Remember students will need a clipboard for recording data. This will also keep papers from blowing away. Depending on your water kit, you may not be able to do some tests on-site.
- Arrange coverage, if required, for your other classes. Notify other teachers that may be affected by your departure from the school.
- Ensure that students with allergies bring an EpiPen or Benadryl.
- Bring a first aid kit with band-aids, antiseptic cream, sunscreen and bug spray just in case.
- Plan for safety. Carry a cell phone for emergencies. All students must wear gloves so you need to bring a garbage bag. A bottle of hand sanitizer is recommended as well as strict orders to kids when arriving back at school to **wash their hands**.
- Plan for waste disposal. Have a large plastic bottle for collecting the tested water. Do not put this back into the environment. Check with your Board for chemical waste disposal procedures.
- Bring good humour!! This trip should be fun for everyone. More important than any water testing results is a sense of enjoyment from being outside.

Student Recording Sheet—Teacher Information

Page 1 of What's in the Water? Student Recording Sheet (BLM 2.6) will guide students through making initial site observations & assessments of water quality

1. Water source: Relevant for assessing both quantitative (water quality test results) & qualitative information (e.g., smell, color) gathered by students. Consider nearby land-uses and whether the water is moving or stagnant.

2/3. Weather/ temperature: Recent weather activity can help explain other factors observed (e.g., heat might increase growth of weeds/algae, the decomposition process, and smell; rain may result in recent contamination events by washing surface water from roads and lawns into waterways OR, may dilute waterways so testing results do not give an accurate picture of water quality, etc.)

(BLM 2.8) Teacher Backgrounder: What's in the Water? (p.2 of 2)

4. Shading: Can affect water temperature (see #2/3)

5. Water appearance:

Clear—Water is free of extra detritus/ sediments (which may indicate erosion problems near water, or someplace upstream); water has few weeds/algae, and so is likely not experiencing any excess nutrient problems.

Foamy—Most foam is natural and does not indicate pollution: when plants and animals decompose they release organic compounds that decrease the surface tension of water and create bubbles (*i.e.*, foam). If there is a waste discharge pipe nearby, and/or the foam smells perfumey and is hard to break apart, this may indicate pollution.

Oily sheen on surface—Usually from bacteria that use iron (red film) or manganese (black film). The breakdown of organic matter (plant and animal material) can also leave an oily sheen on the water. In some cases, a sheen can indicate road pollution (oil or gas). Poke the sheen with a stick—if it swirls back to together instead of dispersing, it's most likely a petroleum product.

Green or blue scum/ film on surface—Could indicate a bloom of blue-green algae (not really algae but a group of organisms called cyanobacteria). Lots of algae in the water can also make it look green. Excess algae or cyanobacteria growth is usually due to an excess of nutrients such as phosphates or nitrates, which indicates pollution (sometimes related to septic systems, sewage overflow from municipal plants, or local agricultural activity—such as runoff from a manure pile or cattle being allowed to access waterways directly)

6. Nearby or upstream land-uses can affect water quality:

Urban (city/ streets)—contamination from surface water run-off may be a problem, including: oil/gas from cars, animal waste, pesticides/herbicides, *etc.*

Industrial (factory)—can influence water temperature (if water from plant cooling re-enters waterway), as well as potential pollution if plant effluent is discharged into local water systems

Residential (houses)—concerns similar to “urban,” above

Agricultural (farm)—concerns around nutrient overloading to waterways (if animal waste or fertilizer application isn't managed properly); also, pesticide/herbicide contamination

Woodlands, swamp—natural areas provide a buffer, and allow water to be soaked up and purified by the soil before entering a nearby waterway and causing contamination events. Wetlands/ swamps also provide a natural means of purifying water; as a result, if water can be “held” in a wetland long enough, it can be purified of contaminants before being released into neighbouring water sources

7. Smell: Common constituents and pollutants in water often have characteristic appearances and smells that provide an initial determination of water quality.

Other human activities: This could include seeing discharge pipes, open sewers, or drainage ditches (for surface water run-off) in the area.

8. Changes to Sampling Procedure: It is important that students note changes to initial sampling procedure, as any changes could influence water quality results. For example:

- If students are not able to sample in flowing water, this should be noted because stagnant water may be more likely to show signs of pollution, due to lack of flush-through.
- If students forget to rinse their sample bottle 3 times in the sampling water, this might also influence results if there are contaminants remaining in the bottle.

