Lake Winnipeg

A Resource for Grade 12
Interdisciplinary Topics
in Science (40S)

Manitoba

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Available in alternate formats upon request.

Contents

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Rationale

The objective of this document is to be a resource for teaching *Grade 12 Interdisciplinary Topics in Science (40S)*. It is designed to provide information to expose Manitoba students to the complexity of issues associated with Lake Winnipeg, and, through science investigations and problem-based approaches to learning, to encourage students to develop decision-making skills associated with the ecological and social dynamics of the Lake Winnipeg environment.

Resource Overview

This resource focuses on environmental stewardship and Lake Winnipeg, and has been organized around the following five guiding or "essential" questions:

Essential Question 1: Why should we care about Lake Winnipeg?

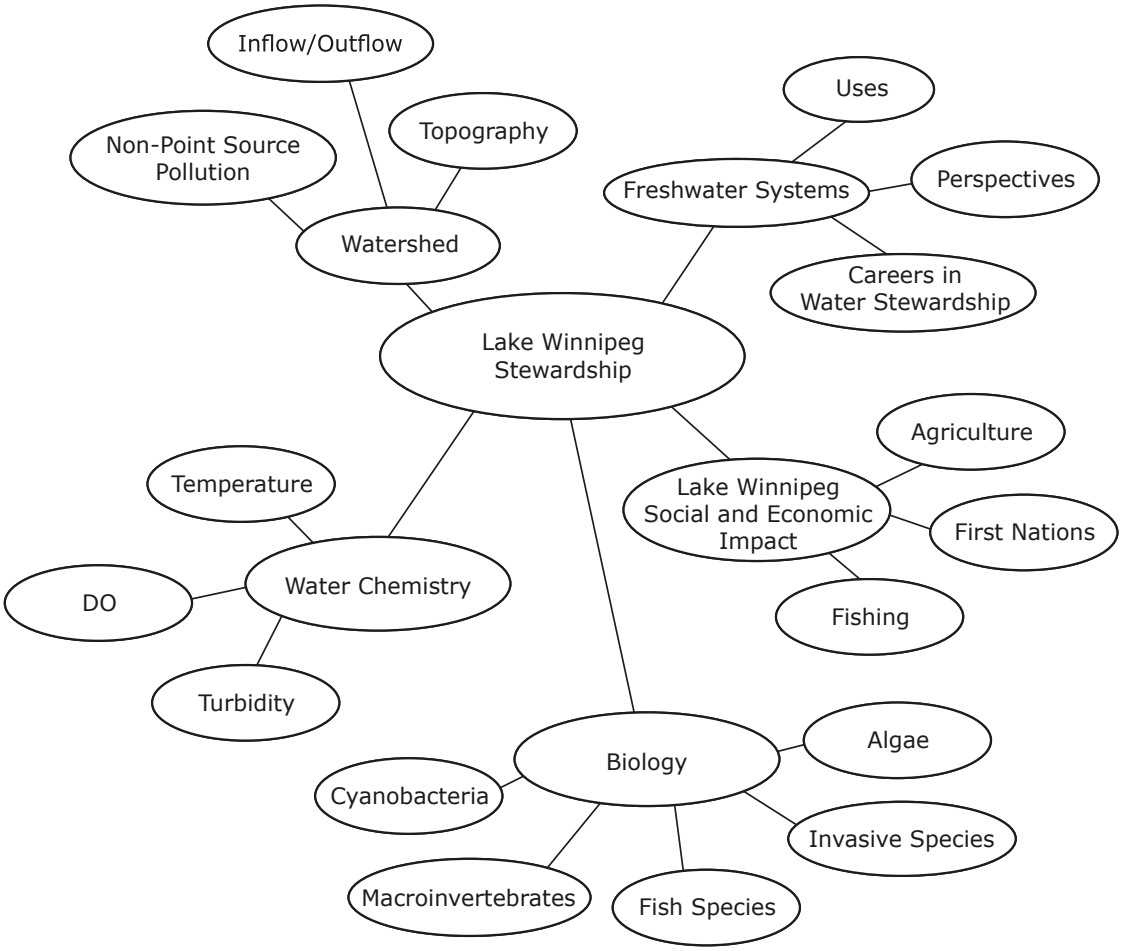
Essential Question 2: How does the Lake Winnipeg watershed affect our ability to take care of the lake?

Essential Question 3: How are social and economic activities affecting the health of Lake Winnipeg?

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

Essential Question 5: How can biotic parameters indicate the health of Lake Winnipeg?

A CONCEPT MAP OF THE MAIN IDEAS PRESENTED IN THIS RESOURCE



Organization of This Resource

This resource is divided into five sections, with one section for each Essential Question. Each section begins with an introduction that describes the intent of the section, and outlines some activities and ideas that will be covered. This is followed by a list of resources that teachers can use to teach the section. Finally, there are a series of lessons that cover the ideas of the Essential Question.

Each lesson has some or all of the following components:

- Learning Outcomes
- Introduction
- Objectives
- Teacher Background
- Resources to Plan Your Teaching
- Three A's Learning Cycle: Activate, Acquire, and Apply
- Probing Questions
- Assessment

Learning Outcomes for This Resource

As this document is a resource for the *Grade 12 Interdisciplinary Topics in Science (40S)* course, its learning outcomes can be found in the Manitoba Education document *Interdisciplinary Topics in Science (40s)* (see <www.edu.gov.mb.ca/k12/cur/science/gr12_interdisciplinary_draft.pdf>).

Specific learning outcomes can be found for each of the learning experiences described, and the entire set of learning outcomes are attached in an appendix.

Resources to Plan Your Teaching

The following resources are recommended. The Duguid and Brandson documents may be especially useful for students.

- Canadian Council for Geographic Education. "The River Lot Farms of the Red River." *The Canadian Atlas Online.* Ottawa, ON: Canadian Council for Geographic Education, n.d. Available online at <www.canadiangeographic.ca/atlas/LessonPlan.../MB6-8%20Red%20River.pdf>.

- Carlesen, William S., Nancy M. Trautmann, & the Environmental Inquiry Team. *Cornell Scientific Inquiry Series Student Edition, Watershed Dynamics.* Arlington, VA: National Science Teachers Association Press, 2004. Available online at <www.nsta.org> and <http://ei.cornell.edu/pubs/wd.asp>.

- Duguid, Terry, & Norm Brandson. *Restoring the Health of Lake Winnipeg, Canada's Sixth Great Lake: A Report by the Lake Winnipeg Implementation Committee*. Winnipeg, MB: Lake Winnipeg Implementation Committee, 2005. Available online at <http://manitobawildlands.org/water_lakewpg.htm>.

- ———. *Restoring the Health of Lake Winnipeg, Technical Annex, Canada's Sixth Great Lake*. Winnipeg, MB: Lake Winnipeg Implementation Committee, 2005. Available online at <http://manitobawildlands.org/water_lakewpg.htm>.

- Grosshans, R.E., D.A. Wrubleski, & L.G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, Winnipeg, MB: University of Manitoba, 2004. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

- Lake Winnipeg Stewardship Board. *Reducing Nutrient Loading to Lake Winnipeg and its Watershed: Our Collective Responsibility and Commitment to Action: Report to the Minister of Water Stewardship.* Winnipeg, MB: Lake Winnipeg Stewardship Board, 2006. Available online at <www.lakewinnipeg.org/web/content.shtml?pfl=public/downloads.param&page=000101&op9.rf1=000101> and <http://manitobawildlands.org/water_lakewpg.htm>.

- Manitoba Wildlands. The Manitoba Wildlands site provides comprehensive information, history, and includes official documents for the following Manitoba subjects: Lake Winnipeg, Winnipeg Floodway, Trans-Boundary Initiatives, Manitoba Hydro projects, Wuskwatim Projects, Hydro Research & Reports, East Side of Lake Winnipeg, East Side Protected Areas, World Heritage Sites, Manitoba World Heritage Site, East Side Planning Initiative, Wabanong Nakaygum Okimawin (WNO), Aboriginal Rights & Title, Treaties & Traditional Territory among many more. Available online at <www.manitobawildlands.org>.

Creating a Long-Term Data Set (Optional)

This resource is intended to help students understand the issues associated with the Lake Winnipeg ecosystem. The work can stand alone and be offered each year without the creation of a long-term data set, but some teachers may wish to develop their teaching so that the data collected from year to year contribute to a database that students can use to compare fluctuations in the ecosystem. In order to create a database that monitors the ecological health of a system, it is necessary to plan out the monitored area and water quality measures in the initial year of data collection.

Some planning items to consider:

1. Consider taking a field trip to Lake Winnipeg or a nearby aquatic site to take all necessary samples. Make sure to store them properly so protocols

and experiments can be conducted on them at a later date. The Education Outreach Coordinator with the Lake Winnipeg Research Consortium can assist by collecting data on the *Namao*, the research vessel based in Gimli.

2. Students should understand the benefits of ecological monitoring and how it can help people understand the freshwater ecosystem over the long term. They need to review protocols for sample collecting.
3. On the first trip to Lake Winnipeg or a nearby aquatic site, record a clear description of the physical geography and the proper co-ordinates using GPS units.

Resources to Plan Your Teaching

The following resources would be helpful in planning for an ecological monitoring program:

- Taccogna, G., & K. Munro (eds). *The Streamkeeper's Handbook: A Practical Guide to Stream and Wetland Care*. Vancouver, BC: Salmonid Enhancement Program, Department of Fisheries and Oceans, 1995. *The Streamkeeper's Handbook* provides comprehensive information on watershed ecology, decree, and provides stream and wetland modules. Available online at <www.pskf.ca/publications/download.html>.
- GLOBE Program: The GLOBE Program offers students an electronic environment to report and share collected data. The GLOBE Program provides educators with sets of protocols for various subject areas, including hydrology, which consists of the following topics:
  - Water transparency
  - Water temperature
  - Dissolved oxygen
  - Electrical conductivity
  - Salinity
  - pH
  - Alkalinity
  - Nitrate
  - Freshwater
  - Macroinvertebrates
  - Optional salinity titration
  - Protocol videos
  - Instrument specifications

  Available online at <www.globe.gov/r>.

- The Manitoba Waterways Project: This project offers Manitoba educators a list of protocols for the following parameters:
  - Stream profiles (temperature, odour, colour, etc.)
  - Dissolved oxygen level
  - Nitrate level
  - Phosphate level
  - Bacteria count
  - Macro-invertebrate representation score
  - pH
  - Biological oxygen demand
  - Velocity
  - Total dissolved solids/conductivity
  - Total suspended solids/turbidity (water clarity)

  Available online at <http://home.cc.umanitoba.ca/~lewthwai/mwp/>.
- World Water Monitoring Day: World Water Monitoring Day is a month-long program that begins every year on September 18. Turbidity, temperature, DO, and pH test kits can be purchased online. Worksheets and lesson plans are available online. Students can post their data results online. Available online at <www.worldwatermonitoringday.org>.
- Nature Watch: Nature Watch has the following monitoring programs: plant, ice, frog, and worm. Background information and observation sheets are available for download. Collected data is displayed on the website. Available online at <www.icewatch.ca/english>.
- The Stream Study (Virginia, USA): This website explains the importance of macro-invertebrates and the materials and procedures needed to set up a monitoring program. This site contains a helpful electronic macro-invertebrate identification book. Available online at <people.virginia.edu/~sos-iwla/Stream Study/StreamStudyHomePage/StreamStudy.HTML>.

Social Aspects and Impacts to the Lake Winnipeg Ecosystem

In addition to the physical, chemical, and biological components of the Lake Winnipeg ecosystem, this resource includes the social and economic importance of the Lake Winnipeg ecosystem and the impacts that result if the ecosystem is disrupted by natural or human events.

A variety of learning experiences can be found in the third section of this resource, and teachers can cover these as a separate section or integrate them into the lessons.

Materials Required

- Lab equipment:
- Aquarium
- Thermometer
- Dissolved oxygen kit
- pH kit (or pH paper)
- Secchi disc
- Compound microscopes
- Microscope slides and cover slips
- Ocular micrometer
- Palmer counting chambers
- 300 mL BOD bottle or Pasteur pipette
- Manganous sulfate
- Alkaline iodide
- Starch solution
- Sulphuric acid (H_2SO_4)
- Standardized thiosulphate working solution (or PAO)
- Aluminum foil
- Graduated cylinder
- Erlenmeyer flask
- Burette
- Algae cultures

Resources to Plan Your Teaching

- Carlesen, William S., Nancy M. Trautmann, & the Environmental Inquiry Team. *Cornell Scientific Inquiry Series Student Edition, Watershed Dynamics.* Arlington, VA: National Science Teachers Association Press, 2004. An overview of the publication and online resources to accompany the book are available at <ei.cornell.edu/pubs/wd.asp>.

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

Videos

- Meeches, Lisa. "The Living Earth." *The Sharing Circle*, season 16, episode 6.

- ———. "The Voice of the Lake, Parts 1 and 2." *The Sharing Circle,* season 14, episodes 16 and 17. Available online at <www.thesharingcircle.com>. Available from the Manitoba Education Library (IRU #D-10548).

- Perkins, Lynsay. *Fat Lake: How Too Much of a Good Thing is Hurting Lake Winnipeg.* Available from the Manitoba Education Library (Instructional Resources Unit). Call #: D-12176.

- Siamandas, George. *Lake Winnipeg's Paradise Beaches.* Prairie Public Television, 2001. This video can be purchased through Prairie Public Television at <http://archive.prairiepublic.org/features/beaches/index.htm>, and is also available at the Winnipeg Public Library (VHS 917.1272).

Assessment Plan

Suggestions for assessment *for* learning and assessment *of* learning for each of the learning experiences.

Essential Question 1: Why Should We Care about Lake Winnipeg?

Lesson: Beautiful Lake Winnipeg! A Conservation Ethic?

Assessment *for* Learning: Provide students with feedback on their participation in the discussion. Ask students to submit an exit slip that describes the environmental ethic they agree with the most.

Assessment *of* Learning: Assess students on the clarity of their letter. Use the following criteria:

1. Identifies why Lake Winnipeg is important to him or her
2. Clearly identifies the ethic depicted in the postcard
3. Provides a justification for assigning the ethics to the picture

Lesson: Identifying the Importance of Lake Winnipeg as a Freshwater Ecosystem

Assessment *for* Learning: Provide students with feedback on their participation in discussion.

Lesson: What Is a Watershed? What Water Systems Characterize Lake Winnipeg?

Assessment *for* Learning: Have students submit answers to questions, and provide them with feedback.

Lesson: Characteristics of Lake Winnipeg: Lake Winnipeg Portfolio Assignment and Report Card

Assessment *for* Learning: Provide feedback to students as they progress through the report card assignment.

Assessment *of* Learning: Use the rubric provided to assess the report card. The summative assessment would not be completed until the end of the course.

Essential Question 2: How Does the Lake Winnipeg Watershed Affect Our Ability to Take Care of the Lake?

Lesson: Stream Order

Assessment *for* Learning: Provide students with feedback on their participation in discussion and their ability to identify stream order in one of the rivers in the Lake Winnipeg watershed.

Lesson: Inflow to Lake Winnipeg and Flood Forecasting

Assessment *for* Learning: Using a checklist, provide students with feedback on their computer skills and ability to work with electronic databases.

Assessment *of* Learning: Assess the answers to the questions at the end of the lesson.

Lesson: Bathymetry of Lake Winnipeg's North and South Basin

Assessment *for* Learning: Using a checklist, provide students with feedback on their computer skills and ability to work with electronic databases.

Assessment *of* Learning: Collect student responses to questions and provide feedback.

Lesson: How to Best Restore Lake Winnipeg from Shoreline Erosion

Assessment *for* Learning: Have students peer-edit each other's reports prior to submitting them.

Assessment *of* Learning: Collect and assess research reports on the shoreline erosion problem using the rating scale provided.

Lesson: Changes in the Netley Marsh

Assessment *for* Learning: Collect responses to questions and provide feedback, or go through the answers to the questions as a class, or have students peer-review answers to questions.

Assessment *of* Learning: Have students submit completed maps and summary paragraphs, and assess responses according to clarity and use of the literature to justify any claims.

Essential Question 3: How Are Social and Economic Activities Affecting the Health of Lake Winnipeg?

Lesson: The Living Earth

Assessment *for* Learning: Review responses in the exit slip, and provide comments on the student's use of evidence.

Lesson: Agricultural Operations

Assessment *for* Learning: Provide feedback to students on their participation in the town hall.

Assessment *of* Learning: Assess the report using the attached rating scale.

Essential Question 4: How Does Knowing Water Chemistry Help Improve Our Ability to Care for Lake Winnipeg?

Lesson: Introduction to Limnology

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.

Lesson: Water Quality

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

Lesson: Phosphorus in Lake Winnipeg

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

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

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.

Essential Question 5: How Can Biotic Parameters Indicate the Health of Lake Winnipeg?

Lesson: Prokaryotes in Lake Winnipeg

Assessment *for* Learning: Collect student responses to the cyanobacteria scavenger hunt, and provide them with feedback.

Lesson: Understanding Algae

Assessment *for* Learning: Provide students with feedback on their use of the microscope and creation of wet mounts.

Assessment *of* Learning: Assess the lab report using a rubric.

Lesson: Lake Productivity

Assessment *for* Learning: Provide students with feedback on their lab skills using a checklist.

Assessment *of* Learning: Assess the lab report using a rubric.

Lesson: Macroinvertebrates as Indicators of Water Quality

Assessment *for* Learning: Provide students with feedback on their participation in the discussion.

Assessment *of* Learning: Collect the individual conclusions students have drawn to the results collected by the class.

Lesson: Fish Populations

Assessment *of* Learning: Assess the presentation using a rubric.

Essential Question 1

Why Should We Care About Lake Winnipeg?

Essential Question 1: Why should we care about Lake Winnipeg?

Introduction

Lake Winnipeg is the sixth largest freshwater body in Canada. Approximately 25 percent of the Manitoba population lives on or around the lake, and many more spend their summer at nearby cottages and campgrounds. Due to the enormous size of the lake, its physical characteristics, and its economic and recreational uses, it is undergoing some changes. This section of the resource helps students understand why the lake is important to them by exploring their own environmental ethics, reviewing characteristics of watersheds, and deciding how they would "grade" the efforts to protect Lake Winnipeg.

Resources to Plan Your Teaching

Duguid, Terry, & Norm Brandson. *Restoring the Health of Lake Winnipeg, Technical Annex, Canada's Sixth Great Lake*. Winnipeg, MB: Lake Winnipeg Implementation Committee, 2005. Available online at <http://manitobawildlands.org/water_lakewpg.htm>. Please refer to pages 2–8 of this resource. You may wish to have the students read these pages as well.

Postel, S., L. Mastny, & Worldwatch Institute. *Liquid Assets: The Critical Need to Safeguard Freshwater Ecosystems*. Washington, DC: Worldwatch Institute, 2005.

Schindler, D.W., & J.R. Vallentyne. *The Algal Bowl: Overfertilization of the World's Freshwaters and Estuaries*. Edmonton, AB: University of Alberta Press, 2008.

UNESCO, & World Water Assessment Programme (United Nations). *Water: A Shared Responsibility* [Table of contents only]. United Nations Educational Berghahn Books, 2006. Available online at <www.loc.gov/catdir/toc/fy0710/2006299804.html> and <http://unesdoc.unesco.org/images/0014/001454/145405E.pdf>.

Wall-sized maps displaying Canada's watershed *(Discover Canada's Watershed Map*), are available by contacting Anne MacDiarmid, ESD Consultant for Manitoba Education, Telephone: 204-945-6943, Toll-Free: 1-800-282-8069, ext 6943, Email: <anne.macdiarmid@gov.mb.ca>

Notes

Lesson: Beautiful Lake Winnipeg! A Conservation Ethic

Specific Learning Outcomes

- **SLO B2**: Recognize that decisions reflect values, and consider their own values and those of others when making a decision. *Examples: maintaining/ preserving the environment, generating wealth, maintaining personal and economic freedoms, maintaining health and well-being…*
- **SLO C19**: Elicit, clarify, and respond to questions, ideas, and diverse points of view in discussions.
- **SLO D2**: Integrate knowledge from various disciplines beyond the natural sciences, as necessary, in order to complement and represent the scientific world view. *Examples: the arts, mathematics, language arts, social studies…*

Introduction

In this lesson, students will look at how their own decisions reflect their values in terms of environmental conservation.

Objectives

Students will identify their own environmental ethics in the context of Lake Winnipeg geography.

Teacher Background

There are various justifications for why it's important to protect the environment. These environmental beliefs may be based in the ecological, social, spiritual, or economic significance a space or place has; it might also be a combination of these viewpoints. Alternatively, these values may be further categorized as utilitarian, ecological, aesthetic, moral, or spiritual. These are all part of a new discipline called *environmental ethics*.

Utilitarian perspectives view the environment as a necessity for survival, and often include justifications that argue that the environment should be conserved for survival and economic benefit.

Ecological perspectives view the environment as a contributor to specific functions that are necessary for the persistence of life.

Aesthetic perspectives view the environment as beautiful and that beauty is of profound importance and value to people.

Moral perspectives view the environment as having a right to exist and that it is our moral obligation to protect and conserve it.

Spiritual perspectives view the environment as a creation that must be respected and preserved.

Aboriginal perspectives are diverse and can be looked at individually, such as in the following quotation: "teachings describe the relations all around—animals, fish, trees, and rocks—as our brothers, sisters, uncles, and grandpas. Our relations to each other, our prayers whispered across generations to our relatives, are what bind our cultures together. The protection, teachings, and gifts of our relatives have for generations preserved our families. These relations are honored in ceremony, song, story and life that keep relations close—to buffalo, sturgeon, salmon, turtles, bears, wolves and panthers. These are our older relatives—the ones who came before and taught us how to live. Their obliteration by dams, guns, and bounties is an immense loss to Native families and cultures. Their absence may mean that a people sing to a barren river, a caged bear, or buffalo far away. It is the struggle to preserve that which remains and the struggle to recover that characterizes much of Native environmentalism. It is these relationships that industrialism seeks to disrupt."

LaDuke, Winona. *All Our Relations, Native Struggles for Land and Life.* Cambridge, MA: South End Press, 1999.

Resources to Plan Your Teaching

Environmental Ethics

- "The Voice of the Lake, part 1 and part 2." *The Sharing Circle* (season 14, episodes 16 and 17): These episodes document the journey of a high school music teacher who was commissioned to create a musical composition to heal Lake Winnipeg. These episodes involve the personal journey of the teacher in finding his Aboriginal identify while creating the composition. This story provides one example of a spiritual ethic.
- Santa Clara University, the Jesuit University in Silicon Valley, Ethics Department: This site provides 12 short environmental ethics lessons. The background information could be useful. Available online at <www.scu.edu/ethics/practicing/focusareas/environmental_ethics>.
- Environmental Ethics, compiled by Prof. Ron Epstein: Available online at <http://online.sfsu.edu/~rone/Environ/Enviroethics.htm>.

Pictures of the Lake Winnipeg Region

- Geological Survey of Canada: The above link provides pictures of the following locations in and around Lake Winnipeg: Grand Beach, Sandy Bar, Netley Marsh lagoon, Limestone Bay, Grand Marais, and Willow Point. Available online at <http://gsc.nrcan.gc.ca/landscapes/provinces_e.php?SelectedProvince=&SelectedGlossary=&SelectedKeyworda=Lake+Winnipeg&SelectedKeywordb=&SelectedKeywordc=&SelectedKeywordd>.

- Canadian Parks and Wilderness (CPAWS), Manitoba Chapter: Canadian Parks and Wilderness (CPAWS) is a national Canadian environmental organization working to protect our natural areas through grassroots efforts. The CPAWS site provides many photographs of the Lake Winnipeg region. These can be found in the site's "photo galleries" drop-down menu. Available online at <www.cpawsmb.org>.

- Wilderness Committee (WC), Manitoba Chapter: The Wilderness Committee works throughout Canada to preserve wilderness species and areas through public education, research, and grassroots campaigns. The WC site offers a photo gallery of various places in the Lake Winnipeg region, including photos of some of the issues affecting Lake Winnipeg, such as clear-cut logging. Available online at <www.wildernesscommittee.mb.ca>.

The Three A's

Activate: Ask students whether they have considered why they are interested in learning about environmental stewardship. Have them write down their primary reason(s) for wanting to learn about Lake Winnipeg.

Acquire and Apply: Watch the video *Lake Winnipeg's Paradise Beaches* by George Siamandas. This video can be purchased through Prairie Public Television at <http://archive.prairiepublic.org/features/beaches/index.htm> or borrowed from the Winnipeg Public Library (VHS 917.1272). A video script is available online at Winnipeg-based photographer George Siamandas' website at <http://siamandas.ca/wp1/?page_id=68>. Follow this page's link or visit <www.siamandas.com> to find many gorgeous photos of Lake Winnipeg attached to a poem entitled "The Many Moods of Lake Winnipeg" by George Siamandas. The poem and photos are found under the website's photo gallery "Lake Moods" section. Alternatively, select a few YouTube clips that represent a variety of views about Lake Winnipeg.

Have students point out the landscape features in the film that they found appealing and unique. Introduce students to some of the defining features of the greater Lake Winnipeg basin by passing around some sample photos. Ask students what they think and feel when they look at the photos. Have students write down reasons for why they think these sites should be protected or conserved.

Probing Questions

1. Are there more photos of destruction or of landscapes that appear intact?
2. Which do they think would be more effective in stating their viewpoint?
3. What percentage of the class pictures are of land, animals, and water?
4. What do students identify and connect with? Why?

5. Do we need environmental ethics for conservation?

Using the videos, photos, and student-provided reasons as a context, present to students the various moral justifications for protecting the environment. Discuss the various environmental justifications. Have students evaluate their own reasons for protecting Lake Winnipeg using different ethical perspectives. Hold a discussion with students. Do they share similar views?

Split students into five groups and provide each group with one article, a section of an article, or a quote. Have students read the material and decide the perspective the author uses to make his or her point (see samples provided). Student groups can present their opinion to the rest of the class.

Have students find two photos that they feel represent their ethic for environmental protection. Ask students to write a letter (e.g., poetry, prose, academic writing, etc.) using this perspective to an individual of their choice on the back of the card. The letter should identify why the lake is important to them. Have students email/mail the cards to other classmates or an individual of their choice to initiate further discussion on identifying views and how others interpret protection.

Assessment

Assessment *for* Learning: Provide students with feedback on their participation in the discussion. Ask students to submit an exit slip that describes the environmental ethic they agree with the most.

Assessment *of* Learning: Assess students on the clarity of their letter using the following criteria:

1. Identifies why Lake Winnipeg is important to him or her
2. Clearly identifies the ethic depicted in the postcard
3. Provides a justification for assigning the ethics to the picture

Response Pieces

Example 1

"With its beautiful beaches and wide open waters, Lake Winnipeg is one of Manitoba's greatest freshwater resources. The world's 10th largest freshwater lake plays a critical role in tourism, recreation, commercial and sport fisheries, and hydroelectric generation in Manitoba. The lake is home to abundant aquatic life including fish, invertebrates, and plants. Over 23,000 permanent residents live in 30 communities along the shores of Lake Winnipeg. Lake Winnipeg's world-class beaches attract many visitors to the province and opportunities for swimming, paddling, sailing, and windsurfing can be found on the east and west shores. Each year, approximately 800 commercial fishers operate on Lake Winnipeg, catching a variety of species including world-class pickerel, goldeye, sauger, whitefish, plus others. Sport anglers find many places to drop a line while enjoying the lake's beauty. Lake Winnipeg is also the world's third largest reservoir, generating hydroelectric power for all Manitobans."

Manitoba Water Stewardship, retrieved from <www.gov.mb.ca/waterstewardship/water_quality/lake_winnipeg/index.html>.

(continued)

Example 2

lake winnipeg in april

the earth shivers beneath snow and frozen stone
cherry branches bend sharp and brittle against
the azure of manitoba sky
winter's freeze has penetrated much too deeply
inside my soul the april sun moves
low on the horizon and whispers
you will be sufficient for all that comes to you
my boots trample the brown withered
leaves of the blue flag iris
greek goddess of the rainbow
i am it's seed tiny enough to be
insignificant tiny enough to have lost
the ancient memory, the push into the cool
moist soil, the warmth of sun
the softening of rain
the reaching down of roots
the reaching up of leaves and flowers
i stumble on toward the lake
slipping on cold and slush
i am the bud on the wild cherry bush
tightly wound and wounded
my first small birthing breath is mostly
foolhardy faith and yet
the swelling grows within
and i can almost taste
soft color, beauty, fragrance
i am a drop of water one of billions
in this lake frozen into mute expanse
from somewhere deep inside
i hear a first clear crystal note a rumbling
a rushing all around and underneath
i feel the energy of water the push
of ice expanding a symphony
beginning in lone notes and growing
to vibrations strong enough to move
this formless void
Creation never dreamed in frozen sleep
i move in rush of crystals long and
beautiful pushing glittering in the sun
lifting up into a shimmering wall
huge boulders ten feet tall
ice chiming into mountains
ice on ice and snow on snow
crystal water piling up to make a
space for all believers in new beginnings
to pass in safety to the other side
to leave the slavery and death of
insignificance, of being lost
to walk through this new path to
sing the song the song that rings in
glorious harmony
you will be sufficient for
all that comes to you and what it is
is life.
madeleine enns

(continued)

Example 3

"Following the 1997 Red River Flood and the 1998 International Joint Commission study of flooding impacts on Lake Winnipeg's south basin, a handful of researchers at the Freshwater Institute, Department of Fisheries and Oceans (DFO), and the University of Manitoba (UM) reached a consensus that flooding impacts on the entire lake needed study. They agreed that the lack of a scientific understanding required a research plan similar to the long-term programs established for the Laurentian Great Lakes. Not since the Lake Winnipeg surveys in 1969 by the Fisheries Research Board of Canada had any intensive limnological studies been undertaken, in spite of considerable economic development occurring throughout the watershed over the intervening 30 years. The LWRC 1999 survey, enabled by funding from Manitoba Hydro and provincial and federal sources, revealed that the Lake Winnipeg ecosystem had changed substantially since 1969—particularly its north basin phytoplankton community, which had become dominated by surface-forming cyanophyte (bluegreen algae) blooms. New exotic biota had entered the lake and their impacts on the food web were unknown. The 1999 survey findings were followed by several media reports and government deliberations. In February 2003, the Lake Winnipeg Action Plan was announced by Manitoba Water Stewardship."

Lake Winnipeg Research Consortium. *2007 Annual Report*. Retrieved from <www.lakewinnipegresearch.org/pdf%20files/LWRC2007ReportFinal.pdf>.

Example 4

The article "Perspective: Pale green: On matters environmental, we fade to the back of the pack" by Mary Agnes Welch and Lindsay Wiebe was posted 04/05/2009 in the *Winnipeg Free Press* (online edition). The article examines a number of environmental issues. Go to the website at <www.winnipegfreepress.com/local/Pale-green-42494747.html> and scroll down to the heading "Lake Winnipeg." The article mentions Lake Winnipeg issues, including phosphate-free soap, the hog barn ban, and the City of Winnipeg sewer system.

Example 5

The article "Keep east side pristine" by David W. Schindler was printed on 01/11/2008 in the *Winnipeg Free Press* (print edition). This article examines the issue of running a power line east of Lake Winnipeg. It is available at <www.winnipegfreepress.com/historic/32670029.html>.

Lesson: Identifying the Importance of Lake Winnipeg as a Freshwater Ecosystem

Specific Learning Outcomes

- **SLO B1:** Identify and explore a current STSE issue. *Examples: clarify what the issue is, identify different viewpoints and/or stakeholders, research existing data/ information…*
- **SLO C1:** Identify and investigate questions that arise from practical problems and issues.
- **SLO C2:** Clarify problems and refine testable questions to facilitate investigation. *Examples: develop a testable question appropriate to circumstances; define and delimit the kind and number of inquiry pathways…*
- **SLO C11:** Synthesize information obtained from a variety of sources.
- **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.
- **SLO D2:** Integrate knowledge from various disciplines beyond the natural sciences, as necessary, in order to complement and represent the scientific world view. *Examples: the arts, mathematics, language arts, social studies…*

Introduction

In this lesson, students will look at the various ways Lake Winnipeg is used, and identify how the uses of the lake affect its ecosystem. This lesson is important, as it begins to look at the complexity of the lake ecosystem.

Objectives

Identify factors that affect the Lake Winnipeg ecosystem by creating questions that probe environmental, economic, and socio-cultural activities on the lake.

The Three A's

Activate: Brainstorm in a group or as a class all the different ways Lake Winnipeg and its water is used.

Acquire and Apply: Show students the video *Fat Lake: How Too Much of a Good Thing is Hurting Lake Winnipeg*, written and directed by Lynsay Perkins (available from the Manitoba Education Library). Have student groups identify the many uses of Lake Winnipeg and its water, as well as the characteristics of the lake ecosystem, and put each use on a sticky note or separate piece of scrap paper. As a class, create a master list of the many uses of Lake Winnipeg and

its water. Add items to the list that were not necessarily in the video. Discuss how the list of characteristics and uses could be grouped. Have the student groups create a cluster diagram showing how they have grouped the identified uses of the lake.

Probing Questions

1. How do your recreational activities in a lake affect the activity of fish, birds, and other mammals?
2. How does commercial fishing affect aquatic plants?

After creating a more complete set of uses, have students individually create five questions examining the inter-relationship between categories that they would want to try to answer while in the course. *For example: How do the recreational activities affect the ecology of the lake?* (socio/cultural; environment) *How do the farming activities surrounding the lake affect the nutrient load in the lake?* (socio-cultural; environment).

> **Teacher's Note:**
>
> This could easily become an inquiry-based essay assignment where students conduct their own research and produce a research essay on one of the questions they have identified.

Assessment

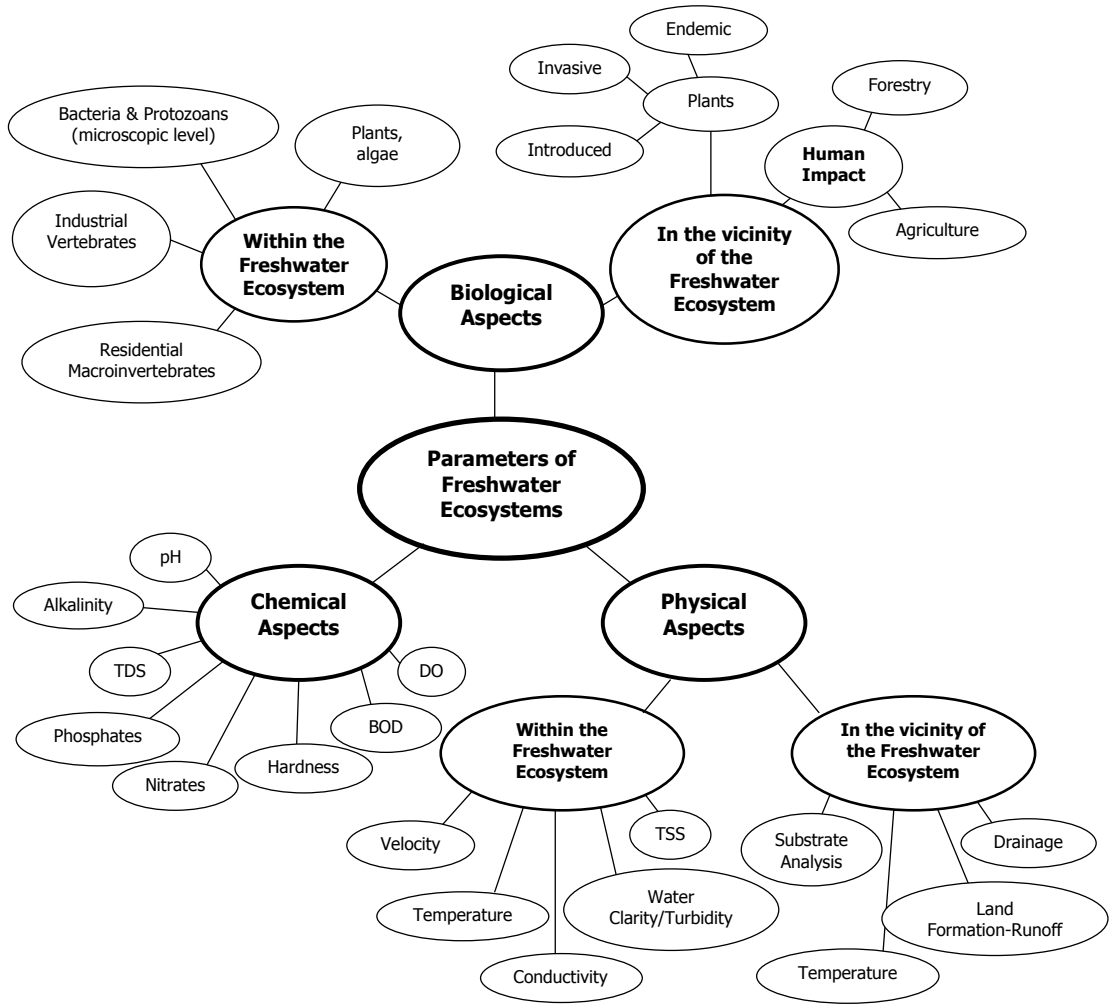
Assessment *for* Learning: Provide students with feedback on their participation in the discussion.

Assessment *of* Learning: Assess students on the clarity of their questions.

Brainstorm Examples of Characteristics and Uses of Lake Winnipeg:

- Swimming
- Fishing
- Photography
- Relaxing
- Drinking
- Boating
- Suntanning
- Tourism
- Holidaying
- Cottaging
- Sailing
- Water-skiing
- Appreciating
- Habitat for fish
- Breeding areas for water birds
- Habitat for mammals like beaver and muskrat
- Electricity
- Habitat for aquatic plants and algae
- Providing oxygen
- Wetlands
- Rare species habitat: piping plover, snail

Sample Cluster Diagram



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

Lesson: What is a Watershed? What Water Systems Characterize Lake Winnipeg?

Specific Learning Outcome

- Integrate knowledge, as necessary, from various science specialties in order to address an issue, engage in problem solving, or conduct scientific inquiries.

Introduction

This is a review of material that was covered in Grade 8: Water Systems, where students studied watersheds and standing and flowing water formations. It is important to review or ensure that students still have a good grasp of the concepts of watershed and watershed dynamics. In order to understand the complex issues involved in Lake Winnipeg, they need to understand that the watershed for Lake Winnipeg is immense. This lesson looks at how the watershed parameters are determined.

Objectives

Discover how to delineate a watershed.

Teacher Background

A drainage basin or watershed is an area that drains all forms of precipitation (above and below ground sources) into one area (river, lake, ocean). For example, Lake Winnipeg is part of the Nelson River drainage basin. The Nelson River drainage basin is one of 23 basins that drain into Hudson Bay. This area can be further divided into the Lake Winnipeg watershed, then into the following sub-basins or watersheds: Saskatchewan River, Lake Manitoba, Assiniboine River, Red River, Winnipeg River, and Lake Winnipeg. These can be further divided into smaller sub-basins or watersheds. Please see this lesson's maps:

Delineation of a Watershed: The parameters of a watershed are determined by identifying a point of interest (e.g., a point on Lake Winnipeg where a monitoring station would be, or the location of a school), and then looking at the contour lines on a contour map and drawing drainage lines.

To be consistent within the curriculum, when referring to the Lake Winnipeg watershed we are referring to all of the drainage areas that flow into Lake Winnipeg (including the Saskatchewan River, Lake Manitoba, the Assiniboine River, the Red River, and the Winnipeg River).

For a detailed description of the Lake Winnipeg watershed, refer to pages 2–9 of *Restoring the Health of Lake Winnipeg, Technical Annex, Canada's Sixth Great Lake* by Terry Duguid and Norm Brandson. Available online at <http://manitobawildlands.org/water_lakewpg.htm>.

Resources to Plan Your Teaching

Maps

1. Hudson Bay Drainage Basin
   http://atlas.nrcan.gc.ca/site/english/maps/environment/hydrology/watershed
2. Nelson River Drainage Basin
   http://atlas.nrcan.gc.ca/site/english/maps/environment/hydrology/drainagebasins
3. Lake Winnipeg Watershed
   www.lakewinnipeg.org/web/downloads/LakeFacts_Watershed.pdf
4. Lake Winnipeg Drainage Basins
   http://mbeconetwork.org/lake_winnipeg_watershed/
5. Manitoba Basins and Watershed Boundaries
   www.gov.mb.ca/waterstewardship/waterstrategy/pdf/index.html
   (Download the full *Manitoba Water Strategy* pdf to view the large map in its appendix.)
6. Watersheds of Manitoba
   www.cier.ca/information-and-resources/publications-and-products.aspx?id=1048
7. East Side of Lake Winnipeg Watersheds
   www.gov.mb.ca/conservation/wno/status-report/index.html
   (found under reference maps) or
   www.gov.mb.ca/conservation/wno/maps/index.html
   (found under Boreal Forest)
8. Sub-basins of the Red River Basin
   www.pca.state.mn.us/water/basins/redriver/subbasins.html

Introductory Watershed Resources

Water on the Web is a great resource for water-related information and activities at the high school level. It can be found at <http://waterontheweb.org/under/watersheds/index.html>.

The Manitoba Eco-network has a great web page on Lake Winnipeg and the major drainage basins that are part of its watershed. The site is located at <www.mbeconetwork.org/water/LWpgmain.php>. Another useful Manitoba Eco-Network resource is its Water Caucus's publication page, which can be found at <http://mbeconetwork.org/publications/>. *Around the Lake Winnipeg Watershed* is one of the Water Caucus's water tabloid publications that provide great graphics and an overview of the Lake Winnipeg watershed.

The Environment Canada Research site found at <http://map.ns.ec.gc.ca/reseau/en/> is also useful for conducting research, as are the local and regional watersheds. Students can enter their city or town name and get some maps and information about the local watershed.

The Three A's

Activate: Review with students the definition of a watershed.

Using the maps available and displayed, ask students what criteria they might use to delineate a watershed.

Acquire and Apply: Using the above resources, have students delineate their local watershed, and answer questions about the importance of the watershed on the health of Lake Winnipeg.

Assessment

Assessment *for* Learning: Have students submit answers to questions, and provide feedback.

Notes

Student Handout: Lake Winnipeg Questions

1. The Saskatchewan River is constantly under threat of more hydro development, which would result in reduced inflow of water to Lake Winnipeg. According to David Schindler, the Saskatchewan River basin is important to the control of algal blooms in Lake Winnipeg because…

2. In the Lake Winnipeg basin, what are two important sources of nutrient loading?

3. In the Lake Winnipeg basin, what are the effects of leaching and erosion from forestry or wildfires?

(continued)

4. Why is the Red River drainage basin so important in understanding the source of nutrients in Lake Winnipeg?

5. Why does the Red River basin provide such a large source of phosphorus to Lake Winnipeg?

Lake Winnipeg Questions Answer Key

1. The Saskatchewan River is constantly under threat of more hydro development, which would result in reduced inflow of water to Lake Winnipeg. According to David Schindler, the Saskatchewan River basin is important to the control of algal blooms in Lake Winnipeg because…

   The Saskatchewan River basin is a major contributor to the quantity of water that goes into Lake Winnipeg, and there is a possibility that this quantity of water will drop off. This would have the same effect as increasing the amount of nutrients that go into the lake, because the reduction in water would increase the concentration of nutrients.

2. In the Lake Winnipeg basin, what are two important sources of nutrient loading?

   Livestock production in and around the lake and inadequate cottage sewage systems are two important sources of nutrient loading to Lake Winnipeg.

3. In the Lake Winnipeg basin, what are the effects of leaching and erosion from forestry or wildfires?

   Both leaching and erosion cause dissolved organic matter and nutrients to go into the water. Phosphorus is one example of a nutrient that contributes to an increase in blue-green algae. Other effects are less clarity in the water (greater turbidity) and lower oxygen levels.

4. Why is the Red River drainage basin so important in understanding the source of nutrients in Lake Winnipeg?

   The Red River drainage basin is the most significant because it contributes much of the nitrogen and phosphorus found in Lake Winnipeg.

5. Why does the Red River basin provide such a large source of phosphorus to Lake Winnipeg?

   The Red River travels through very active agricultural areas, and it receives water from tributaries such as the Seine River, which travels through sections where there is a great deal of hog farming.

Lesson: Characteristics of Lake Winnipeg; Lake Winnipeg Portfolio Assignment and Report Card

Specific Learning Outcomes

- **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.
- **SLO C11:** Synthesize information obtained from a variety of sources.
- **SLO C14:** Communicate information in a variety of forms appropriate to the purpose, audience, and context. Include: technical science writing *(e.g.,proposals, laboratory reports, research reports…)*, popular science writing *(e.g., magazine articles, comics, short stories, poetry…).*
- **SLO C17:** Select and use appropriate media to communicate information/ data/ideas. *Examples: software, video, photography, visual arts…*
- **SLO C21:** Demonstrate confidence in their ability to carry out investigations and to address STSE-related issues.
- **SLO C22:** Value skepticism, honesty, accuracy, precision, perseverance, and open-mindedness as scientific and technological habits of mind.

Introduction

There are many environmental organizations that monitor the effectiveness of governments in following through with initiatives and policies established to ensure that the health of an ecosystem is maintained. Students have previously explored the Lake Winnipeg watershed and identified certain characteristics. They have identified the social, economic, and environmental issues of the lake, and have identified some issues associated with caring for the lake. Through the remainder of their study of Lake Winnipeg, students will be compiling a report card on the progress of recommendations made by the Lake Winnipeg Stewardship Board.

Objectives

Identify some of the characteristics of the Lake Winnipeg watershed, and evaluate the effectiveness of the policies established to protect the lake.

Teacher Background

This lesson is part of a cumulative activity, stretching though the next three sections of this resource. Throughout the duration of their study of

Lake Winnipeg, students will use information gathered in this lesson and subsequent lessons to build a portfolio on the watershed, water quality, and ecosystem health of Lake Winnipeg. The final activity will be the completion of a report card on the health of Lake Winnipeg. Students will need to keep all assignments, as these can be used as their reference material in creating the report card. Students should be encouraged to seek out other publications as reference material. Students will be given the assignment shown below to create the report card.

Resources to Plan Your Teaching

- *How Canada Performs: A Report Card on Canada*
  This website identifies indicators used to evaluate how Canada performs in relation to 17 other countries, and gives Canada a grade on economy, innovation, environment, education, health, and society. The environmental link is especially useful as it provides the indicators for creating the grade.
  www.conferenceboard.ca/HCP/default.aspx

- *Waterproof 2: Canada's Drinking Water Report Card*
  This report identified how the regional treatment of water varied in Canada, and evaluated each province on the treatment of its drinking water resources.
  www.waterquality.ec.gc.ca/web/Environment~Canada/Water~Quality~Web/assets/PDFs/waterproof.II.report.pdf

- *Canada's National Sewage Report Card 2*
  This report describes and grades the wastewater treatment for 21 cities in Canada.
  www.ecojustice.ca/publications/reports/the-national-sewage-report-card-ii?searchterm=report+card

- *The Nottawasaga Valley Conservation Authority Watershed Report Cards*
  (see <www.nvca.ca>) These are good examples of the types of report cards that can be created for the Lake Winnipeg watershed or a sub-watershed. The reports are simple to understand, provide a summary of the grades on the front page, and then go into more detail for each of the areas graded. The following link is a report on a sub-watershed that could be used as a sample.
  www.town.bradfordwestgwillimbury.on.ca/ws_par/groups/public/@pub/@nvca/documents/web_content/wspar_01671

The Three A's

Activate: Ask students whether they have been on or along the shores of Lake Winnipeg, or to bring in pictures they may have of a part of Lake Winnipeg. Have each student provide a description of the lake and post some of the features so the class can see. Show a map of the lake, and have students add other characteristics to the list already posted.

Acquire and Apply: Have students read the description on pages 4–6 of the Lake Winnipeg Stewardship Board report to the Minister of Water Stewardship, *Reducing Nutrient Loading to Lake Winnipeg and Its Watershed: Our Collective Responsibility and Commitment to Action* (see <www.lakewinnipeg.org/web/downloads/LWSB_December_2006_Report_3.pdf>). This document provides a short and clear description of the physical characteristics of Lake Winnipeg. Have students identify all the physical characteristics of the lake by underlining or highlighting the features. As well, provide students with a map of the Hudson Bay watershed. A map entitled *Discover Canada's Watershed* can be ordered at no cost from the Canadian Wildlife Federation (see <www.wildeducation.org/programs/oceans06/watershed_map.html>).

Write the following question on the board:

How do the unique characteristics of Lake Winnipeg impede or assist our ability to become better stewards of the lake?

Discuss the question, and then explain the following scenario:

Lake Winnipeg Report Card: A Problem-Based Assignment

Since 1993, the Sierra Club of Canada has written a report card for the Canadian federal and provincial governments on commitments they made at the 1992 Earth Summit in Rio de Janeiro. In the case of the Sierra Club report card, the provinces are graded on their commitments to climate change and biodiversity (see <www.sierraclub.ca/national/rio/>).

Scenario

> The Lake Winnipeg Stewardship Board (LWSB) is currently designing a report card system to evaluate their commitment to improving the state of Lake Winnipeg. In its December 2006 publication *Reducing Nutrient Loading to Lake Winnipeg and Its Watershed: Our Collective Responsibility and Commitment to Action* (see <www.lakewinnipeg.org/web/downloads/LWSB_December_2006_Report_3.pdf>), the LWSB identified 38 sets of recommendations that need to be addressed in order to take care of Lake Winnipeg and its watershed. Manitoba Water Stewardship released this report on February 6th, 2007. The stewardship board, which is now responsible for monitoring how these recommendations are undertaken, will create a grading system that helps them monitor how effective they are in dealing with the recommendations that describe the health of the watershed, water quality, and the Lake Winnipeg ecosystem. It is your job to create a report card for the state of Lake Winnipeg using some of these recommendations. The report card will be based upon the parameters that you select as the most important indicators of watershed, water quality, and ecosystem health.

The report card assignment will be set up as a portfolio with a few mandatory entries. The select entries provide evidence for your grading of the

parameters you select to include in the report card. In the following weeks, you will be looking at Lake Winnipeg from a watershed, water quality, and biological perspective, and will explore different parameters for each of these approaches. After each section, you will be expected to develop grades for three different parameters that will then be included in a final report (a total of nine parameters must be included in the portfolio). Your final report will grade a minimum of three parameters each for watershed, water quality, and ecosystem health. For each grade assigned, you need to provide a summary description of the parameter and a justification for the grade by using classroom-obtained data, experiments conducted on your own, and/or readings, articles, or interviews. You will create a presentation (this could be a bulletin board assignment as well) that outlines your report and the grading system you used.

Using information from the hydrology section (found as subsection of Environment) on the *Atlas of Canada* website (see <http://atlas.nrcan.gc.ca/site/english/index.html>), identify your drainage basin and create thematic maps for any of the following:

- Drainage Basins Map
- Watersheds Map
- Physical Components of Watersheds Map
- Human Components of Watersheds Map
- Current Water Levels Map

Using this information, create the first five entries of the Lake Winnipeg portfolio assignment. For each entry, discuss your findings in small groups.

> **TEACHER'S NOTE:**
>
> The provided maps (which can be found in the following student handout) can be used to complete entry 2 of the portfolio assignment, as the relief is shown in much more detail.

The first five entries to the assignment will be a general description of the Lake Winnipeg watershed and serve as an introduction to the report card.

Assessment

Assessment *for* Learning: Provide feedback to students as they progress through the report card assignment.

Assessment *of* Learning: Use the provided rubric to assess the report card. The summative assessment would not be complete until the end of the course.

Rubric for Report Card Assignment

	1	2	3	4
Information Seeking, Selecting, and Evaluating	Information gathered lacked relevance, quality, depth, and balance.	Information was gathered from a limited range of resources and displayed minimal effort in selecting quality resources.	Information was gathered from a variety of quality electronic and print resources.	Information was gathered from a variety of quality electronic and print resources. Sources are relevant and balanced and used to justify the grading system used in the report.
Analysis	Conclusions were not supported by any evidence.	Conclusions could be supported by stronger evidence.	Good effort was shown in analyzing the information and making conclusions or inferences to support grading system.	Student carefully analyzed the information and drew appropriate conclusions or inferences to support grading system.
Synthesis	Student work in not logically or effectively structured.	The information is organized but greater effort could have been made to draw connections between ideas.	The information is logically organized and there are good connections made among ideas.	The information is logically and creatively organized with smooth transitions. The justification for grades assigned is clear and well supported.
Documentation	Documentation of sources was absent.	Documentation of sources was poorly constructed or absent.	Sources are documents with some care and citations in-text and in works cited are mostly accurate.	All sources are clearly documented. Sources are properly cited in-text and on Works Cited page.
Product	Student showed little evidence of thoughtful research. The report card does not convey ideas effectively.	Student needs to work on communicating ideas more effectively. The report card is unclear.	The report card effectively communicates the information to the audience.	The report card is visually creative and original. The presentation of information is organized and clear.

Notes

Student Handout: Portfolio Assignment: A Lake Winnipeg Report Card

Since 1993, the Sierra Club of Canada has written a report card for the Canadian federal and provincial governments on commitments they made at the 1992 Earth Summit in Rio de Janeiro. In the case of the Sierra Club report card, the provinces are graded on their commitments to climate change and biodiversity (see <www.sierraclub.ca/national/rio/>).

Scenario

The Lake Winnipeg Stewardship Board (LWSB) is currently designing a report card system to evaluate their commitment to improving the state of Lake Winnipeg. In its December 2006 publication *Reducing Nutrient Loading to Lake Winnipeg and Its Watershed: Our Collective Responsibility and Commitment to Action* (see <www.lakewinnipeg.org/web/downloads/LWSB_December_2006_Report_3.pdf>), the LWSB identified 38 sets of recommendations that need to be addressed in order to take care of Lake Winnipeg and its watershed. Manitoba Water Stewardship released this report on February 6th, 2007. The stewardship board, which is now responsible for monitoring how these recommendations are undertaken, will create a grading system that helps them monitor how effective they are in dealing with the recommendations that describe the health of the watershed, water quality, and the Lake Winnipeg ecosystem. It is your job to create a report card for the state of Lake Winnipeg using some of these recommendations. The report card will be based upon the parameters that you select as the most important indicators of watershed, water quality, and ecosystem health.

This assignment will be set up as a portfolio with a few mandatory entries. You will then provide evidence for the grades you assign each of the parameters you select to include in the report card.

In the following weeks, you will be looking at Lake Winnipeg from a watershed, water quality, and biological perspective, and explore different parameters for each of these approaches. After each approach is covered, you will be expected to develop grades for three different parameters that will then be included in a final report (a total of nine parameters must be included in the portfolio). Your final report will grade a minimum of three parameters each for watershed, water quality, and ecosystem health. For each grade assigned, you need to provide a summary description of the

(continued)

parameter and a justification for the grade by using classroom-obtained data, experiments conducted on your own, and/or readings, articles, or interviews.

You may be required to create a presentation or bulletin board that outlines your report and the grading system you used.

Portfolio Layout

For an outline of all the entries required for the portfolio, see Table 1.

For the initial entries into your portfolio, you will explore the physical geography of Lake Winnipeg by creating five different maps.

Go to the Atlas of Canada website (see <http://atlas.nrcan.gc.ca/site/english/index.html>). Using the site's hydrology section (which is a subsection of Environment), you will be able to identify your drainage basin and create thematic maps for any of the following:

- Drainage Basins Map
- Watersheds Map
- Physical Components of Watersheds Map
- Human Components of Watersheds Map
- Current Water Levels Map

Using this information, create the first five entries of the Lake Winnipeg portfolio assignment. For each entry, discuss your findings in small groups.

Table 1: Portfolio Requirements

Entry	Map	Small Group Discussion	Individual Entry
1	Map showing Lake Winnipeg watershed/ drainage basin	When looking at the size of the watershed/ drainage basin, discuss the challenges that governments, researchers, and water stewards have in monitoring pollutants entering Lake Winnipeg.	Reflect on the group discussion and provide a personal view of the most difficult challenges water stewards will have in monitoring pollutants entering Lake Winnipeg.

(continued)

Entry	Map	Small Group Discussion	Individual Entry
2	Relief map of the land surrounding the entire lake or a section of the lake. Draw drainage arrows onto the map.	When looking at the topography of Lake Winnipeg and the drainage, discuss the challenges to monitoring and preventing pollutants from entering the lake.	Reflect on the group discussion and provide a personal view of the most difficult challenges water stewards will have in monitoring pollutants entering Lake Winnipeg.
3	Select two other maps under the physical components of the watershed.	Discuss how the physical components of the lake may affect the way we can take care of the lake.	Summarize or discuss how the two physical components affect the way we take care of the lake.
4	Human components of the watershed: create a map of the agricultural areas in the watershed.	Discuss how the distribution of agricultural activity can affect the lake and the challenges to looking after Lake Winnipeg.	Reflect on the group discussion and suggest some possible way to reduce the impacts of agriculture on the Lake Winnipeg watershed.
5	Select two other maps under the human components in the watershed.	Discuss how these human components of the watershed may affect the way we can take care of the lake.	Summarize or discuss how the two additional human components affect the way we take care of the lake.
6–8	Provide at least three entries identifying the parameters for the watershed that will be indicators for the report card.		In these entries, include research, experiments, interviews, etc., that were conducted to explore the parameters further.
9–11	Provide at least three entries identifying the parameters for the chemistry of the lake that will be indicators for the report card.		In these entries, include research, experiments, interviews, etc., that were conducted to explore the parameters further.
12–14	Provide at least three entries identifying the parameters for the biology of the lake that will be indicators for the report card.		In these entries include research, experiments, interviews etc. that were conducted to explore the parameters further
15	Report card		Provide a summarized account of the watershed and the chemical and biological parameters examined, and give each a grade.

Sample Entry:

The Lake Winnipeg Watershed

Source: Reproduced from <www.ec.gc.ca> under the terms for non-commercial reproduction as cited therein.

The Hudson Watershed

The Lake Winnipeg watershed is almost one million square kilometres. Over six million people live in this area, stretching from the Rocky Mountains across the prairies, its wetlands, and the taiga. It is an area of enormous human activity. Human population numbers and the resulting human activities, such as agriculture, make up just part of the many challenges that water stewards face.

As the watershed crosses First Nations territories, four provinces, and four US states, monitoring the incoming water is an issue. Also, water is a provincially controlled resource. As such, the quality and care are causes for concern, as watersheds flow through and are not regulated by political boundaries.

Sample Report Card:

A Report Card on the Health of Lake Winnipeg

This sample report card lists some of the parameters students can use to assess the health of Lake Winnipeg.

The Watershed

Grade	Parameter	Justification/Comments
	Red River flood management	
	Cooperation and collaboration	
	Livestock management	
	Public education and outreach	

Water Quality

Grade	Parameter	Justification/Comments
	Cosmetic use of pesticides	
	Sewage	
	Nutrient reduction	

Ecosystem Health

Grade	Parameter	Justification/Comments
	Boreal forest conservation	
	Wetland conservation	
	Endangered species	

Essential Question 2

How Does the Lake Winnipeg Watershed Affect Our Ability to Take Care of the Lake?

Essential Question 2: How does the Lake Winnipeg watershed affect our ability to take care of the lake?

Introduction

Although students looked at watersheds in Grade 8, the topic was not context-specific. It only provided an introduction to the topic of watershed, and it provided just a brief opportunity to explore the terminology used to understand watersheds. In this section, students will be exposed to an in-depth look at watersheds and use Lake Winnipeg as their context for learning. This section will explore some ways to describe the Lake Winnipeg watershed, such as identifying stream order, looking at how to examine and predict flooding, describing the "topography of a lake" (bathymetry), and exploring the importance of maintaining a shoreline. Finally, students explore the Netley-Libau marsh wetland, as well as the impact wetlands have on a watershed. Students are asked to reflect on how each of these watershed features affects the way we can take care of a lake such as Lake Winnipeg.

Resources to Plan Your Teaching

- Soukhome, J., G. Peaslee, C. Van Faasen, & W. Statema. *Watershed Investigations: 12 Labs for High School Science*. Arlington, VA: National Science Teachers Association, NSTA Press, 2009. This valuable resource provides some excellent investigations. It can be ordered through the NSTA website at <www.nsta.org>. The investigation in Chapter 8, "Flood Frequency Analysis for a River," is included in this document with modifications to suit the Lake Winnipeg context. Other excellent investigations can be found in Chapter 6: Stream Channel Morphology. This is a great investigation on stream channel morphology that uses teacher-created styrofoam stream tables. This investigation looks at pollutants and invasive species.

- Carlesen, William S., Nancy M. Trautmann, & the Environmental Inquiry Team. *Cornell Scientific Inquiry Series Student Edition, Watershed Dynamics.* Arlington, VA: National Science Teachers Association Press, 2004. It can be ordered through the NSTA website at <www.nsta.org>. An overview of the publication and online resources to accompany the book are available at <http://ei.cornell.edu/pubs/wd.asp>. The following is an excellent investigation from *Watershed Dynamics*:

  Protocol 3, Delineating a Watershed: This is a simple activity that helps students map and draw watershed boundaries.

- Andrews, W.A., & S. J. McEwan. *Investigating Aquatic Ecosystems*: Scarborough, ON: Prentice-Hall Inc, 1987. Note: This book is out of print but is a very useful resource for this course.

- Taccogna, G., & K. Munro (eds). *The Streamkeeper's Handbook:* À *Practical Guide to Stream and Wetland Care*. Vancouver, BC: Salmonid Enhancement Program, Dept. Fisheries and Oceans, 1995. *The Streamkeeper's Handbook* provides comprehensive information on watershed ecology, decree, and provides stream and wetland modules. Available online at <www.pskf.ca/publications/download.html>

- *Globe Program-Hydrology Chapter*
  The GLOBE Program offers students an electronic environment to report and share collected data. The GLOBE Program provides educators with sets of protocols for various subject areas, including hydrology. Available online at <www.globe.gov/r>.

Lesson: Stream Order

Specific Learning Outcomes

- **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.

Introduction

The stream order lesson helps students understand the complexity of the Lake Winnipeg issue by examining the sources of inflow into the lake. To this point, students have looked at the characteristics of the Lake Winnipeg watershed and delineated their local watershed. In this lesson, they will select a source of inflow to the lake and examine all the contributing water sources. This will help students reflect on the possible sources of nutrient influx to the lake, and on the challenges water stewards face in identifying specific areas for large nutrient loading.

Objectives

Students will interpret maps to determine major headwaters and subsequent stream order and flow direction for an area in the Lake Winnipeg watershed.

Teacher Background

Stream order is a classification system that orders streams and rivers from smallest to largest. The stream order system was designed by Horton, and in the 1950s the classification system was improved upon by Arthur Newell Strahler to classify waterways by size.

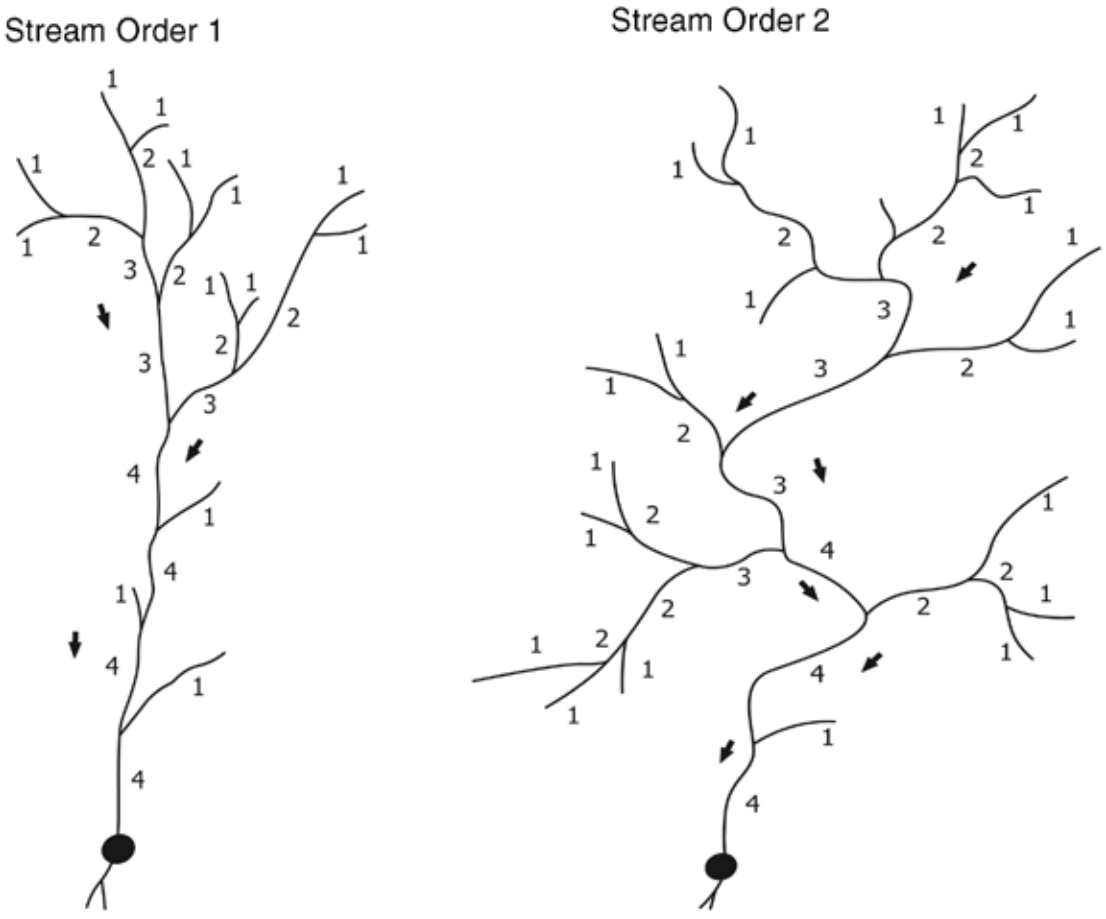
Small streams that have no tributaries are classified as first-order streams. Second-order streams are streams that unite two first-order steams. When two second-order streams come together, they form a third-order stream. However, if a first-order stream joins a second-order stream, the stream remains a second-order stream. **When one stream meets another stream of the same order, this is when the stream increases by an order.** For example, a third-

order stream combining with a third-order stream would result in a fourth-order stream.

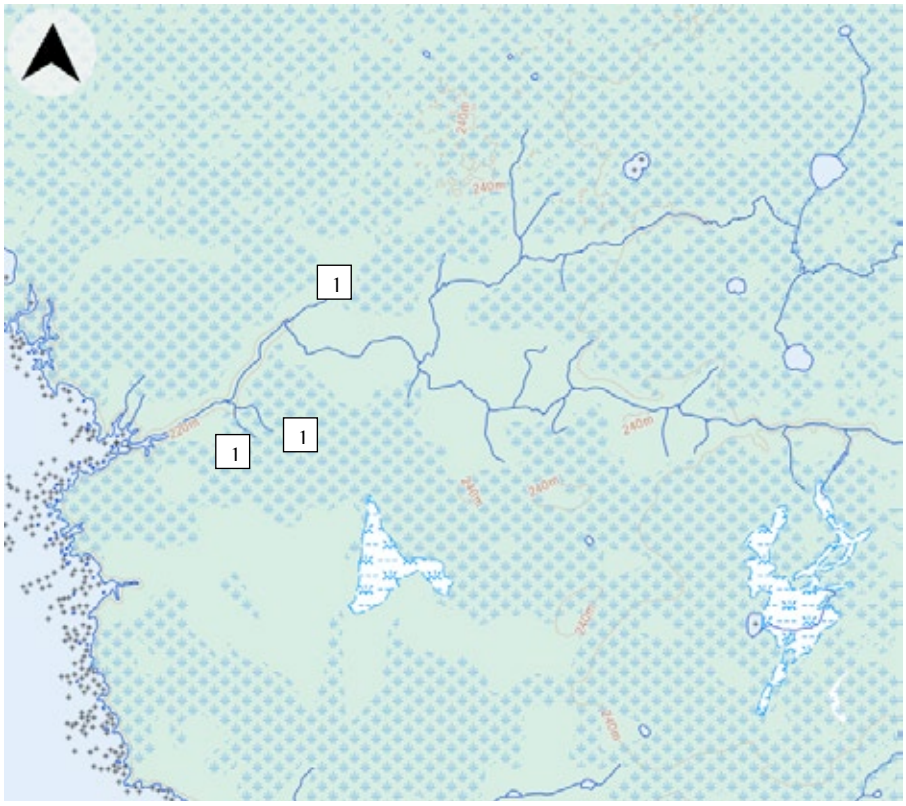
As streams increase in order, so do their velocity, width, depth, and the amount of water they discharge. Stream size is a result of the topography and geology of a region.

The stream classification system is important to scientists studying streams, as it can help to locate the best areas in which to collect data. Based on stream size, scientists can also delineate the types of aquatic organisms expected, which is part of the river continuum concept developed by Robin L. Vannote (1980).

Stream Order Example



Stream Order of the Poplar River Area



Source: *Atlas of Canada*. Reproduced from <http://atlas.nrcan.gc.ca/site/english/maps/topo/map> under the terms for non-commercial reproduction as cited at <www.nrcan.gc.ca/important-notices>. (Stream order added.)

Resources to Plan Your Teaching

- *Maps of Canadian drainage basins, watersheds, physical components of watersheds, human components of watersheds, and current water levels*
  http://atlas.nrcan.gc.ca/site/english/maps/environment/hydrology
- *Manitoba Land Initiative*
  This resource is free to those who register with a user name and password. All maps are listed by the categories of Administrative Boundaries, Base Maps, Cadastral, Digital Elevation Models, Digital Imagery, Environment, Forest Inventory, Geographical Names, Geology Mapping, Hydrography, Land Use/Cover Maps, Municipal Maps, Provincial Highways and PTHs, Quarter Section Grids, Soil Classification, Spatial Referencing, Topographic Maps, and Town and Village Plans.
- *Provincial Park Maps*
  www.gov.mb.ca/conservation/parks/park_maps/index.html
- *Protected Areas Initiative Maps*
  www.gov.mb.ca/conservation/pai/pai_material.html

- *Legislative Library Virtual Reference Desk: Map Links*
  www.gov.mb.ca/chc/leg-lib/vrd/maps.html

- *Introductory Stream Order Resources*
  The US Environmental Protection Agency has a great website called *Watershed Academy Web*. It covers a variety of topics on watershed management. The section that is important for this lesson is called "Stream Corridor Structure." The section "A Longitudinal View along a Stream Corridor" also provides information on stream order and patterns.
  www.epa.gov/watertrain/stream/

The Three A's

Activate: Show students a map of Manitoba that includes all the rivers and streams contributing to Lake Winnipeg. Ask students to come up with ideas on how we could determine how much water each of these rivers and streams contributes to Lake Winnipeg, and why this information may be important.

Acquire and Apply: Have students look at a map of Manitoba or a map that shows a sub-basin to see whether they can spot any geometric patterns in the rivers and streams. Have students identify the major rivers that feed into Lake Winnipeg. They are the following:

- Red River
- Winnipeg River
- Dauphin River
- Fisher River
- Saskatchewan River

Have students use the topographic maps on the *Atlas of Canada* site to select an area in the Lake Winnipeg basin, remove all data that is not pertinent to stream order from the topographic map, and then identify the stream order for the rivers on the map. Ask students: "Where are the large rivers located?" "Do these rivers have lots of 'arms'?" "If so, where do these occur?" "Can you tell which way the river is flowing?" Have students record their observations and discuss.

> NOTE:
>
> You could also order a free road map of Manitoba from Manitoba Tourism, and cut the map into segments based on drainage basins. Have students determine the stream order for the selected basin.

Assessment

Assessment *for* Learning: Provide students feedback on their participation in discussion and their ability to identify stream order in one of the rivers in the Lake Winnipeg watershed.

Assessment *of* Learning: Evaluate the completed stream order worksheet.

Student Handout: Stream Order Questions

1. As stream order increases, what happens to the width of the stream?

2. As stream order increases, what happens to the slope of the stream?

3. As stream order increases, what happens to the drainage area of the stream?

(continued)

4. Looking at the contour lines, what do you think the terrain looks like?

5. How does stream order help us understand the complexity of reducing nutrients into Lake Winnipeg?

Stream Order Questions Answer Key

1. As stream order increases, what happens to the width of the stream?

   As stream order increases, so will the size and width of the stream.

2. As stream order increases, what happens to the slope of the stream?

   As stream order increases, the slope of the stream decreases.

3. As stream order increases, what happens to the drainage area of the stream?

   As stream order increases, the drainage area of the stream increases.

4. Looking at the contour lines, what do you think the terrain looks like?

   The answer to this question will vary depending on the map you are using. Generally, the terrain is going to be fairly flat, visible by a large distance between the contour lines.

5. How does stream order help us understand the complexity of reducing nutrients into Lake Winnipeg?

   Looking at the major rivers that flow into Lake Winnipeg and their tributaries helps identify the possible sources of nutrients to the lake. By looking at stream order, you can see how some rivers may contribute more nutrients. These rivers may not flow through dense agricultural areas, but their tributaries do. Larger streams will contribute a greater amount of nutrients; rivers with many different levels of streams would be more difficult to control for nutrient loading.

Lesson: Inflow to Lake Winnipeg and Flood Forecasting

Specific Learning Outcomes

- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures…*
- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, introversion of units, significant figures.
- **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 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…*

Introduction

Students have been exposed to watershed characteristics and stream order and now are introduced to a new watershed dynamic: flooding. The issue of flooding is important when studying Lake Winnipeg because it is in a watershed that is greatly affected by flooding. Understanding flooding and how to predict flooding is important when trying to prevent the influx of nutrients into a river and lake system. In this lesson, students will learn how to use water data to predict floods in the Lake Winnipeg watershed.

Objectives

Predict the recurrence intervals and percent chance of various flows for a river.

Teacher Background

There are many rivers that feed into the Lake Winnipeg watershed, and each of these rivers experiences periods of high and low levels. Floods are a source of nutrient influx into the Lake Winnipeg watershed because the rivers that flow into the lake are often bordered by agricultural land. When a flood occurs, a greater amount of nutrients are brought into the lake, which affects the lake ecosystem. It is helpful to know how often the rivers that flow into

Lake Winnipeg flood, and to have some way of forecasting when the next flood may occur in order to take some proactive measures. The following activity uses data from Canada's Water Survey to create graphs and predict the flood frequency of a river system. A sample river is provided and can be used as a model, but students can examine any river that is monitored by the Water Survey and in the watershed.

This lesson is a modified version of the "Flood Frequency Analysis of a River" activity found in the resource by Soukhome, et al., cited below.

Some terms used in the lesson include the following:

Recurrence Interval of a Flood: A recurrence interval of a flood is an estimate of the average time between past flood occurrences. For example, a 10-year flood, a 100-year flood, and the Flood of the Century.

Annual Exceedance Probability: The annual exceedance probability is a measure of the likelihood of a flood reaching or exceeding a certain magnitude. For example, a 10 percent flood has a 10 percent chance of occurring or being exceeded at a location in any year.

Resources to Plan Your Teaching

- Environment Canada's Water Survey website: www.wsc.ec.gc.ca/products/main_e.cfm?cname=products_e.cfm
- Soukhome, J., G. Peaslee, C. Van Faasen, & W. Statema. *Watershed Dynamics: 12 Labs for High School Science*. Arlington, VA: NSTA Press, 2009.

The Three A's

Activate: Show students a map of the Lake Winnipeg basin. Ask students from what major rivers the bulk of incoming water in Lake Winnipeg originates.

Answer:

- Red River
- Winnipeg River
- Dauphin River
- Fisher River
- Saskatchewan River

Acquire and Apply: Explain to students the two terms *recurrence interval* and *annual exceedance probability*. Explain to them that by looking at previous water data, we can get a clearer understanding of the fluctuations in water levels and use them to predict large flood events.

Probing Questions

1. Using the flood frequency chart, estimate the discharge of 10-year, 25-year, and 100-year floods. Read the years off the x-axis, and find the discharge that corresponds on the y-axis.
2. What was the highest peak stream flow for the river studies, and what year did it occur? What are the probability and the recurrence interval of this discharge?
3. Look at the peak discharge of the Red River at Emerson over the years. Has the peak discharge increased or decreased? Give a reason why or why not.
4. Explain why major flood events can benefit us in understanding how to care for Lake Winnipeg.

Assessment

Assessment *for* Learning: Using a checklist, provide students with feedback on their computer skills and their ability to work with electronic databases.

Checklist for Database Management

The student

- ❑ enters or downloads data into a spreadsheet
- ❑ manipulates data using a formula
- ❑ creates a graph using a data management program
- ❑ adds headings to the graph

Assessment *of* Learning: Assess the answers to the questions at the end of the lesson.

Notes

How to Obtain the Data Set from Water Survey of Canada:

1. Go to the Water Survey of Canada website at <www.wsc.ec.gc.ca/staflo/index_e.cfm>. This website address will bring you to the stream flow statistics site.

2. Type in the river for which you would like data. There may be several monitoring stations that come up with your search (e.g., if you type *Red River,* you will get 27 different stations). Select one of these stations by marking it with a checkmark and clicking on *Obtain report.* The report will give you information about the maximum and minimum flow of the river, and a historical set of data on peak flow. The historical data is what you want for your graph.

3. Cut and paste the historical data into *Excel* or another database program.

4. Insert a column in between the year and peak flow columns to calculate recurrence interval data. Calculate the recurrence interval (T) using the formula $T=(n+1)/m$, where m is the rank number and n is the total number of years in the data set.

5. Insert a column to the right of the peak flow column for the annual exceedance probability (AEP). Calculate the AEP by taking the inverse of the recurrence interval using the formula AEP = $m / (n + 1)$. Put the formula into the spreadsheet.

6. Make a semi-logarithmic graph of peak stream flow versus recurrence interval. (In *Excel,* this is done by selecting *Insert Chart* and selecting a scatterplot chart type.) Highlight the recurrence interval and peak flow columns for the data set. Select *Next* and then type in the names for the x-axis and y-axis. Select *Next* and *Finish*. Right-click on the x-axis, select *Scale*, and check *Logarithmic*. To add a best-fit line, right-click on the graphed data and select *Add Trendline,* and then select *Logarithmic*.

Student Handout: Flood Forecasting

Select a river in the Lake Winnipeg watershed that you would like to investigate.

How to obtain the data set from Water Survey of Canada:

1. Go to the Water Survey of Canada website at <www.wsc.ec.gc.ca/staflo/index_e.cfm>. This website address will bring you to the stream flow statistics site.
2. Type in the river for which you would like data. There may be several monitoring stations that come up with your search (e.g., if you type *Red River,* you will get 27 different stations). Select one of these stations by marking it with a checkmark and clicking on *Obtain report.* The report will give you information about the maximum and minimum flow of the river, and a historical set of data on peak flow. The historical data is what you want for your graph.
3. Cut and paste the historical data into *Excel* or another database program.
4. Insert a column in between the year and peak flow columns to calculate recurrence interval data. Calculate the recurrence interval (T), using the formula $T = (n+1)/m$, where m is the rank number and n is the total number of years in the data set.
5. Insert a column to the right of the peak flow column for the annual exceedance probability (AEP). Calculate the AEP by taking the inverse of the recurrence interval using the formula AEP = $m/(n + 1)$. Put the formula into the spreadsheet
6. Make a semi-logarithmic graph of peak stream flow versus recurrence interval. (In *Excel,* this is done by selecting *Insert Chart* and selecting a scatter-plot chart type.) Highlight the recurrence interval and peak flow columns for the data set. Select *Next* and then type in the names for the x-axis and y-axis. Select *Next* and *Finish*. Right-click on the x-axis, select *Scale*, and check *Logarithmic*. To add a best-fit line, right-click on the graphed data and select *Add Trendline,* and then select *Logarithmic*.

Probing Questions

1. Using the flood frequency chart (Figure 1 on page 82), estimate the discharge of 10-year, 25-year, and 100-year floods. Read the years off the x-axis, and find the discharge that corresponds on the y-axis.

2. What was the highest peak stream flow for the river studies, and what year did it occur? What are the probability and the recurrence interval of this discharge?

3. Look at the peak discharge of the Red River at Emerson over the years (Figure 2 on page 82). Has the peak discharge increased or decreased? Give a reason why or why not.

(continued)

4. Explain why major flood events can benefit us in understanding how to care for Lake Winnipeg.

Sample Data Set

Year	FEB	MAR	APR	Peak	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PERIOD
1913	14.1	8.55	11.3	378	90.1	49.8	37.9	27.1	34.3	33.6	37.9	24.6
1914	15.3	13.9	22.7	117	91.9	125	98.7	39.1	37.8	39	39.5	28.5
1915	25.3	24.6	28.1	144	106	142	372	83.5	50.9	51.5	45.4	32.5
1916	25.4	22.3	26.1	820	588	225	304	145	120	91	79.4	56.5
1917	35.6	29.6	32.3	397	164	73.3	41.7	18.2	13.2	19.3	25.5	16
1918	6.75	6.27	30.3	68.9	51.4	65.1	28.2	20.7	18.9	11.6	19.1	16.3
1919	13.3	12	16.8	219	112	61	221	103	43.4	33	22.6	20.6
1920	23	25.6	82.8	520	119	138	95.1	43.7	32.1	34.3	35.1	28.7
1921	23	22.1	32.3	181	73.9	78.2	50.5	25	23.8	23.7	20.4	18.7
1922	13.2	10.7	56	361	227	95.6	42.3	18.2	16.9	14.2	20.7	10.6
1923	8.65	9.27	11.2	287	219	57	69.6	23.1	17	17.3	17.3	11.3
1924	6.38	6.71	8.67	80.2	87.5	38	25.4	11.5	10.1	20	15	5.91
1925	3.99	5.25	30.4	137	46.7	299	96.3	14.7	15.8	26.5	25.2	18.6
1926	13.2	14.7	47.8	150	38	72.9	59.7	13.8	12.8	27.6	23.1	14
1927	11.8	11.1	113	380	415	247	93.8	45.1	42	38.8	31.3	22.8
1928	17.1	19	55.3	215	80.7	93.4	128	54.4	68.6	51.6	45.3	30.9
1929	29.7	25	167	192	75.1	48	21.4	12	9.14	12.8	13.6	8.33
1930	5.67	5.07	81.9	247	146	54.5	30.1	10.3	6.1	6.56	7.57	6.68
1931	4.98	5.65	27.2	95.9	25	18.7	10.1	4.46	2.29	2.4	6.25	5.3
1932	4.71	3.91	38.6	221	54.5	16.6	7.25	1.77	1.13	1.3	3.44	2.52
1933	1.53	1.4	24.4	165	43.8	29	7.18	2.07	1.3	1.38	2.4	1.31
1934	1.54	0.923	13.9	61.7	18.8	5.55	3.91	1.32	0.673	1.33	2.19	1.18
1935	0.399	0.763	21.2	94.2	33.2	12.4	30.6	14.6	7.61	3.31	2.2	1.68
1936	1.61	1.53	1.65	191	73.7	16.5	3.41	2.24	1.89	0.811	0.672	0.947
1937	0.201	0.034	0.064	57.4	82.3	30	23.5	44.3	23.2	11.4	7.95	2.05
1938	1.51	2.15	41.2	36.3	138	73.1	24.2	6.16	5.48	5.66	5.87	5.15
1939	5.6	7.23	7.35	105	33.8	18.6	16	5.31	6.52	10.1	10.9	7.87
1940	3.83	4.2	6.35	144	63.2	29.8	10.1	7.23	5.29	6.68	11.1	8.38
1941	8.84	9.86	10.2	387	88.3	150	40.4	21.4	52.5	86.8	39.3	25.1
1942	16	18	55.5	468	254	119	51.2	35.5	88.1	46.5	32.1	21.9
1943	22.6	19.8	34.2	655	206	352	184	73.2	51.5	41.7	40.5	26.2
1944	18.8	20.8	21.7	123	107	197	193	170	167	82.3	114	77.3
1945	36.6	38.7	258	571	245	114	61.9	37.1	50.3	55.9	39.6	28
1946	26.8	22.4	162	414	117	62.9	69.1	36	33	47	45.8	33.1
1947	29.2	25.4	29.9	505	338	341	164	57.5	44.5	52.8	46.8	38.1
1948	30.7	23.9	24.1	704	568	109	88.9	47	28.6	19.1	20.2	15.8
1949	12.7	12.9	16.9	417	144	172	96.7	93.1	51.1	32.4	39.3	30.2
1950	23.4	21.2	26.2	751	2060	631	286	108	74.1	94.3	58.7	61.2
1951	58.1	51	64.8	556	308	140	77.6	41.4	55.4	44.8	40	54
1952	50.6	54.2	56.9	486	217	108	166	64.7	39	26.8	24.5	19.8
1953	17.3	17.3	38.6	115	89.2	252	157	65.2	37.3	25.3	27.2	26.5

(continued)

Year	FEB	MAR	APR	Peak	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PERIOD
1954	23.6	24	38.9	165	120	121	83.8	40.7	25.4	23.1	23.5	20.3
1955	20.7	18.5	18.5	300	91.4	121	77.6	51.4	26.7	26.7	17.1	12.7
1956	12.2	12.9	14.4	361	412	154	116	32.7	57.4	19.3	37.5	17.4
1957	12.5	11.6	40.9	167	128	119	263	81.6	181	107	95.8	48.5
1958	39.2	37	52.9	94.3	46.7	40.3	115	28.5	13	12.2	13.8	10.1
1959	9.86	9.7	17.9	171	59.8	77.8	58.5	21.5	15.4	16	16.6	17.8
1960	17.5	15.8	13.4	468	147	88.1	64.6	16.7	17.5	9.68	15.7	10.7
1961	9.76	8.29	48.7	73.4	68	31.5	12.5	7.77	7.55	16.8	11.6	7.43
1962	5.6	5.66	6.37	418	340	720	455	204	95.3	69.4	61.6	46.3
1963	35.3	30.4	42.9	222	106	212	86.4	37.2	34.3	39.5	27.4	19.7
1964	21.7	21.4	19.4	240	155	269	103	37.4	19	48.2	39.3	25.8
1965	25.8	25.2	26.9	708	526	284	160	66.4	59.3	125	94.5	78.2
1966	53.2	46.7	165	1300	573	198	135	107	81.9	56.4	60.4	51.6
1967	46.2	41.8	59.1	720	566	185	102	42.1	26.9	25.7	27.3	19.1
1968	13.9	14	40.6	138	70.9	171	194	93.2	84.8	62.4	60.7	55.4
1969	48	45.7	61.5	825	777	183	114	58.8	46.9	59	57.8	44.5
1970	41.2	40	44.7	544	650	480	156	45.7	39.6	36.3	47.2	31
1971	29.3	28.3	55.5	410	155	92.1	82.4	41.4	42.4	114	146	75.9
1972	55.6	45.2	193	677	308	180	70.3	70.2	58.3	51.9	48.4	32.7
1973	31.5	31.6	165	76.7	48.6	37.1	17.6	22.1	72.7	118	74	58.9
1974	48.5	47.8	57.3	548	840	305	106	92.4	58.1	54.9	60.6	38.5
1975	37.2	40	46.7	367	773	196	794	133	72.5	68.8	68.2	44.3
1976	43.1	46.5	79.1	494	125	67.3	44	31.7	20.6	11	8.89	5.01
1977	5.11	5.38	11.3	59.5	34	24.4	18	7.38	15.1	40.3	31.9	36.6
1978	34.7	28	49.2	1020	290	110	102	49	31.7	27.1	24.7	18.3
1979	15.9	16.4	21.9	698	1390	229	182	95.5	63.1	49.6	55.4	43.3
1980	38.3	37.7	41.9	287	68	46.2	24.4	13.7	23.7	15.6	18.6	10.2
1981	8.27	8.4	41.6	51.2	39.3	44.8	77.5	43	51.2	68	55.6	31.3
1982	32.6	29.9	49.7	625	251	121	116	69.8	38.1	124	71.8	54.8
1983	45.7	39	265	355	114	144	184	74.3	79.9	63.1	60.5	48.8
1984	39.1	36.1	82	542	120	328	96.3	43.3	27.2	52.4	52.7	40.9
1985	34.2	32.7	183	209	258	225	209	208	166	128	79.5	59.4
1986	57	51.3	172	760	631	209	142	80.6	82.6	102	59	56.2
1987	51.1	45.7	195	637	120	104	88	74	31.4	23.5	23.7	19.9
1988	13.3	14.4	63.9	188	40.9	30.8	13.1	7.98	9.41	9.55	8.77	7.27
1989	7.45	10.8	11.2	608	195	76.2	32.2	12.2	29.6	12.8	10.6	7.31
1990	4.88	7.39	32.5	100	47.1	61.7	33.7	13.2	10.4	8.46	8.91	6.57
1991	5.02	6.95	16.8	59.4	79.9	65.3	112	36.7	44.7	24.4	25.2	16.2
1992	15.6	15.7	200	287	128	71.1	84.3	36.1	74.1	34.4	24.1	26.4
1993	24.3	28.8	37.1	425	117	131	298	765	283	120	78.7	57.8
1994	42.3	42.6	153	498	214	173	377	125	135	170	143	83.4
1995	55.4	50.4	434	950	405	171	236	107	77	97.9	91.1	64.7

(continued)

Year	FEB	MAR	APR	Peak	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PERIOD
1996	53.5	50.9	107	819	1170	421	134	87.8	50.6	53.5	67.4	61.9
1997	55.9	59.1	65.3	1360	1550	306	535	122	83.6	111	97	77.5
1998	54.5	69.3	580	545	408	294	460	99.1	66.6	103	95.5	100
1999	63	59.2	212	1270	610	420	272	177	325	134	109	90.6
2000	61.7	49.1	239	173	125	329	461	99.6	96.9	76.7	390	115
2001	76	69.6	106	1120	861	325	202	257	77.6	65.5	107	80.3
2002	58.9	48.1	55.6	153	162	647	704	180	232	69.8	57.4	39.2
2003	33.2	27.1	70.9	139	158	162	208	47.5	19.7	18.7	17.9	15.2
2004	15.3	12.4	105	799	289	512	156	63.1	115	135	348	96.1
2005	60.8	61.4	88.9	663	249	700	787	232	172	124	111	104
2006	100	85.4	114	1490	567	159	59.8	44.4	41.7	43.3	32.9	26.2
2007	24.2	19.3	174	657	290	607	371	64	36.6	48.1	49.8	31.9
2008	30.8	24.8	30	244	169	274	103	78.4	88.1	260	313	82.1

Sample Table Created from Data Set

Rank	Year	Recurrence Interval	Peak Discharge	AEP
56	2008	1.732142857	244	0.577319588
20	2007	4.85	657	0.206185567
1	2006	97	1490	0.010309278
19	2005	5.105263158	663	0.195876289
11	2004	8.818181818	799	0.113402062
76	2003	1.276315789	139	0.783505155
72	2002	1.347222222	153	0.742268041
5	2001	19.4	1120	0.051546392
67	2000	1.447761194	173	0.690721649
4	1999	24.25	1270	0.041237113
28	1998	3.464285714	545	0.288659794
2	1997	48.5	1360	0.020618557
10	1996	9.7	819	0.103092784
7	1995	13.85714286	950	0.072164948
33	1994	2.939393939	498	0.340206186
38	1993	2.552631579	425	0.391752577
54	1992	1.796296296	287	0.556701031
93	1991	1.043010753	59.4	0.958762887
83	1990	1.168674699	100	0.855670103
24	1989	4.041666667	608	0.24742268
65	1988	1.492307692	188	0.670103093
22	1987	4.409090909	637	0.226804124

(continued)

Rank	Year	Recurrence Interval	Peak Discharge	AEP
12	1986	8.083333333	760	0.12371134
62	1985	1.564516129	209	0.639175258
30	1984	3.233333333	542	0.309278351
50	1983	1.94	355	0.515463918
23	1982	4.217391304	625	0.237113402
95	1981	1.021052632	51.2	0.979381443
53	1980	1.830188679	287	0.546391753
17	1979	5.705882353	698	0.175257732
6	1978	16.16666667	1020	0.06185567
92	1977	1.054347826	59.5	0.948453608
34	1976	2.852941176	494	0.350515464
47	1975	2.063829787	367	0.484536082
27	1974	3.592592593	548	0.278350515
88	1973	1.102272727	76.7	0.907216495
18	1972	5.388888889	677	0.18556701
42	1971	2.30952381	410	0.432989691
29	1970	3.344827586	544	0.298969072
8	1969	12.125	825	0.082474227
77	1968	1.25974026	138	0.793814433
14	1967	6.928571429	720	0.144329897
3	1966	32.33333333	1300	0.030927835
15	1965	6.466666667	708	0.154639175
57	1964	1.701754386	240	0.587628866
58	1963	1.672413793	222	0.597938144
39	1962	2.487179487	418	0.402061856
89	1961	1.08988764	73.4	0.917525773
37	1960	2.621621622	468	0.381443299
68	1959	1.426470588	171	0.701030928
85	1958	1.141176471	94.3	0.87628866
69	1957	1.405797101	167	0.711340206
49	1956	1.979591837	361	0.505154639
51	1955	1.901960784	300	0.525773196
71	1954	1.366197183	165	0.731958763
81	1953	1.197530864	115	0.835051546
35	1952	2.771428571	486	0.360824742
26	1951	3.730769231	556	0.268041237
13	1950	7.461538462	751	0.134020619
40	1949	2.425	417	0.412371134
16	1948	6.0625	704	0.164948454

(continued)

Rank	Year	Recurrence Interval	Peak Discharge	AEP
32	1947	3.03125	505	0.329896907
41	1946	2.365853659	414	0.422680412
25	1945	3.88	571	0.257731959
79	1944	1.227848101	123	0.81443299
21	1943	4.619047619	655	0.216494845
36	1942	2.694444444	468	0.371134021
44	1941	2.204545455	387	0.453608247
75	1940	1.293333333	144	0.773195876
82	1939	1.182926829	105	0.845360825
96	1938	1.010416667	36.3	0.989690722
94	1937	1.031914894	57.4	0.969072165
64	1936	1.515625	191	0.659793814
86	1935	1.127906977	94.2	0.886597938
91	1934	1.065934066	61.7	0.93814433
70	1933	1.385714286	165	0.721649485
59	1932	1.644067797	221	0.608247423
84	1931	1.154761905	95.9	0.865979381
55	1930	1.763636364	247	0.567010309
63	1929	1.53968254	192	0.649484536
61	1928	1.590163934	215	0.628865979
45	1927	2.155555556	380	0.463917526
73	1926	1.328767123	150	0.75257732
78	1925	1.243589744	137	0.804123711
87	1924	1.114942529	80.2	0.896907216
52	1923	1.865384615	287	0.536082474
48	1922	2.020833333	361	0.494845361
66	1921	1.46969697	181	0.680412371
31	1920	3.129032258	520	0.319587629
60	1919	1.616666667	219	0.618556701
90	1918	1.077777778	68.9	0.927835052
43	1917	2.255813953	397	0.443298969
9	1916	10.77777778	820	0.092783505
74	1915	1.310810811	144	0.762886598
80	1914	1.2125	117	0.824742268
46	1913	2.108695652	378	0.474226804

Figure 1

Red River at Emerson Flood Frequency Curve

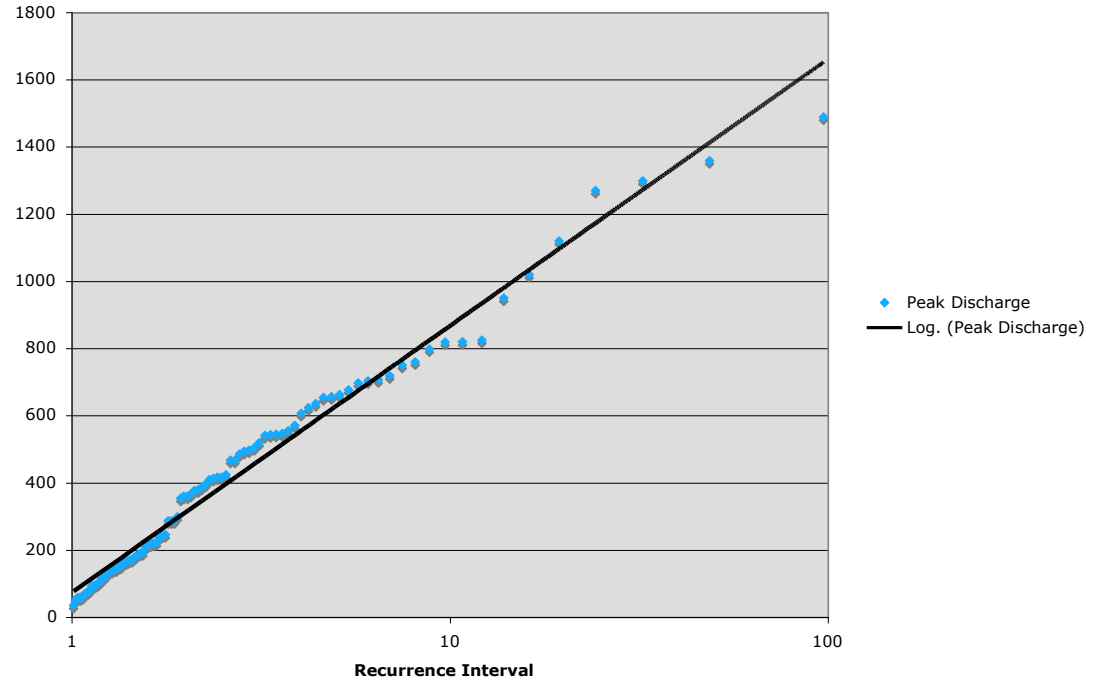
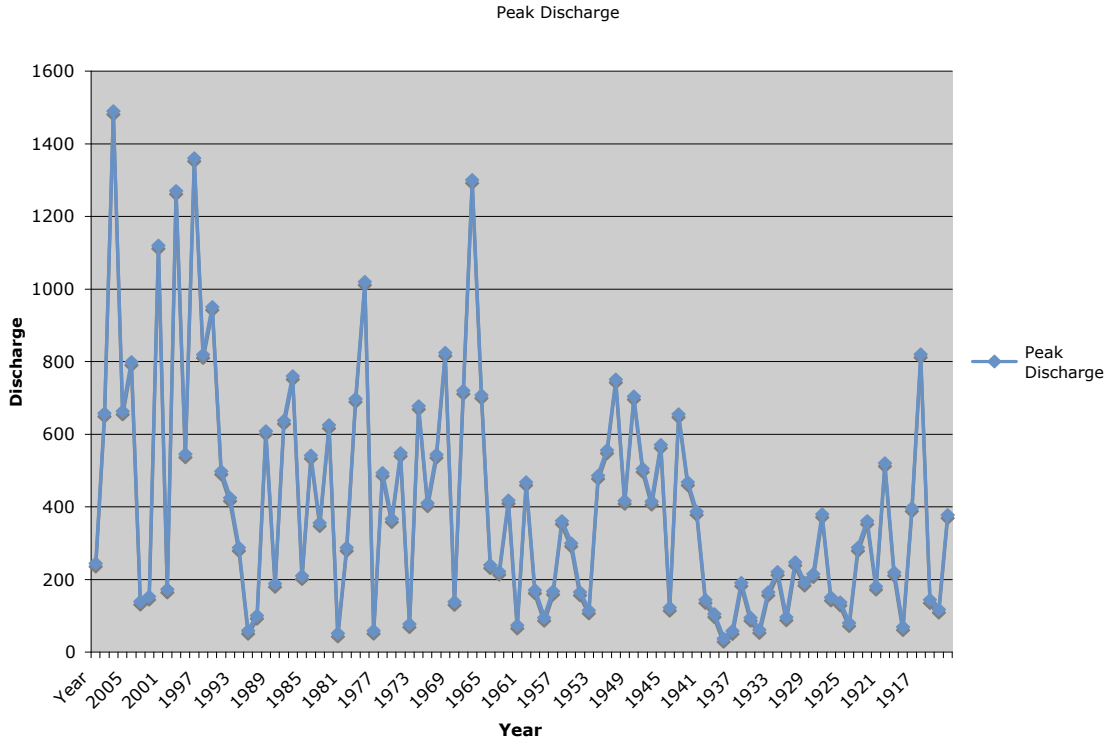


Figure 2

Red River at Emerson Peak Stream Flows



Lesson: Bathymetry of Lake Winnipeg's North and South Basin

Specific Learning Outcomes

- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.
- **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)…*

Introduction

One of the characteristics of Lake Winnipeg is that the north and south basins have very different characteristics, and they are joined by a very narrow channel. This means that these areas of the lake are also affected by nutrient influx quite differently. Students have used topographic maps in previous lessons. In this lesson, students examine the characteristics of the north and south basins using bathymetric maps.

Objectives

Using the bathymetric maps of Lake Winnipeg's north and south basins, students will compare basin depths by profiling each basin.

Teacher Background

A topographic map displays Earth's elevational changes. A bathymetric map is similar to a topographic map in that it displays the changes in elevation for the floor of a body of water. Bathymetric maps use metres above sea level (MASL) as a reference point. A slope or relief is indicated by the distance between contour lines or, in the case of a bathymetric map, the distance between isobaths. For example, isobaths that are close to one another will indicate a steep slope.

There are a few techniques employed when creating a bathymetric map such as a sonar and eco sounder. The maps in this lesson were created in part by sonar transects done on Lake Winnipeg in 1969. They are part of G.J. Brunskill, S.E.M. Elliott, and P. Campbell's 1980 report "Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg Western."

In this lesson, students will create a cross-section or profile of Lake Winnipeg's north and south basins. A bathymetric profile is a representation of the floor of any body of water between two points. It provides an overview of the changes in the depth within the two points.

A description of the geographical features of Lake Winnipeg's north and south basins can be found on page 8 (paper) or 12 (electronic) of *Restoring the Health of Lake Winnipeg, Technical Annex, Canada's Sixth Great Lake* by Terry Duguid and Norm Brandson. Available online at <http://manitobawildlands.org/water_lakewpg.htm>.

Terminology

Bathymetry: The measurement of changing depth in the bottom of a body of water.

Bathymetric Profile: This displays the changes in elevation for chosen points in a body of water.

Isobath: This is a contour line connecting points of equal depth under water.

Trace Line: This is a line connecting two points, which the bathymetric profile will represent.

The Three A's

Activate: Ask students if they know of ways we can visually represent depth in various regions in a lake. After discussing, provide students with the bathymetric maps of Lake Winnipeg (1 for the north basin and 1 for the south basin).

Acquire: Using the bathymetric maps, have students make observations and record their data on the Lake Winnipeg Bathymetric Worksheet.

Using an overhead, show students what a trace line is, and how to create a profile of the trace line.

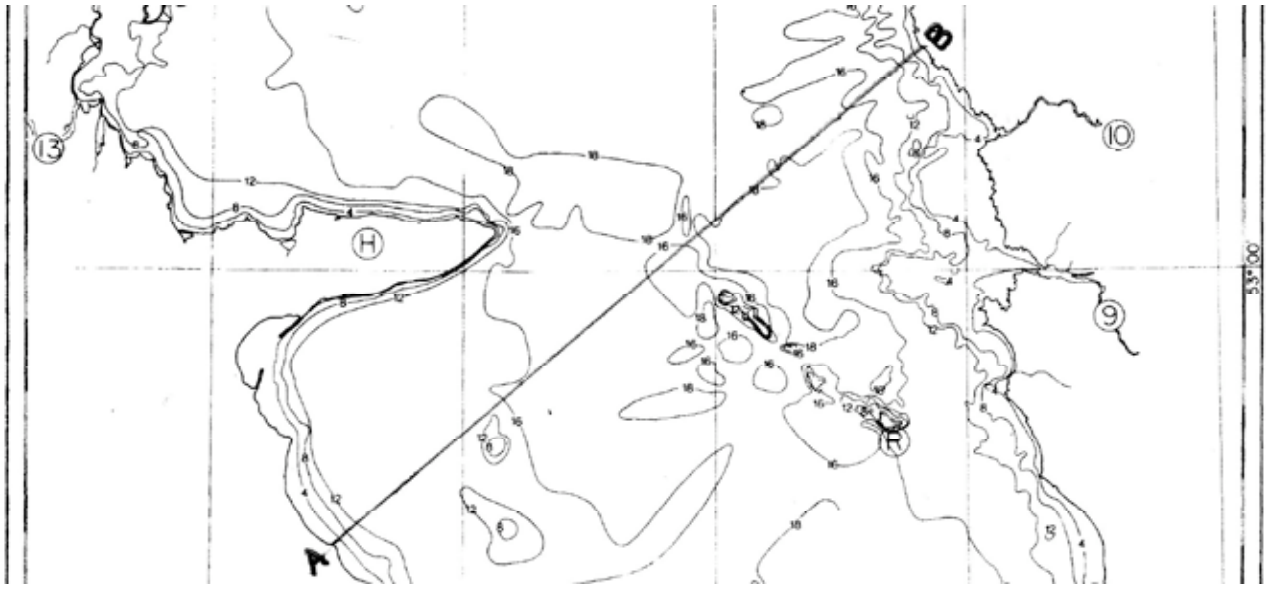
Apply: Have students choose a trace line for each map, and depict the results on graph paper. Let students know that they must include a title and properly label the x- and y-axes. After completing the profile, have students input the data into one graph using *Excel* (see the instructions on how to create a profile in *Excel* below).

Assessment

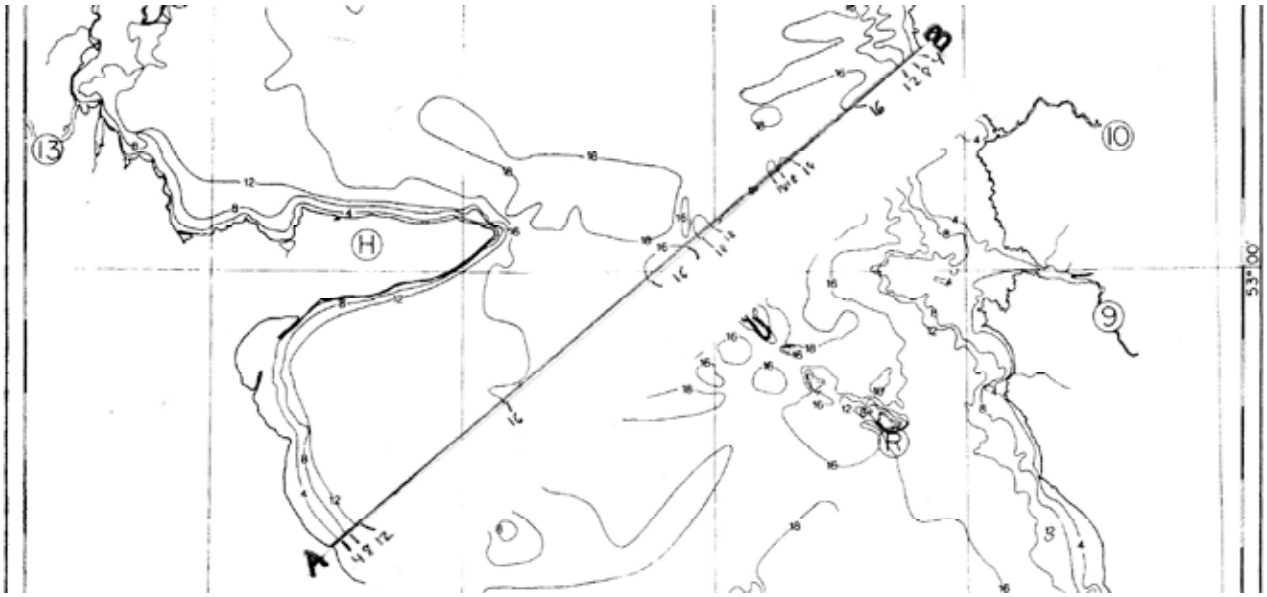
Assessment *for* Learning: Using a checklist, provide students with feedback on their computer skills and their ability to work with electronic databases.

Assessment *of* Learning: Collect student responses to questions, and provide feedback.

Steps to Create a Bathymetric Profile



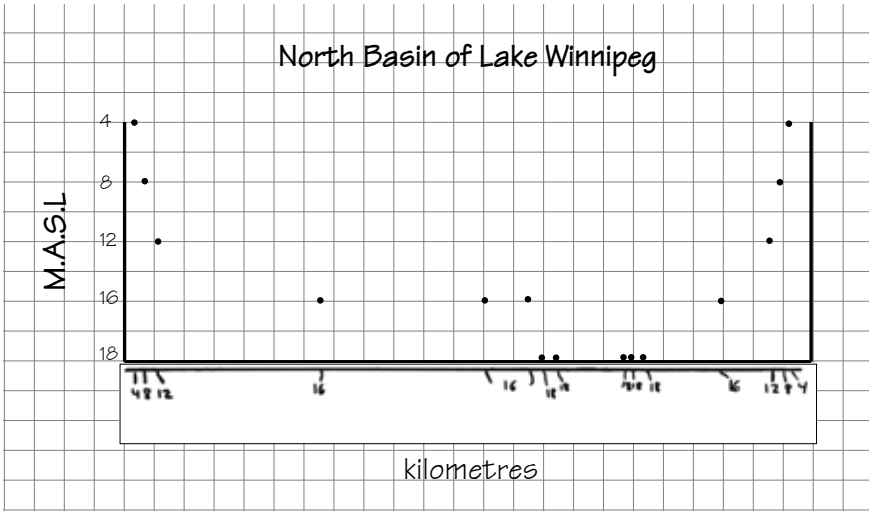
Create a trace line. This trace line should connect two points from shore to shore.



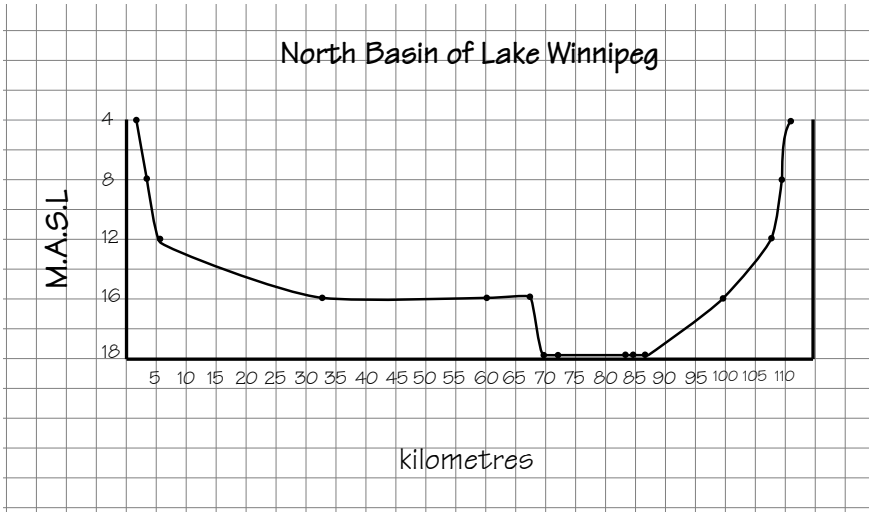
After creating the trace line, cut a piece of paper that stretches across the two points. Using this paper, match and mark off all of the isobaths.

Source: Brunskill, G.J., S.E.M. Elliott, & P. Campbell. *Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg*. Winnipeg, MB: Minister of Supply and Services Canada, 1980. Available online at <www.dfo-mpo.gc.ca/library/74105.pdf>. Reproduced under the terms for non-commercial reproduction, as cited at <www.dfo-mpo.gc.ca/notices-avis-eng.htm>.

(continued)

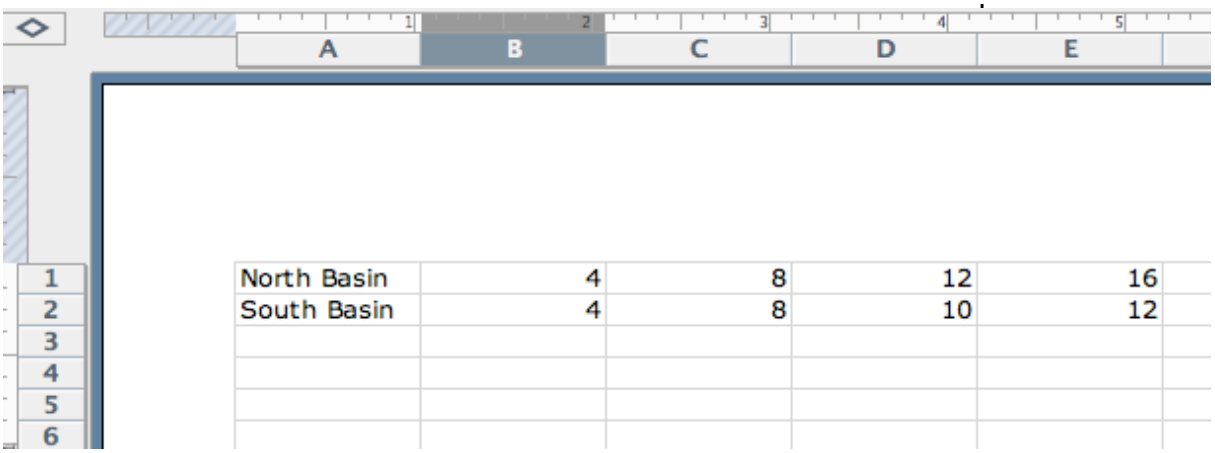


Place the paper that has the isobaths recorded on a piece of graph paper. Mark and label the x- and y-axes. Now graph the isobaths and connect the points. Make sure to title your map, and then you will have a finished profile, as seen below.



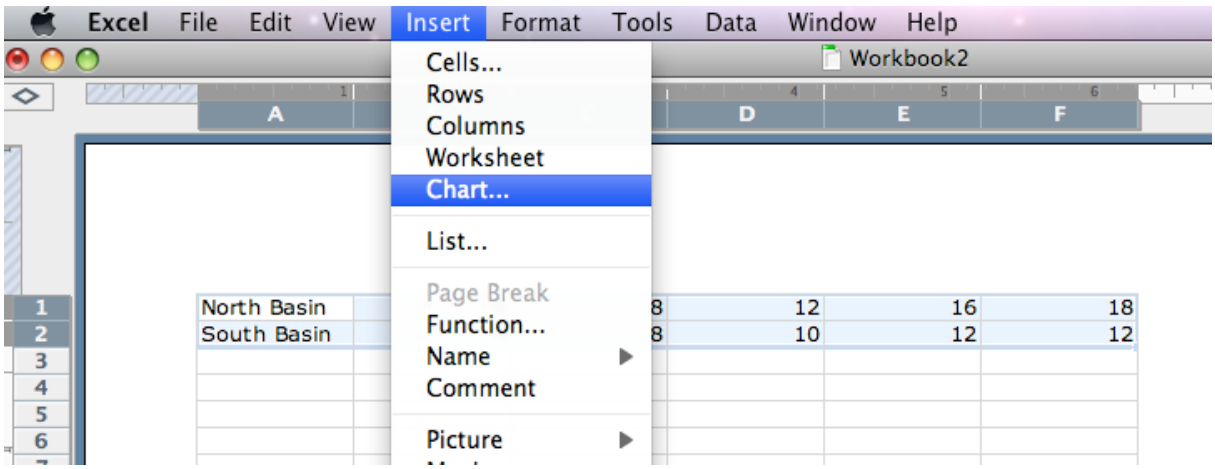
Creating a Profile in Excel

You will need to enter the isobaths for the north and south basins into separate columns.



	A	B	C	D	E
1	North Basin	4	8	12	16
2	South Basin	4	8	10	12
3					
4					
5					
6					

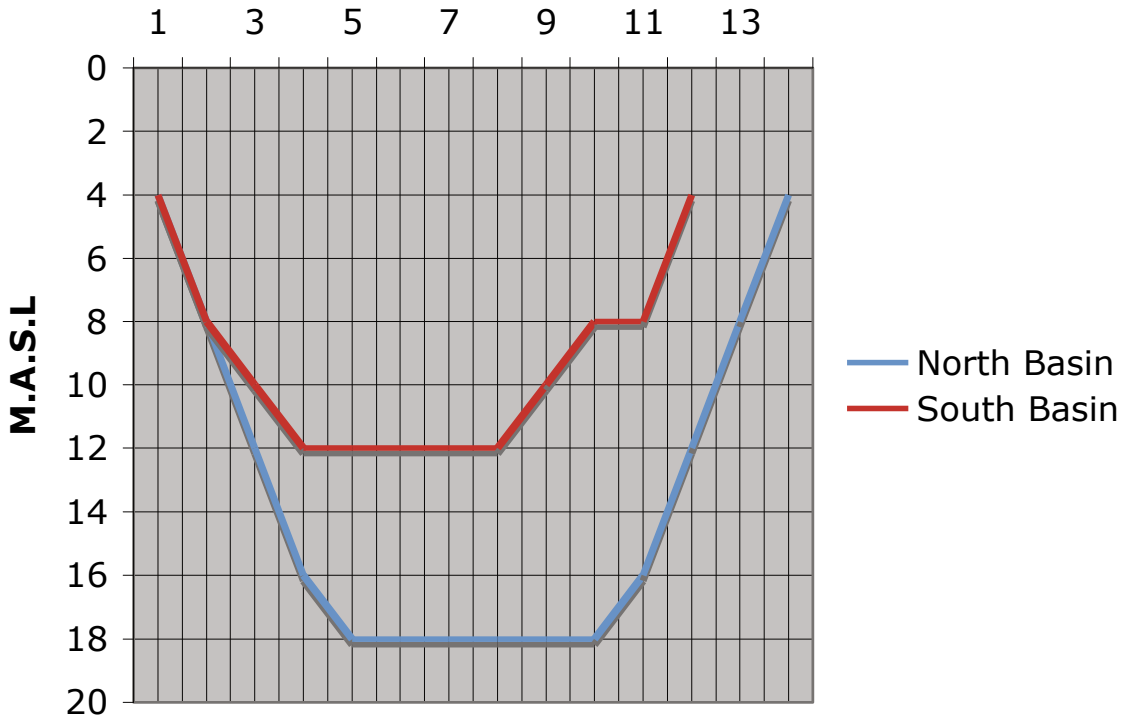
Then highlight all of your data, chose *Chart* under the *Insert* menu. Then choose the most appropriate chart type in which to display your data.



(continued)

An example of a finished profile:

A Bathymetric Profile of Lake Winnipeg's North & South Basin



Bathymetric Worksheet 1

Student name:_____Date:_____

1. What are some of the unique and or interesting features of the maps on BLM 2-3-1?

2. What are the map scales?

3. What is the isobath (contour) interval?

4. What do the isobath (contour) lines indicate?

5. Is the north basin deeper or shallower than the south basin?

(continued)

6. How does the lake depth change around islands?

7. What does the map tell us about the narrows?

8. What are the major rivers that enter the north basin?

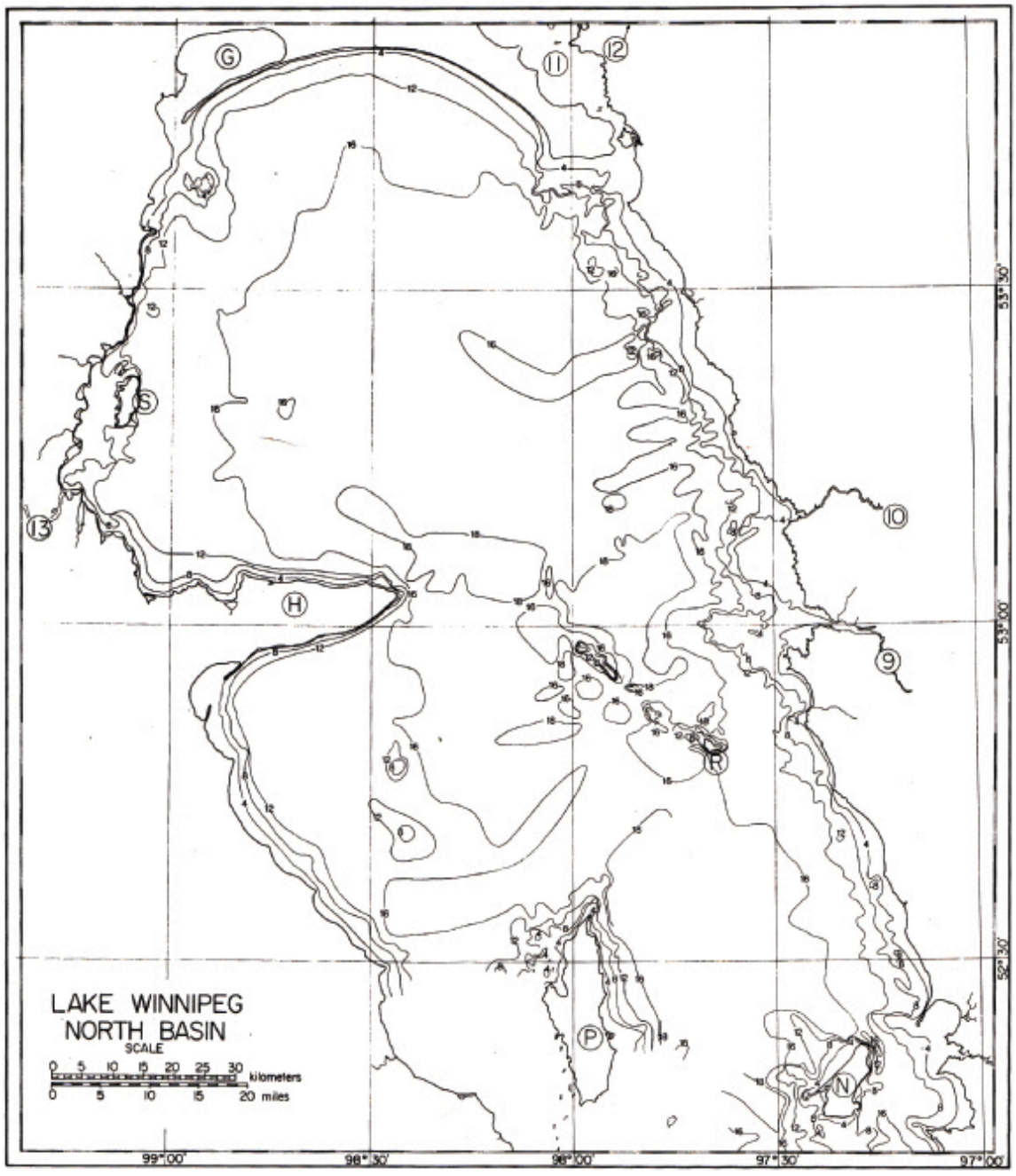
9. What are the major rivers that enter the south basin?

10. What distance does your trace line represent for the north and south basins?

11. How does bathymetry contribute to our understanding of how to care for Lake Winnipeg?

(continued)

Lake Winnipeg's North Basin

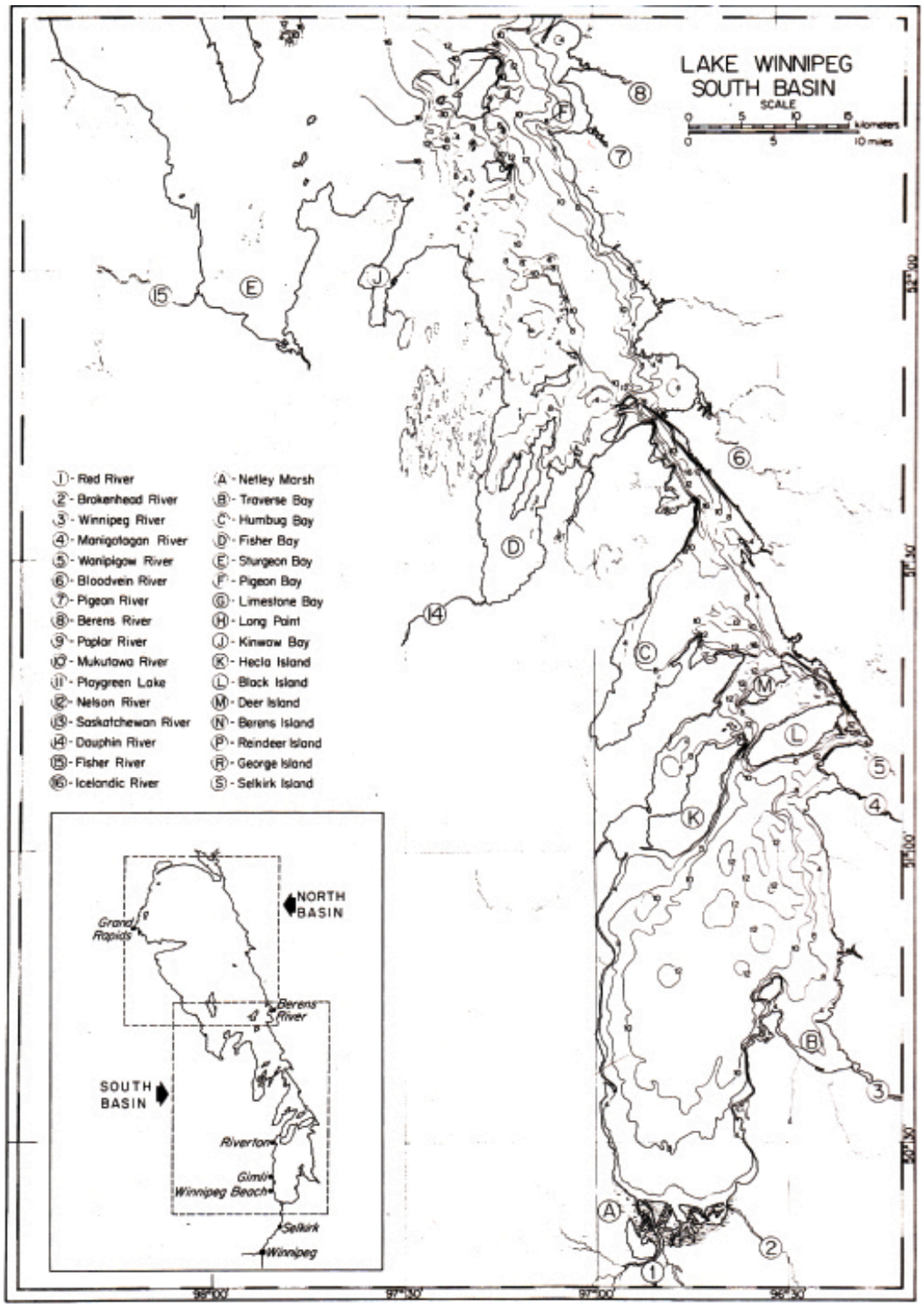


Source: Brunskill, G.J., S.E.M. Elliott, & P. Campbell. *Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg*. Winnipeg, MB: Minister of Supply and Services Canada, 1980, p. 25. Available online at <www.dfo-mpo.gc.ca/library/74105.pdf>. Reproduced under the terms for non-commercial reproduction, as cited at <www.dfo-mpo.gc.ca/notices-avis-eng.htm>.

(continued)

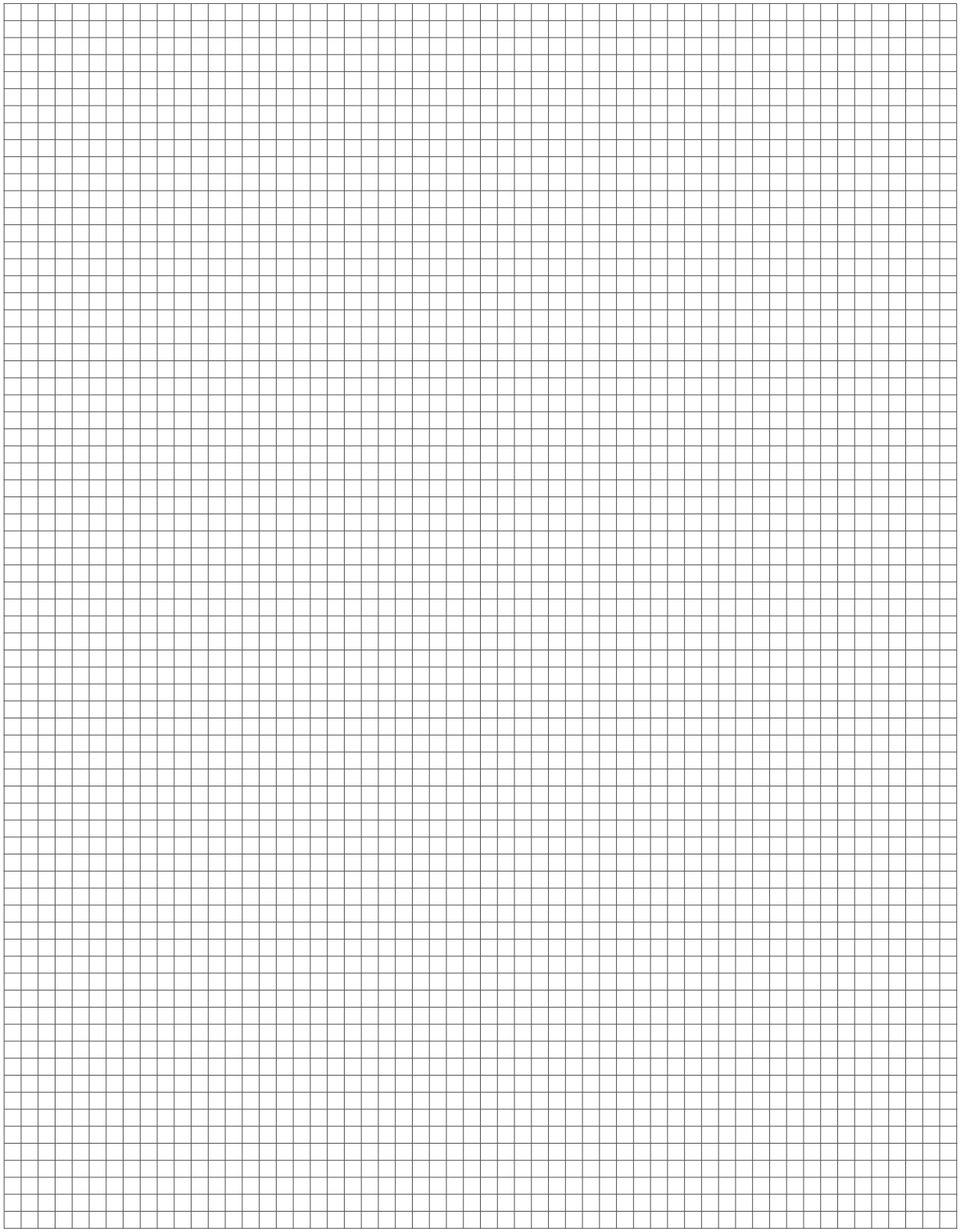
BLM 2-3-3 (continued)

Lake Winnipeg's South Basin



Source: Brunskill, G.J., S.E.M. Elliott, & P. Campbell. *Morphometry, Hydrology, and Watershed Data Pertinent to the Limnology of Lake Winnipeg*. Winnipeg, MB: Minister of Supply and Services Canada, 1980, p. 26. Available online at <www.dfo-mpo.gc.ca/library/74105.pdf>. Reproduced under the terms for non-commercial reproduction, as cited at <www.dfo-mpo.gc.ca/notices-avis-eng.htm>.

(continued)



Lesson: How to Best Restore Lake Winnipeg from Shoreline Erosion

Specific Learning Outcomes

- **SLO C1:** Identify questions to investigate that arise from practical problems and issues.
- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures…*
- **SLO C11:** Synthesize information obtained from a variety of sources.
- **SLO C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*

Introduction

The erosion of a shoreline along a lake increases the amount of particulates and rotting vegetation that is released into the water. This decreases the clarity of the lake and inhibits light from penetrating into the water column. Therefore, it is important to reduce shoreline erosion on Lake Winnipeg. Students have previously been exposed to sources of nutrient loading into the lake. Examining shoreline erosion is important to understand nutrient loading.

Objectives

Identify the shoreline features of Lake Winnipeg, and investigate one shoreline management technique.

Teacher Background

There are many ways to try to prevent or stabilize eroded shoreline. "Soft" approaches are more environmentally friendly, as they work with the natural environment. Below is an overview of some "soft" approaches.

Preserve the Natural Shoreline

One of the most effective and easiest ways is to take a "do nothing" approach. It is as simple as not mowing the grass or cutting the trees and shrubs on the shoreline. This allows natural vegetation to grow or become re-established. A naturally vegetated shoreline has many benefits, such as preventing contaminants or excess nutrients from entering the water; preventing erosion caused by rain, wind, wave, and ice action; and supplying food, shade, and

cover for fish in the shallow water. If some vegetation must be removed, limit the amount. Try to prune trees and shrubs back instead of removing them.

Shoreline Planting

The establishment of natural vegetation can be accelerated by selectively planting native deep-rooted species. Willow, alder, and red osier dogwood are some common species that have roots that extend deep into the soil, helping to keep the soil and shoreline together. The best time to plant is after the last frost in spring. When damage occurs, natural shoreline plants can re-establish themselves often without your assistance. Repairing damaged retaining walls or harder structures is usually difficult and more expensive.

Bioengineering

The planting of native species may not be sufficient to stop the erosion of a shoreline; in which case, a bioengineering approach may be more appropriate. Bioengineering incorporates plants in combination with natural materials (logs, live stakes, live brush bundles, etc.) into the shoreline stabilization design. It is sometimes referred to as a "living fence."

The advantage of bioengineering a shoreline is that the shoreline looks natural, can provide fish habitat, and allows natural vegetation a chance to root. Providing protection to enable vegetation to root increases the chances of long-term stability of the shoreline, and may prevent the need for hard structures such as rip-rap.

Hard Structures

In certain situations, hard structures are needed. While not as aesthetically pleasing as soft structures and much more expensive, they are useful in situations where soft structures by themselves do not provide enough protection. When hard structures are combined with soft structures, the results may be enhanced. The application of rip-rap is a common example of the use of a hard structure.

Rip-rap

Rip-rap is the use of boulders and rock to reduce erosion caused by wave action. In general, the boulders need to be heavy enough to resist movement by the waves and placed on an appropriate slope. The appropriate slope is generally 1 to 2. This means that for every metre in rise, there needs to be two metres of run toward the lakeshore. The size of the material deposited upon the bank needs to be large enough and sloped appropriately that the waves will "roll-up" the slope rather than crash into the materials. This helps to reduce the erosion force of the waves, and prolongs the stability of the rip-rap.

The use of filter cloth under the rock helps to prevent erosion of the finer particles under the rock. The planting of appropriate vegetation also assists in prolonging the stability of the rip-rap.

If done appropriately, the installation can enhance fish habitat by reducing sediment problems in fish habitat, and can also provide spaces for fish to feed, protected from large predators.

For a brief description of Lake Winnipeg's shoreline and its erosion issues, read pages 12 and 80 (electronic) of *Restoring the Health of Lake Winnipeg, Technical Annex, Canada's Sixth Great Lake* by Terry Duguid and Norm Brandson. Available online at <http://manitobawildlands.org/water_lakewpg.htm>.

Resources to Plan Your Teaching

- Pattimore, John H. *Outdoor Education Activity Program, Lakeshore Environment.* Winnipeg, MB: Manitoba Parks Branch Department of Natural Resources, 1980.

  This resource is very useful for those classrooms located close to a beach or shoreline. Many of the activities specifically look at wave action as a cause of shoreline erosion.

- Baird, W.F., & Associates Coastal Engineers LTD. Stantec Consulting LTD. Shoreline Erosion Advisory Group, Technical Report #5, Shoreline Erosion Study, Shoreline Erosion Advisory Group, September 2005.

- Grosshans, R.E., D.A. Wrubleski, & L.G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

- Manitoba Natural Resources, & Canada Fisheries and Oceans. *Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat.* Winnipeg, MB: Manitoba Natural Resources, May 1996.

  This resource provides a number of definitions and diagrams that are very useful to understand terms used in erosion prevention and fish habitat enhancement. Available online at <www.gov.mb.ca/waterstewardship/fisheries/habitat/sguide.pdf>.

- Manitoba Education. *Lake Winnipeg Water Stewardship A Resource for Grade 8 Science.* Winnipeg, MB: Manitoba Education, 2010.

  This resource provides a starting point for an understanding of sustainability issues for Lake Winnipeg. It has a very extensive bibliography. Additionally, the 57 pages of blackline masters use photographs and/or diagrams to illustrate concepts, such as natural means of erosion prevention, rip-rap, bulkheads, and breakwaters/groynes and gabions. Available online at <www.edu.gov.mb.ca/k12/esd/water/index.html>.

The Three A's

Activate: Have students discuss areas along a waterway that have been eroded and what they look like.

Acquire and Apply: Show a picture of the shores for the east and west side of Lake Winnipeg and for the south basin. Discuss the physical differences, such as geological, soil, and vegetation differences. Show an extremely eroded shoreline of Lake Winnipeg. Pinpoint the areas that are very eroded, and discuss reasons and possible solutions to this problem.

The Problem

Lake Winnipeg is extremely long, and the predominant winds from the north can result in extremely large waves along the southern shores—a phenomenon known as a **setup** or **wind tide**. Setups greater than 1 m above normal lake levels have been recorded along many of Lake Winnipeg's southern beaches. Wind tides have caused considerable storm damage and shoreline erosion. The highest setups occur in the fall, when the northerly winds are strongest. If the winds die down suddenly, the waters rush northward, and then withdraw back in a process called **seiching**. The extreme energy of this wave action has resulted in tremendous damage to the shoreline, including the removal of vegetation, extensive loss of soil, and even property damage. You have been asked to consult on the best restoration solution for a cottage property on the northeast side of Lake Winnipeg.

This is the shoreline of the property:

Property Description

- