Essential Question 4

How Does Knowing the Water Chemistry Help Improve Our Ability to Care for Lake Winnipeg?

Essential Question 4: How does knowing the water chemistry help improve our ability to care for Lake Winnipeg?

Introduction

Students have now looked at the watershed dynamics and social and economic factors involved in looking after Lake Winnipeg. However, they have not had an opportunity to measure parameters involved in determining water quality. In this section of the resource, students will explore a variety of water quality measures used by limnologists to understand the health of a lake ecosystem. Students will use data and samples collected from their own field trip or data that is provided. The parameters examined in this course are the following:

- Temperature
- Dissolved elements
- pH
- Phosphorus
- Turbidity
- Nitrogen
- Dissolved oxygen

Teacher's Note:

There are several websites that contain water-quality testing procedures and student worksheets. As a teacher, you can select some of the parameter or do them all. Included are both classroom-based and field-based activities related to water quality measures. Teachers can use the classroom-based measures if they are not close to a water source, or if they would like to explore the measures in detail and go through the protocols prior to going out in the field. The classroom-based activities give teachers the opportunity to talk about the importance of keeping the same procedures for all sampling that is done, and reinforce the idea of comparing different areas of a lake.

Resources to Plan Your Teaching

- *Water-Quality Testing*

  Manitoba Waterways Project: Brian Lewthwaite at the University of Manitoba led a school-based water quality program called the Manitoba Waterways Project. This website could be the basis for your water quality section of the course, and students could contribute their findings to a larger database being collected by the Waterways project. There are several online links to resources, as well as procedures for each of the indicators identified above. It can be found at <http://home.cc.umanitoba.ca/~lewthwai/mwp/mainpage.html#contents>.

- *The Streamkeeper's Handbook*

  Taccogna, G., and K. Munro (eds). *The Streamkeeper's Handbook: A Practical Guide to Stream and Wetland Care.* Vancouver, BC: Salmonid Enhancement Program, Dept. Fisheries and Oceans, 1995. Available online at <www.pskf.ca/publications/download.html>.

  The Streamkeeper's Guide was developed to help teachers implement water quality measures in their local area. The guide contains procedures for water quality measures and student worksheets for recording data. It can be found at <www.pskf.ca/publications/handbook.html>.

- *RSAT Assessments*

  As a complement to water quality monitoring, classes may also consider using a rapid stream bioassessment method (i.e., Rapid Stream Assessment Technique or RSAT), an excellent and relatively straightforward rubric used by Manitoba Water Stewardship for assessing stream characteristics.

  RSAT is used to provide a simple, rapid assessment of overall stream quality conditions on a watershed scale. The RSAT method considers stream channel stability (erosion, slumping, bank failure), sediment deposition/channel scouring, depth of flow, water velocity, water temperature, substrate type, water clarity, odour, riparian zones, and biological indicators (benthic invertebrates). The technique is simple and does not require a lot of equipment and resources. Here is the link to the method: <www.stormwatercenter.net/monitoring%20and%20assessment/rsat/smrc%20rsat.pdf>.

Lesson: Introduction to Limnology

Specific Learning Outcomes

- **SLO C10:** Identify new questions or problems that arise from an investigation.
- **SLO C23:** Demonstrate a continuing, more informed interest in science and science related careers and issues.
- **SLO D1:** Integrate knowledge, as necessary, from various science specialties in order to address an issue, engage in problem solving or conduct scientific inquiries. *Examples: biotechnology, astrophysics, climatology, chemical engineering, entomology, planetary geology…*

Objectives

Identify *limnology* as the study of freshwater systems by exploring the methods used to examine freshwater ecosystems.

Probing Questions:

Chemical Aspects:

- How does the interaction of the chemicals leeching into the lake affect the water quality of the lake?
- How do you isolate different chemical parameters of a lake and study them? Is this possible?

Biological Aspects:

- How does agricultural activity affect the ecology of a lake?
- Why are researchers so concerned about the amount of algae in the lake?
- Have the plants and animals in Lake Winnipeg changed over time, and, if so, why?

The Three A's

Activate: Ask students what are some of the ways we can scientifically go about studying a lake? Record answers.

Acquire and Apply: Explore all the different approaches to studying Lake Winnipeg by profiling some of the scientists who are professionally involved as stewards.

Introduce students to the study of limnology and how limnologists look at a lake from its physical, chemical, and biological properties. Have students

create a concept map and includes as many physical, chemical, and biological aspects they can think of that could be examined in a freshwater ecosystem.

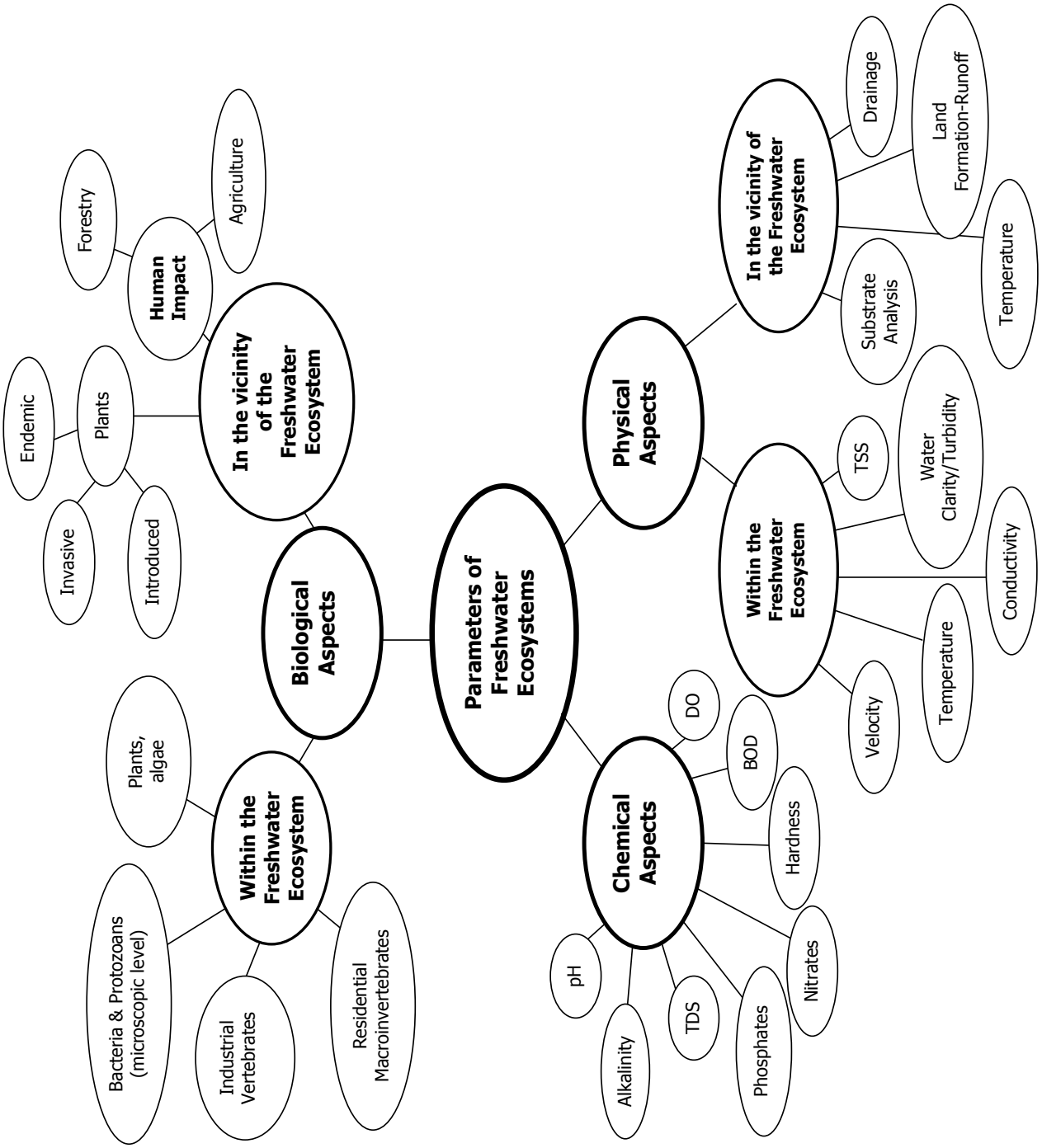
Using the cluster diagram (BLM 4-1-1), have students identify some questions they would like to answer while examining each of the parameters of a freshwater ecosystem. Establish one of these questions as an inquiry assignment that will be conducted during the course.

Assessment

Assessment *for* Learning: Provide feedback to students on their participation during the creation of the cluster diagram of physical, chemical, and biological properties of Lake Winnipeg.

Assessment *of* Learning: Have students submit an inquiry-based project on one question they would like to answer on the chemical parameters of Lake Winnipeg.

The concept could include the following items:



Source: "Freshwater Studies" by Brian Lewthwaite. For more information, see <http://home.cc.umanitoba.ca/~lewthwai/mwp/mainpage.html>.

Lesson: Water Quality

- **SLO C12:** Evaluate information obtained to determine its usefulness for one's needs. *Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias…*
- **SLO C5:** Select and use scientific equipment appropriately and safely. *Examples: volumetric glassware, microscopes, balances, test kits, probeware…*
- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.
- **SLO C7:** Evaluate the relevance, reliability and adequacy of data and the methods used to collect data. Include: discrepancies in data, sources of systemic error, precision versus accuracy.
- **SLO C8:** Interpret patterns and trends in data, and infer and explain relationships. *Examples: line of best fit, regression equations, statistical analysis, modes of representation (visual, numerical, graphical, symbolical)…*
- **SLO C9:** Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results. *Examples: cause and effect relationships, alternative explanations, support for or rejections of a hypothesis or prediction statement…*
- **SLO C10:** Identify new questions or problems that arise from an investigation.

Objectives

Students will conduct water quality analysis in the field or in the classroom, and relate findings to the water quality issues of Lake Winnipeg.

Ask students to bring in water samples from their home and/or the yard.

1. Set up measurement stations for each of the protocols your students will be performing.

The Three A's

Activate: Show students the equipment that will be used for the water quality procedures. There are three different measurements that will be taken at these stations: temperature, dissolved oxygen, and pH.

Acquire and Apply: Depending upon your situation you can either do the water quality classroom-based activities or water quality field-based activities. Both are described in the following section.

Assessment

Assessment *for* Learning: Have students complete the probing questions for each of the protocols and provide feedback.

Water Quality: Classroom Based

Provided here are some water quality tests that can be done without any lake water samples. These activities are suggested so students can still have the opportunity to practise water quality protocols and then compare their results with the results found in the literature. The protocols are modified from the *Streamkeeper's Guide,* but other protocols could be used from different sources.

Create three stations, and have students eventually rotate through each station. Each station should take approximately 20 minutes. Before giving students this task, explain each of the measures.

Have students use the *Water on the Web* website to help them answer the questions listed for each parameter. It can be found at <http://waterontheweb.org/under/waterquality/index.html>.

Classroom-Based Stations

Temperature: Station 1

Ask students why it might be important to take the temperature of a lake.

Invite suggestions.

Demonstrate to students how to take temperature measurements in the field. You can do this by using an aquarium and showing them the correct depth to submerge the thermometer, and then taking the reading while it is still submerged. Use the aquarium as the water temperature station.

Procedure at the water temperature station

1. Lower the thermometer 10 cm below the water surface and keep it submerged for two minutes.
2. Read the temperature while the thermometer is still in the water.
3. Record the temperature readings.

- Each member of the group should take a turn measuring the temperature of the same sample with the same thermometer. Make sure everyone in the group can read the thermometer. Compare your readings. Are they within 0.5°C of each other? Why or why not? If not, repeat this exercise with another water sample until you are obtaining readings within 0.5°C of each other.
- With each member of the team using a different thermometer and following the steps of the water temperature protocol, measure the temperature of a single water sample and compare your readings. Do you get readings within 0.5°C of each other? Why or why not? If not, your thermometers may need calibration.

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- Measure the temperatures of water from the hot and cold water taps, ice water, and the water that has been standing in the bucket.
- Discuss the range of measurements possible with each of the thermometers.
- Can you take temperatures below the freezing mark? Why? Why not?

Probing Questions

1. Why do you have to wait two minutes before you take the thermometer reading?

   The thermometer needs to adjust to the temperature of the water. Two minutes is enough time for it to adjust and take a more accurate temperature measurement.

2. Why do you have to take the reading while the thermometer is still underwater?

   The temperature of the air will most likely differ from the water temperature. If you take the thermometer out of the water, it will begin to read the air temperature instead of the water temperature.

3. Why would water temperature and temperature stratification be an important parameter to know when looking at Lake Winnipeg?

   Water temperature affects the biotic environment of the lake. Increasing temperature stimulates plant growth and enhances the food available to the aquatic animals. However, it could decrease dissolved oxygen levels as these plants decompose. Lake Winnipeg is a shallow lake, at least in the south basin, and so there is no temperature stratification.

Station 2: Dissolved Oxygen

Show students the Hach dissolved oxygen kit, and demonstrate how to take a water sample for the dissolved oxygen test.

- Following the steps in the dissolved oxygen kit, each member of the group takes a turn measuring the DO of the same sample. Compare your readings. Are they within 0.2 mg/L of each other? Why? Why not? If not, repeat this exercise with another water sample until you obtain readings within 0.2 mg/L of each other.
- If your water faucets have aerators on them, test a water sample freshly drawn from the faucet. Make sure it was drawn at the beginning of the day and allowed to sit undisturbed in a bucket, and that the preserved sample was drawn at the same time. Record the time at which you tested the water in the bucket. How long has it been since the water was drawn? Compare the readings. Are they different? Why? Why not? What might account for the differences?

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Probing Questions

1. What do dissolved oxygen levels tell about the quality of a body of water?

   Dissolved oxygen is the amount of oxygen available to aquatic organisms in a body of water. The oxygen is dissolved into the water through diffusion, aeration by turbulence, and as a waste product of photosynthesis. High oxygen levels in a water system can cause fish and other organisms to get "gas bubble disease." This is rare. Low dissolved oxygen levels put the aquatic ecosystem under stress—the lower the oxygen level, the greater the stress. Extremely low dissolved oxygen levels, even for a few hours, can cause large fish kills.

2. What are some factors that affect DO levels?

   Temperature is a primary factor that affects the dissolved oxygen in an aquatic ecosystem. If the water is too warm, the dissolved oxygen level is depleted by bacteria and the decomposition of organic material.

3. Why is excessive plant growth and excessive nutrient input not good for a healthy aquatic ecosystem?

   It will deplete the dissolved oxygen level in the aquatic ecosystem.

Station 3: pH

Create several solutions of various pHs to have students practise reading pH paper and the colour scale or the pH meter. Review with students the results to see if there were any difficulties.

Probing Questions

1. What does the pH tell us about the quality of a body of water?

   The lower the pH of a body of water, the more acidic it is. Greater acidity affects the aquatic ecosystem. For example, a low pH affects how a fish maintains a balance of salts and minerals in its body. This is called osmoregulation. A low pH will cause a disruption in the balance of the minerals in the body of fish. Low pH causes mucous to form on the gills of the fish, and affects its ability to take in oxygen.

2. What are some factors that affect pH levels in a lake?

   The pH levels in a lake can be affected by acid rain from spring runoff (often referred to as spring acid shock).

Temperature

Probing Questions

1. Why do you have to wait two minutes before you take the thermometer reading?

2. Why do you have to take the reading while the thermometer is still underwater?

3. Why would water temperature and temperature stratification be an important parameter to know when looking at Lake Winnipeg?

Dissolved Oxygen

Probing Questions

1. What do dissolved oxygen levels tell about the quality of a body of water?

(continued)

2. What are some factors that affect DO levels?

3. Why is excessive plant growth and excessive nutrient input not good for a healthy aquatic ecosystem?

pH

Probing Questions

1. What does the pH tell us about the quality of a body of water?

2. What are some factors that affect pH levels in a lake?

Water Quality: Field Based

The following description is for classrooms that have access to a lake or aquatic system and can conduct field studies, or can conduct a field trip to a lake system and have students practise water quality protocols. As an alternative to conducting these field investigations on your own, you can arrange for your class to participate in a data-gathering expedition on the *MV Namao* with researchers from the Lake Winnipeg Research Consortium. For information about booking a class trip, contact <outreach@lakewinnipegresearch.org>, or visit the website at <www.lakewinnipegresearch.org/edandoutreach.html>.

Temperature

Take temperature readings twice a day if you suspect problems with daily temperature fluctuations. Measure as early in the morning and as late in the afternoon as possible. If you suspect thermal pollution, take temperature readings upstream and downstream of the source within a very short time span.

1. Lower the thermometer 10 cm below the water surface, and keep it submerged for two minutes.
2. Read the temperature while the thermometer is still in the water.
3. Record the temperature readings.

Probing Questions

1. Why do you have to wait two minutes before you take the thermometer reading?
2. Why do you have to take the reading while the thermometer is still underwater?
3. Why would water temperature and temperature stratification be an important parameter to know when looking at Lake Winnipeg?

Dissolved Oxygen

1. Take the dissolved oxygen sample in late afternoon when you are measuring temperature. The oxygen level generally is at its lowest for the day then. Follow the instructions and safety procedures included in the Hach kit. Collect the water samples carefully, so you do not introduce air from agitation or bubbling.
2. The test results are in parts per million (ppm) or milligrams per litre (mg/l).

   The recorder can complete the calculations in the field or this can wait until the students return to the classroom.

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3. Students can use the *Streamkeeper's Handbook* data collection sheet to calculate the percent saturation. Use the temperature and oxygen concentration data to calculate percent saturation using Figure 2 on the data sheet (*Streamkeeper's Handbook*, Module 3, p. 12). Use a ruler to join up the oxygen and temperature readings. Read the percent saturation value where the ruler crosses the middle line. Record the concentration and percent saturation on the Field Data Sheet, Part B.

Probing Questions

1. What do dissolved oxygen levels tell about the quality of a body of water?
2. What are some factors that affect DO levels?
3. Why is excessive plant growth and excessive nutrient input not good for a healthy aquatic ecosystem?

pH

Measure pH in late afternoon, when you are measuring the temperature. Follow the directions included with the Hach pH kit. If you are using pH paper instead of the Hach kit, dip the paper in the stream water, then match the colour to the chart included with the paper. Repeat the test to check for reliability. If you use a pocket pH meter, make sure you calibrate it properly. Record the result.

Probing Questions:

1. What does the pH tell us about the quality of a body of water?
2. What are some factors that affect pH levels in a lake?

Turbidity

Procedure

There are two possible methods, each suited for a particular freshwater ecosystem.

Deep Water, Lake Ecosystem

1. The secchi disc method is based on a 20 cm black and white disc being lowered on a measuring tape until it disappears. The distance at which it disappears can then be used as an indicator of water **clarity**.

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> TEACHER'S NOTE:
>
> You can find instructions on how to make your own secchi disc at a variety of websites. Here is one site: <http://des.nh.gov/organization/divisions/water/wmb/vlap/documents/secchi.pdf>.

Water removed from its source, shallow water, stream ecosystem

2. An effective method of determining water **clarity** from water that is shallow or has been removed from its source is to fill a one-litre measuring cylinder with your water sample. Create a small toonie-sized disc out of white flexible plastic that has alternating black and white quadrants (this would be a smaller version of the secchi disc). Attach this disc to the end of a wooden metre stick by a tack so that the coloured part of the disc is projected up the stick. Lower this end of the stick into your water sample until it is no longer visible. At the point that it is no longer visible, measure the length of the submerged metre stick. Record this measurement in millimetres. For water, **clarity** in excess of the cylinder's depth, record this depth as greater than the depth measured. The Water on the Web site has a modified version of this procedure using a graduated cylinder at <http://watertheweb.org/under/waterquality/turbidity.html>.

> TEACHER'S NOTE:
>
> This procedure is described on the Manitoba Waterways Project website at <http://home.cc.umanitoba.ca/~lewthwai/mwp/parameters/tss_clarity.html>.

Probing Questions & Answers

1. What causes turbidity? Why is turbidity an important indicator of water quality?

   Turbidity is a measure of the particulate matter in the lake. Phytoplankton is a common cause of turbidity, as well as clay and silt particulates that may be more prevalent closer to the shoreline. Turbidity affects the amount of light that enters into the lake ecosystem, so the greater amount of particulates, the less light can enter the ecosystem. The amount of light affects photosynthesis and the release of oxygen into the water. As well, particulates affect the invertebrates that remain on the bottom of the lake (called benthics). Increases in silt and other particulates can then settle on the bottom and smother the invertebrates and their eggs.

2. Considering the sources of turbidity, what are two ways to avoid the problems caused by this parameter?

   Phytoplankton growth can be reduced by reducing the nutrient loading of the lake.

Student Handout: Water Quality: Field Based

Temperature

Probing Questions

1. Why do you have to wait two minutes before you take the thermometer reading?

2. Why do you have to take the reading while the thermometer is still underwater?

3. Why would water temperature and temperature stratification be an important parameter to know when looking at Lake Winnipeg?

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Dissolved Oxygen

Probing Questions

1. What do dissolved oxygen levels tell about the quality of a body of water?

2. What are some factors that affect DO levels?

3. Why is excessive plant growth and excessive nutrient input not good for a healthy aquatic ecosystem?

(continued)

pH

Probing Questions

1. What does the pH tell us about the quality of a body of water?

2. What are some factors that affect pH levels in a lake?

Turbidity

Probing Questions

1. What causes turbidity? Why is turbidity an important indicator of water quality?

(continued)

2. Considering the sources of turbidity, what are two ways to avoid the problems caused by this parameter?

Lesson: Phosphorus in Lake Winnipeg

Specific Learning Outcome

- **SLO C9:** Analyze data or observations in order to draw conclusions consistent with the available results of an investigation, and identify the implications of these results. *Examples: cause and effect relationships, alternative explanations, support for or rejections of an hypothesis or prediction statement…*

Objectives

Students will use previously collected data from tributary rivers to answer questions related to their contributions to the nutrient overload in Lake Winnipeg.

Resources to Plan Your Teaching

- Chapter 9: Compare phosphate levels in stream sediment from data in the following resource:

  Brunskill G.J., S.E.M. Elliott, and P. Campbell. *Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg.* Winnipeg, MB: Western Region Department of Fisheries and Oceans, Canadian Manuscript Report of Fisheries & Aquatic Sciences No. 1556, April 1980.

The Three A's

Activate: Show students some of the research papers that have been done on Lake Winnipeg over the years, and explain that there are several scientists looking at Lake Winnipeg.

Acquire and Apply: Using the following datasets, have students input these sets into *Excel,* and then create charts to explore the fluctuation of Total Nitrogen and Total Phosphorus in tributaries of Lake Winnipeg

Table 1: Rates of transport of total nitrogen per unit watershed area per year for selected tributary rivers flowing to Lake Winnipeg over 1969–1974.

River	1969	1970	1971	1972	1973	1974	Ad
Red River	5.59	9.76	2.76	3.64	1.46	7.85	287,500
Winnipeg River	13.7	13.8	11.5	12.8	9.73	19.1	126,400
Dauphin River	2.1	2.53	4.79	3	2.04	5.86	80,000
Fisher River	3.02	3.8	0.82	1.76	1.12	8.42	1360
Manigotagan River	10.1	8.64	6.33	9.52	8.96	15.2	1,800
Pigeon and Berens	21	9.89	10.1	8.49	8.85	14	19,700
Poplar	22.1	6.82	7.7	6.82	6.67	7.62	6,790
Saskatchewan R	3.81	3.17	2.91	4.94	3.1	3.97	340,000

Table 2: Rates of transport of total phosphorous per unit watershed area per year for selected tributary rivers flowing to Lake Winnipeg over 1969–1974.

River	1969	1970	1971	1972	1973	1974	Ad
Red River	0.39	0.85	0.16	0.24	0.13	0.46	287,500
Winnipeg River	0.39	0.37	0.54	0.31	0.2	0.43	126,400
Dauphin River	0.019	0.029	0.033	0.021	0.009	0.042	80,000
Fisher River	0.13	0.19	0.034	0.031	0.014	0.29	1360
Manigotagan River	0.21	0.23	0.16	0.11	0.13	0.31	1,800
Pigeon and Berens	0.44	0.26	0.29	0.24	0.22	0.4	19,700
Poplar River	0.82	0.22	0.27	0.2	0.21	0.31	6,790
Saskatchewan R	0.048	0.045	0.045	0.075	0.041	0.093	340,000

Data reproduced from Brunskill G.J., S.E.M. Elliott, and P. Campbell. *Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg.* Winnipeg, MB: Western Region Department of Fisheries and Oceans, Canadian Manuscript Report of Fisheries & Aquatic Sciences No. 1556, April 1980. p. 14. Available online at <www.dfo-mpo.gc.ca/library/74105.pdf>.

Using their charts and other sources of information, have students answer the following questions:

Probing Questions

Nitrogen

1. Why is nitrogen an essential part of all ecosystems?
2. List some of the sources of ammonia and nitrogen compounds in water.
3. Provide some possible explanations for the fluctuation in the amount of nitrogen in a river system from year to year.
4. Which tributary is the greatest source of nitrogen?

Phosphorus

1. Why is phosphorus an essential part of all ecosystems?
2. List the main sources of phosphates in water.
3. Why is fertilizer runoff not a major source of phosphate pollution?
4. Why do some sewage treatment plants remove most of the phosphorus from the sewage water before they release it?
5. Why would phosphate concentrations fluctuate from year to year?
6. Which tributary is the greatest source of phosphorus?

Assessment

Assessment *for* Learning: Have students complete the probing questions for the nitrogen and phosphorus fluctuation in the lake.

Notes

Student Handout: Nitrogen

1. Why is nitrogen an essential part of all ecosystems?

2. List some of the sources of ammonia and nitrogen compounds in water.

3. Provide some possible explanations for the fluctuation in the amount of nitrogen in a river system from year to year.

4. Which tributary is the greatest source of nitrogen?

Student Handout: Phosphorus

1. Why is phosphorus an essential part of all ecosystems?

2. List the main sources of phosphates in water.

3. Why is fertilizer runoff not a major source of phosphate pollution?

4. Why do some sewage treatment plants remove most of the phosphorus from the sewage water before they release it?

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5. Why would phosphate concentrations fluctuate from year to year?

6. Which tributary is the greatest source of phosphorus?

Lesson: Exploring the Sources of Nitrogen and Phosphorus in Lake Winnipeg

Specific Learning Outcomes

- **SLO C11:** Synthesize information obtained from a variety of sources.
- **SLO C12:** Evaluate information obtained to determine its usefulness for one's needs. *Examples: scientific accuracy, reliability, currency, relevance, balance of perspectives, bias…*
- **SLO C13:** Quote from or cite sources as required, and reference sources according to an accepted practice.
- **SLO C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*
- **SLO C18:** Collaborate with others to achieve group goals and responsibilities.
- **SLO C19:** Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions.

Objectives

Students will research one suggested source of phosphorus and one suggested source of nitrogen that contribute to the eutrophication problem in Lake Winnipeg, and create a presentation on the percentage contribution of the source and the regulation policies established by various governments.

The Three A's

Activate: Read to students a newspaper article that describes how the nutrients nitrogen and phosphorus enter into the Lake Winnipeg ecosystem.

Potential articles include the following:

- Macdonald, Nancy. "Canada's sickest lake." *Maclean's.* August 20, 2009. Available online at <http://www2.macleans.ca/2009/08/20/canada%E2%80%99s-sickest-lake>. This two-page article discusses sources of phosphorus and nitrogen. It also includes a picture of blue-green algae washing up on the shores of Lake Winnipeg.
- Werier, Val. "Lake struggles with abuse." *Winnipeg Free Press.* April 13, 2000. The article is available online with a paid subscription to *Winnipeg Free Press Archives*. The two-page article covers sources of phosphorus, such as sewage and agriculture. It also provides a perspective of Lake Winnipeg's problems from the year 2000.

- Manitoba Eco-Network. "The Vitality of Lake Winnipeg is in Jeopardy." *Around the Lake Winnipeg Watershed*. 2008: 1–3. Available online at <http://mbeconetwork.org/publications>. This publication discusses sources of phosphorus that are derived from the drainage systems of the Saskatchewan, Assiniboine, Winnipeg, and Red rivers, as well as from the areas near Lake Manitoba and Lake Winnipeg. A satellite photo of the result of nutrients in Lake Winnipeg is shown. Maps showing the different drainage systems are also shown.
- Current articles from magazines and/or newspaper articles regarding nutrients in Lake Winnipeg would also be appropriate.

Acquire and Apply: Divide students into pairs, and have each pair research newspaper articles covering the sources of the nutrients nitrogen and phosphorus that are in the tributaries of Lake Winnipeg. Have students identify the percentage each of these sources of nutrients contributes to the total found in Lake Winnipeg, and have students identify the policies that cover how each of these sources is regulated.

The following sources could be assigned:

- Hog producers
- Dishwashing detergents
- Cosmetic lawn fertilizers
- Wastewater and sewage

Hold a debate that covers the regulation of one of these sources of phosphorus or nitrogen.

Assessment

Assessment *for* Learning: Using an exit slip, provide feedback to students on their participation in the debate.

Assessment *of* Learning: Students will submit a section in the report card on the chemical parameters they examined.