(BLM 2.9) What's in the Water:

Student Field Trip Checklist

**Taken with permission from "Testing Water Quality: Teacher Guide" prepared by the Ontario Society for Environmental Educators (with support from the Ontario Teachers Federation)
Gr.7/8 cross-curricular resource "Water, Water Everywhere"*

- Pencil (not a pen, because ink runs if it gets wet in the rain)
- Hat
- Gloves
- Warm coat or jacket
- Raincoat or umbrella
- Sunscreen
- Bug repellent
- Long pants
- Rubber boots or running shoes, no sandals
- EpiPen or allergy medicine if you have allergies
- Refillable bottle of water
- Backpack to carry all your stuff
- Good behaviour

Part II: Interpreting the Results

Learning Goal: To interpret water quality results from student water quality field testing.

Description: Through research on water quality standards, students will determine which of their results show areas for concern. Using their knowledge of the watershed and of water quality parameters, students will interpret their test results and make preliminary conclusions about the data.

Time required: 1-2 class periods (65-70 min)

Materials & Preparation:

- (BLM 2.2) Student Guide: Water Quality Parameters may serve as a guide for some test results
- Water quality test kit manual and/or accompanying lesson plan(s)
- Contact information for local Conservation Authority (if applicable)

Engagement Strategy:

- Have students transfer their recorded test results (BLM 2.7) to a class chart on the blackboard/ whiteboard/ SMART board. Make sure students record the result for the parameter under the proper heading and sample location. The class recording chart might look something like this:

Parameter	Results: <i>Location 1</i>			Average
	<i>Group 1</i>	<i>Group 2</i>	<i>Group 3</i>	
Temperature				
Dissolved oxygen				
pH				

- Divvy up the task of calculating the class average for the test results recorded at each location
- **Note:** If students have completed the Community Water Map, you can plot the water quality results directly onto the map. This might help to better visualize where potential impacts are occurring, and why.
- Discuss with students whether they found any of the results surprising—why? Circle the results you want to explore further as a class.

Teaching Strategy:

- Refer students back to the sheet (BLM 2.7) where they recorded site observations for each of their samples. Can any of this information help to explain the results? Discuss.
 - ***Note:** Refer to (BLM 2.8) to give you background information to help students
- If students have not done any research on water quality standards, yet, they may want to investigate to see if some of the results fall outside of acceptable standards. Keep in mind there are different standards depending on the water use (e.g., swimming vs. drinking). As a starting point, refer to the resource materials that came with the water testing kit.
- In addition to referring students back to site observations and the Community Water Map, you can also refer them to the Community Water Profiles (compiled by the Polaris Institute as a companion to this resource). They can be found, listed by County, at <http://www.polarisinstitute.org/education>
- Have students communicate their findings on the health of the water that was sampled. Some ideas are:

- Create a newscast where students present a 2-3 min “breaking bulletin” on the latest community water quality test results
- Write and submit a letter to the editor to the local newspaper about the class project, results found, and any other information you want the public to consider in light of your findings
- Add data and findings to the Community Water Map or present them in some other visual way at a school- or community-wide open house event

Assessment:

- Class discussion:
 - Did students submit their water quality data to the class average? (If not, why?)
 - Did students participate? How well did they synthesize learning? Evaluate critical thinking skills with respect to water quality test results and interpretation
- Communicating the results
 - Evaluate student learning through their chosen communication medium (*e.g.*, newscast, letter to the editor, open-house information session, *etc.*)

Differentiated Instruction: Allow students to work in pairs or small groups for communicating their water quality findings (as outlined above.)

Extension: Groundwater

Much of the content of this resource has focused on determining the quality of surface water sources, rather than groundwater. If we get our water from municipal treatment facilities, we can be fairly confident that the quality of our tap water is being monitored for us, and treated accordingly. However, as we learned in the “Community Water Map” activity, ground and surface water sources are closely connected. Not to mention, those who get their water from private wells are responsible for monitoring their own water quality. According to one source, well water should be tested a minimum of twice per year!

In this activity, we are primarily testing surface waters to get an idea of overall ecosystem sustainability and health. If students opt to test tap water as part of their sampling procedure, the parameters they choose to test for may be slightly different. Refer to the matrix under Resources: “Choosing a Test Kit” to compare kits designed for testing surface waters VS. kits to test drinking water quality.

Sources for further information:

- Contact Public Health Ontario about testing your well water for bacterial contamination
- Local Public Health Units can also provide information on keeping drinking water safe
- Ontario Ministry of the Environment: Information on well regulations
<<http://www.ene.gov.on.ca/environment/en/subject/wells/index.htm>>
- Well Aware (Green Communities Canada): Program for enhancing public knowledge of well water safety <<http://www.wellaware.ca>>

Resources:

- *Canada National Drinking Water Guidelines* - <http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php>
- *Ontario Drinking Water Standards* - http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079707.pdf

Post-Activity: Protecting & Restoring Water Quality

The main goal of this section is to develop an understanding of the various tools, measures, and organizations/ institutions available to help (a) protect; and (b) restore, water quality.

Part I: Revisiting “So-What?” Scenarios

Learning Goal: Propose ways to protect and/or restore water quality

Description: Students are asked to revisit the scenarios from *Water we Looking For? (Pre-Activity, Part II)*. Through basic research and application of critical thinking skills, students will outline protection/ mitigation/ restoration measures for the water quality impacts present in a scenario of their choice.

Time required (varies, depending on the amount of research students will undertake):

- *Minimum:* One class period (65-70 min) to discuss as group (no research)
- *Maximum:* One class period (65-70 min) per week over 4 weeks (research)
 - 2 periods in the computer lab to enable students to research water quality protection/ restoration
 - 2 periods for students to put together a “scientific briefing” on water quality protection or restoration measures based on their scenario/ impact of choice

Materials & Preparation:

- If choosing to make this a more in-depth research activity, book a 1-hr session in the computer lab over a consecutive 2-week period
- Completed “So-What Scenario” student worksheets (*BLM 2.3*)—one per group of 2-4 students
- Completed “Water Quality Learning Chart” (*BLM 2.5*)—one per student
- (*BLM 2.10*) Research Recording Sheet (1 per group or student)

Engagement Strategy:

- Engage students in a discussion of whose responsibility it is to protect/ restore water quality. Consider the scenarios. This discussion will allow you to gauge how much students have thought about the topic. Refer to the Teacher Background Information on p.78 for your own knowledge, and to help point students along the way in their research project.
 - **Note:* The Community Water Profiles compiled as a companion to this resource also provide some useful information in this regard (<www.polarisinstitute.org/education>)
- With students, establish the difference between **protecting** and **restoring** water resources. Ask students to give you examples of activities that might fall under each category (e.g., protection = leaving a “buffer” of trees 10-m wide next to all waterways; restoring = installing digger logs to restore stream flow after an alteration has occurred).
 - **Protection:** *How could the impact have been prevented? If not preventable, what could have been done to lessen the impact?*
 - **Restoration:** *What can be done now that the impact has already occurred?*

Teaching Strategy:

- Have students get back into their group of 2-4 (from the initial examination & presentation of the “So-What” scenarios)
- Explain to students that they will be revisiting the scenarios they examined earlier when first learning about water quality parameters
- As a group, they should choose *one example* from their scenario of a human activity that had a negative impact on water quality.
- Students’ task will be to identify the following:
 - Effect(s) on water quality
 - Are the effects temporary? Long-term? How easy will water quality be to restore? What factors must be considered?
 - What were the impacts to the ecosystem?
 - Why was the activity taking place (if applicable)?
 - *E.g.*, Land being cleared for development
 - Could the impact have been prevented/ lessened? How?
 - Recommendations for future (protection/ restoration measures)
- Students will prepare a short (1-page) “scientific briefing” about water quality & human impacts, and measures identified for protecting/ restoring the ecosystem. The report should include all of the above components.

Assessment: As a class, determine the “success criteria” for this task; mark students’ scientific briefings (students to submit paper copy or present to small groups/ class).

Differentiated Instruction: Provide alternate forms of assessing learning, as needed/ appropriate.

Extension: Have students choose a human activity that has a negative impact on water quality (that was not presented in the scenarios). Have students contrast this with a human activity that might have a positive impact on water quality.

Part II: Ask an Expert

Learning Goal: To further understanding of local water realities by interviewing an expert.

Description: Students work in teams to develop questions for an “expert” about local water sources, impacts to water quality, and potential protection and/or restoration measures.

Time required: One class period (65-70min) per week, over 4 weeks

Materials & Preparation:

- Water quality testing results & interpretation/ conclusions

Teaching Strategy:

- **1st period:**
 - Prepare a list of the largest impacts to water quality in your community, based on the class' findings and interpretations. If applicable (and not already done), plot where these impacts are occurring on the Community Water Map.
 - Brainstorm ways to gather more information about the extent of these impacts within the local watershed (*i.e.*, web research, interviewing individuals from the Conservation Authority/ local environmental groups, *etc.*)
- **2nd period:** If students were going to interview an expert on the subject of these, or other common impacts to water quality in the community, what questions would they have? Ask them to draft a few questions and share them in a group. Have the group pick out their three best questions to share with the class.

Some ideas for questions include:

1. What are the top three water issues you deal with?
 2. How are you/ your organization responsible for maintaining water quality?
 3. What protection/ restoration activities are you involved in, through your work in the watershed?
 4. Are there any special considerations with these activities (*e.g.*, cost, time, effectiveness, further impacts, *etc.*)
- **3rd period:** Bring in an expert to answer student questions about local water and managing water quality. This could be someone from: the municipality (who deals in water management); the Conservation Authority; a non-profit group doing watershed protection & restoration work; or possibly the regional Public Health Unit. Refer to the **Where to Start?** sections in (*BLM 1.0, Section I*) for more information on possible points of contact.
 - **4th period:** Have students write a journal entry reflecting on the following:
 - What they've learned about water quality within their community (1-2 pts)
 - What they see as the greatest threats to water quality, locally (2-3 pts)
 - Ways to address these threats, and how effective these solutions are (give one example, and examine its pros/cons)

Assessment:

- Interview questions
- Engagement in expert visit (*e.g.*, asking questions)
- Journal reflection

Differentiated Instruction: Provide students with a different means for asking their “expert questions” (*e.g.*, via email, Skype or instant chatting). Adapt other assessment measures as needed.

Extension: Have students incorporate new learning from the expert visit into their cumulating activity in *Part II: Interpreting the Results*.

(BLM 2.10) Protecting & Restoring Water Quality:

Student Research Sheet

Using the information gathered below, write a “scientific briefing” outlining the effects of one human activity on water quality and/or the health of the ecosystem.

Describe and discuss at least one action that can be taken in future to protect or restore water quality (from this impact).

You will likely need more room to write. Attach an extra sheet to this one, or continue writing on the back. Try to write at least 2-3 sentences for each research point.

	Notes
Human activity which caused impact	
Effect(s) on water quality? <i>i.e., what do test results show?</i>	<u>Hint</u> —Refer to Student Guide: Water Quality Parameters
Impacts to the ecosystem? <i>Short term? Long term?</i>	<u>Hint</u> —Refer to Student Guide: Water Quality Parameters
Reason for activity? <i>i.e., why was it happening in the first place?</i>	
Could the impact have been prevented/lessened ? How?	Try to think beyond “don’t continue the activity.” If this isn’t a possibility, how could things be done <i>differently</i> to <u>prevent</u> or <u>lessen</u> the ecosystem impact?
Recommendations for future (protection/restoration measures)	Expand on information from the previous question:

Appendix A: Curriculum Expectations

Science (Gr.9), SNC1D – academic

Strand A: Scientific Investigation Skills

A. Demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating)

Strand B: Biology – Sustainable Ecosystems

B1: Assess the impact of human activities on the sustainability of terrestrial and/or aquatic ecosystems, and evaluate the effectiveness of courses of action intended to remedy or mitigate negative impacts;

B2: Investigate factors related to human activity that affect terrestrial and aquatic ecosystems, and explain how they affect the sustainability of these ecosystems;

B3: Demonstrate an understanding of the dynamic nature of ecosystems, particularly in terms of ecological balance and the impact of human activity on the sustainability of terrestrial and aquatic ecosystems

Science (Gr.9), SNC1P – applied

Strand A: Scientific Investigation Skills

A. Demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating)

Strand B: Biology – Sustainable Ecosystems

B1: Analyse the impact of human activity on terrestrial or aquatic ecosystems, and assess the effectiveness of selected initiatives related to environmental sustainability;

B2: Investigate some factors related to human activity that affect terrestrial or aquatic ecosystems, and describe the consequences that these factors have for the sustainability of these ecosystems;

B3: Demonstrate an understanding of characteristics of terrestrial and aquatic ecosystems, the interdependence within and between ecosystems, and the impact humans have on the sustainability of these ecosystems

Environmental Science (Gr.11), SVN3M – university/college preparation

Strand B: Scientific Solutions to Contemporary Environmental Challenges

B2: Investigate a range of perspectives that have contributed to scientific knowledge about the environment, and how scientific knowledge and procedures are applied to address contemporary environmental problems

Strand C: Human Health & the Environment

C2: Investigate environmental factors that can affect human health, and analyse related data

Environmental Science (Gr.11), SVN3E – workplace preparation

Strand B: Human Impact on the Environment

B2: Investigate air, soil, and water quality in natural and disturbed environments, using appropriate technology

B3: Demonstrate an understanding of some of the ways in which human activities affect the environment and how the impact of those activities is measured and monitored

Strand C: Human Health & the Environment

C3: Demonstrate an understanding of the ways in which environmental factors can affect human health

Strand E: Natural Resource Science & Management

E3: Demonstrate an understanding of the sustainable use of resources and its relationship to the biodiversity and sustainability of ecosystems

Note re: curriculum

Although designed to meet expectations from the Gr.9 Science: Biology, *Sustainable Ecosystems* strand of the Ontario secondary school curriculum (2008), this resource may also provide useful activities for geography courses (see Activity __: Community Water Map), as well as Gr.11 Environmental Science.

This package was designed as a progression of learning activities that build on one another, but activities can also be taken and used as stand-alone resources.

Appendix B: Engaging Students in Action Projects

There are several good reasons for engaging your students in action projects. For example:

- They cater to different learning styles (because they are experiential in nature)
- They offer relevant and meaningful learning opportunities (which is motivating for students)
- These projects allow students to relate to the trans-disciplinary nature of real-world issues, and encourage holistic thinking and problem-solving¹

Learning for a Sustainable Future (LSF) has created a guide for educators entitled: “Engaging Students in Sustainable Action Projects.” It can be accessed via LSF’s *Resources for Rethinking* website: <<http://resources4rethinking.ca/en/professional-development/resources>>. The document outlines 12 steps for facilitating the creation of meaningful action projects with your students.

One of these steps outlines how to **facilitate choosing a project idea** with students. The guide also makes available a 9-page **Project Planning Template**, which takes students through a step-by-step thought process for designing the most effective action project (using their initial project idea). Another step in the guide addresses **building motivation** for student engagement in the project. It involves exercises for exploring the diverse reasons for students to care about something, as well as activities for exploring the difference between emotional and rational responses to an issue.

There are various types of action projects students can engage in. Some examples include:

- Projects to **educate and inform** (often with the intent to **persuade others** to initiate change)
- Projects for **political or civic action** (and/or to **influence policy**)
- Projects that **support the needs of organizations** (already working for change)

Common Types of Action Projects

Educate/ inform/ persuade

- Awareness campaigns (*e.g.*, posters/ pamphlets, videos, public service announcements, advertisements, school fairs, *etc.*)
- Community education programs (*e.g.*, workshops, presentations, special events, *etc.*)
- Written communication (*e.g.*, newspaper articles, letters to the editor, short stories, poems, *etc.*)
- Oral communication (*e.g.*, plays, street theatre, public debates, mock town halls, *etc.*)

Political/ civic action & public policy

- Meeting with elected officials
- Speaking at public meetings or hearings (*e.g.*, making presentations to city hall or town council)
- Circulating petitions
- Supporting political candidates (*e.g.*, volunteering with a campaign)
- Engaging in peaceful dissent (*e.g.*, parades with protest signs, gatherings in public places [with a permit], *etc.*)

Supporting “change-maker” organizations

- Assisting with community clean-ups
- Engaging in citizen science monitoring projects
- Beautification projects (*e.g.*, tree plantings, public space naturalizations)

¹ Burgess, Terry. (2003). *Engaging Students in Sustainable Action Projects*. Learning for a Sustainable Future <<http://resources4rethinking.ca/en/professional-development/resources>>

Appendix C: Teacher Background Information

Water Quality Testing

Water quality is evaluated by looking at the physical, chemical and biological characteristics of water. Although these parameters can be influenced by naturally occurring factors in the environment, water quality is also affected by how the surrounding land is used by humans—almost everything we do on land impacts water. The mapping activity in *Part I* was intended to demonstrate this close relationship between land and water, as well as the connectivity of water sources within a community (and watershed).

Water quality may be tested for many different things, in many ways, and for many reasons. For example, water managers may test water quality to ensure its safety for human consumption or for recreational purposes, such as swimming. Ensuring that water remains fit for drinking might mean anything from monitoring source waters (such as a lake or aquifer) for contaminants, to testing and treatment of water within a municipal distribution facility.

Before testing local water quality in your area, students will need to define:

- (1) *Reason* for water quality testing (*i.e.*, what do we want to ensure it is safe for?)
- (2) *Where* the samples should be taken from, & how many (to obtain accurate results)?
- (3) *Which* water quality parameters to test for*

***The parameters students choose to test the water for may depend on the following:**

- Reason for water quality testing
 - The standards we compare results against will vary based on the water use (*e.g.*, drinking water will have a higher standard than water used for recreation)
- Historical water quality data (if available)
 - For example: Do past results show particular cause for concern? If so, with which parameters?
- Potential impacts of land use on water quality
 - Based on observations of land uses/ practices within the watershed, are there any particular parameters (or contaminants) that may be of concern? *E.g.*, water body is surrounded by agricultural land, so nutrient contamination and pesticides may be of particular concern.

It is also important that before water quality testing is done, students have a sense of what certain results might tell them about the water source. After all, there's not much sense having students conduct tests and collect data if they haven't any idea what the results might mean!

We've provided you with some background information on a variety of commonly tested water quality parameters (physical, chemical, and biological). The pre-learning activity, *Water We Looking For?* (p.32) is designed to help introduce these parameters (and their potential implications for water quality) to students. If you need more information related to the water quality parameters, for your own background or for your students, it is readily available online. **Health Canada** has information regarding *Guidelines for Canadian Drinking Water Quality* (search: Main menu→ Environmental and Workplace Health→ Water Quality→ Drinking Water). The *Guideline Technical Documents* include background information on drinking water quality parameters, including what often influences the levels/ concentrations found in different water sources. The **U.S. Environmental Protection Agency (EPA)** also has several good fact sheets. In your internet search engine, try keying in (for example): "turbidity as a measure of water quality." Some relevant factsheets can also be found under "Resources" on the Safe Drinking Water Foundation website.

Water Quality Parameters

Physical	
Color	<ul style="list-style-type: none"> Color may indicate the presence of dissolved organic matter in the water, or inorganic contaminants such as iron, copper, or manganese
Odor	<ul style="list-style-type: none"> Caused by dissolved organic matter, biological activity (such as anaerobic bacteria), or industrial pollution
Taste	<ul style="list-style-type: none"> Can indicate the presence of inorganic compounds such as: magnesium, calcium, sodium, copper, iron, or zinc
Temperature	<ul style="list-style-type: none"> Determines the amount of dissolved oxygen that water can contain Cause for changes: large fluctuations in air temperature, changes to shape or flow of waterway, reductions in overhanging vegetation (shade), cloudiness, reductions in water flow, warm-water effluent from processing plants Impacts of higher temperatures: lower dissolved oxygen levels, physical stresses to aquatic organisms (such as insects and cold-water fish)
Suspended Sediment	<ul style="list-style-type: none"> Those sediment particles of greatest concern for water quality are silt and clay (the two smallest) Impacts: clog or damage fish gills, suffocate bottom-living aquatic insect larvae and fish eggs, destroy habitat by filling in the spaces between gravel where fish lay eggs, interfere with photosynthesis & aquatic plant growth by reducing water clarity (which affects the whole aquatic food chain), carry nutrients or other chemicals into water (such as heavy metals)
Turbidity	<ul style="list-style-type: none"> Closely related to suspended sediment, turbidity refers the relative clarity/cloudiness of water It is the result of particles (such as clay, silt, plankton, or microscopic organisms) suspended in water Can be an indication of surface runoff, siltation events, or erosion Impacts: Same as for suspended sediment; also, if turbidity is largely caused by microorganisms, their decomposition can lead to lower dissolved oxygen levels in the water
Chemical	
pH	<ul style="list-style-type: none"> Measure of the amount of hydrogen ions (H⁺) present in water Certain organisms can tolerate specific levels of pH; it can have a wide range of impacts on aquatic wildlife, as it affects the solubility and availability of nutrients in an ecosystem Slightly acidic water is corrosive and can dissolve metals, especially copper, from pipes and pumps, into the water Acceptable measurement: 6.0-8.5 (pH below or above the recommended range can lead to toxic effects); values outside the expected range of 5.0 to 10.0 could be considered an indication of industrial pollution Can influence the effectiveness of certain water treatment procedures
Conductivity	<ul style="list-style-type: none"> Measures how electrically conductive the water is, which indicates the presence of dissolved substances Although these substances may be naturally occurring minerals, high conductivity could also indicate contaminants that are in the water as a result of human activities

Hardness	<ul style="list-style-type: none"> • Determined by the amount of dissolved calcium and magnesium in the water, usually measured as calcium carbonate (CaCO₃). Higher concentrations indicate “harder” water • Source: Often dissolved out of soil/ rock • Impacts: Hard water makes it difficult to lather up soap and can cause scale deposits to develop (e.g., insides of water pipes). Soft water can corrode metal pipework because it tends to be slightly acidic (see pH)
Total alkalinity	<ul style="list-style-type: none"> • Measure of the capacity of a water body to neutralize acids (from rainfall or wastewater) • Influenced by rocks and soils, salts, some plant activities, and certain industrial wastewater discharges • Impacts: low alkalinity will affect the ability of the water to resist pH changes (meaning pH can change from acidic to basic fairly rapidly); can also be corrosive (dangers of copper or lead leaching out of pipework) & irritate eyes
Dissolved oxygen (DO)	<ul style="list-style-type: none"> • A basic requirement for a healthy aquatic ecosystem (fish, insects, and microorganisms). Certain organisms are sensitive to specific levels of dissolved oxygen. • Cause: organic materials, such as sewage or food processing wastes, that enter surface waters and then consume available oxygen through decomposition; temperature (colder water can hold more oxygen, warm temperatures increase bacterial activity) • Impacts: suffocation of adult cold-water fish or egg/juveniles, reduced health/ populations of insects & microorganisms, foul odor (due to anaerobic bacterial activity) • Common standard is 8.0 mg/L
Nutrients <ul style="list-style-type: none"> • Most common nutrients that cause water quality issues: nitrogen and phosphorus • Inorganic forms (those not bound up in plant or animal tissues) are necessary for growth, but too many are problematic because they stimulate too much bacterial and/or plant growth in aquatic systems 	
Ammonia	<ul style="list-style-type: none"> • NH₃: An inorganic form of nitrogen found in water • Formed through bacterial breakdown organic matter in water that contains nitrogen • Although necessary for aquatic life, high concentrations can be toxic • Sources: runoff of animal wastes, fertilizers, sewage, animal and food-processing wastes, urban stormwater • Impacts: see nitrate; can also negate the effectiveness of the chlorination process when concentrations are high, cause taste and odor problems, and interfere with the removal of manganese (a heavy metal)

Nitrate	<ul style="list-style-type: none"> • NO_3: An inorganic form of nitrogen, caused by the breakdown of ammonia • Sources: same as ammonia • Impacts: In combination with phosphates, can stimulate excessive aquatic plant growth ('eutrophication'). Usually weeds and algae, these out-compete native species and can destroy habitat used by other aquatic animals. When the plants decompose, they use up oxygen dissolved in the water. This can negatively impact other aquatic species (such as insects and fish). High levels of nitrate also negatively affect pregnant women & bottle-fed infants. • Long-term impacts: groundwater contamination (excess nitrates can leach through soils and enter drinking water sources)
Phosphate	<ul style="list-style-type: none"> • Plants require phosphorous (as phosphates) to grow. Phosphorus is typically the nutrient in demand in aquatic ecosystems, so even a small increase in phosphorus levels can cause eutrophication (when adequate & accessible nitrogen is present) • Sources include: soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure piles, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations
Biological	
Microbiological contaminants <ul style="list-style-type: none"> • Sources: untreated sewage (septic tanks, treatment plant overflow), stormwater (including runoff from manure-fertilized land or manure piles), animal processing plants, wildlife (living in and around water bodies), <i>etc.</i> • Impacts: human illnesses (ranging from gastro-intestinal disease to minor respiratory and skin diseases) • Both groundwater and surface water can become contaminated. The most common causes of groundwater contamination are ineffective septic fields, poorly protected wellheads, infrastructure leakage, <i>etc.</i> • Cannot test for <i>every</i> disease-causing organism in water, so usually test for indicator bacteria (those found in high numbers in the stomachs and intestines of warm-blooded animals, including humans) 	
Total coliforms	<ul style="list-style-type: none"> • Coliforms are bacteria associated with environmental sources such as vegetation, tree roots, insect infestation and soil, or possibly fecal material • Even a low count (1 - 5) may indicate the presence of other more harmful bacteria (see <i>E. coli</i>) • Higher total coliform counts (6 - >80) indicates strongly that disease-causing microorganisms may be present
<i>E. coli</i>	<ul style="list-style-type: none"> • The most common indicator bacteria we test for is <i>E. coli</i> (<i>Escherichia coli</i>), a type of coliform bacteria associated with human and animal feces. • When found in drinking water sources, it is a strong indication of sewage or animal waste contamination (and water is considered unsafe to drink due to serious health risks) • Standard acceptable range is <100 microorganisms/ 100mL sample
Parasites	<ul style="list-style-type: none"> • These are organisms that live inside others to get food. Animals, including humans, can be infected by parasites if they drink water that contains them • <i>Giardia</i> is a common water parasite that affects the water supply in Ontario. It causes giardiasis, symptoms of which include: vomiting, cramps and diarrhea.

Other potential water quality concerns:

- ***Dissolved salts*** (sodium, chloride, potassium)
 - These can derive from natural sources (*e.g.*, water running through/over rock), or unnatural sources, such as surface water runoff carrying road salt in waterways
- ***Fluoride***
 - Low levels of fluoride occur naturally in most sources of drinking water in Canada (sources: particles from atmosphere, rocks/ soils)
 - Unnatural sources include: manufacturing processes, fertilizers, metals
 - In some communities, fluoride is added to drinking water sources to prevent dental decay. It is the responsibility of municipalities, or the appropriate provincial or territorial authorities, to decide whether to fluoridate their drinking water.
 - Maximum Acceptable Concentration in a drinking water test sample is 1.5 mg/L
- ***Metalloids and heavy metals***
 - Arsenic (metalloid), and high-density metals (such as lead, zinc, copper, chromium, manganese, mercury) occur naturally in the environment. However, human activities (such as industrial processes and mining) also contribute sources
 - Can be associated with both surface and groundwater contamination. In surface waters, they usually enter with sediments (which then settle to the bottom, so water testing is of little use). In groundwater, they do not usually move very far from their source (because of these strong bonds to sediment particles)
- ***Radon*** (radioactive element sometimes found in drinking water): naturally occurring, but can enter water in greater volumes if disturbed by digging, mining or oil and gas production; concerns include: birth defects, tumour growth, & higher incidence of cancer
- ***Trihalomethanes (THMs)***: When chlorinated, any organic material that is present in the water can combine with the chlorine to form these compounds. Chloroform is a common THM and is considered potentially carcinogenic.
- ***Toxic organic chemicals***
 - ***Hydrocarbons***: chemicals used in petroleum products, refrigerators, insecticides, solvents, propellants, and cleaners. They can contaminate water as a result of spillage or disposal. Because hydrocarbons are frequently stored in underground tanks, they pose risks to groundwater.
 - ***PCBs*** (polychlorinated biphenyls): carcinogenic, do not break down easily (bio-accumulative); major source is runoff from landfills or and discharge of waste chemicals
 - ***Pesticides*** (fungicides, insecticides, herbicides and growth regulators): any substance that is used to control a particular organism; transported into surface waters via runoff from areas such as road surfaces or farmland/ lawns/gardens.
- ***Medical waste/ pharmaceuticals*** (including: drugs, hormones, residual medication)
 - Antibiotics and steroids are of particular concern, as the former can cause resistance to pathogens and the latter, interfere with metabolic and reproductive processes of aquatic and other organisms

Sources:

1. Environment Canterbury (NZ) <<http://ecan.govt.nz/advice/your-water/water-quality/pages/measuring-water-quality.aspx>>
2. Health Canada < <http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php>>
3. Lamotte Lesson Plans, Outdoor Monitoring Series: Water Quality Monitoring <http://www.lamotte.com/component/option,com_pages/lang,en/mid,/page,194>
4. Safe Drinking Water Foundation, Operation Water Drop (Lesson Plans) < <http://www.safewater.org/education/school-programs/operation-water-drop.html>>
5. Stream Side Science Lesson Manual <<http://extension.usu.edu/waterquality/htm/educator-resources/lessonplans/sss/sssmanual/>>
6. U.S. Environmental Protection Agency <<http://water.epa.gov/drink/contaminants/basicinformation/>>

Teacher's Corner: <i>Water Quality Protection – Whose Responsibility is it?</i>	
Who?	How are they responsible?
Province (Drinking Water Ontario)	<ul style="list-style-type: none"> Acts & Regulations (update & enforce); see more information, below
Conservation Authorities	<ul style="list-style-type: none"> “Watershed managers” Create & administer source water protection plans (with multi-stakeholder groups)
Local non-governmental organizations	<ul style="list-style-type: none"> Conduct watershed restoration activities Provide public input to water resource management (such as source water protection plans)
Municipal or private water managers	<ul style="list-style-type: none"> Test & treat drinking water before it reaches our taps Treat & test sewage outflow before it reaches source waters
Individuals	<ul style="list-style-type: none"> Maintain well and septic systems Do not pour unwanted items down the drain Consider what they apply to land (e.g., pesticides, chemicals) Clean up spills properly Use biodegradable soaps Conserve ...can you think of more?
<p style="text-align: center;"><u>Protecting Drinking Water</u></p> <p>Provincially, the <i>Clean Water Act</i> (2006) provides a legislative framework for protecting source water. It requires that local source water protection committees assess <u>existing</u> and <u>potential</u> threats to drinking water, and then take action to <u>reduce</u> or <u>eliminate</u> these threats. The creation of a source water protection plan requires public participation, and is open to the community. To learn more about source water protection in your community, contact your local <u>Conservation Authority</u>.</p> <p>Under the <i>Clean Water Act</i>, Ontario also has the ODWS (Ontario Drinking Water Stewardship Program). This program offers financial assistance to farmers, landowners and small-scale businesses, to implement measures to reduce threats to drinking water sources.</p> <p>Other drinking-water related acts & regulations include:</p> <ul style="list-style-type: none"> <i>Safe Drinking Water Act</i> (2002)—Systems, operators, testing, licensing, standards, <i>etc.</i> <i>Ontario Water Resources Act</i> (1990)—Water taking, large-scale water users, wells, <i>etc.</i> <p style="text-align: center;"><i>Source: Drinking Water Ontario: Protecting Source Water</i></p> <p>For more information on drinking water in your community: <http://www.ene.gov.on.ca/environment/dwo/en/mapping/> <ul style="list-style-type: none"> Provides information on utility (if municipally sourced), water source (<i>e.g.</i>, Lake Ontario), population served (#), source protection (who to contact), and water treatment procedures commonly employed </p>	

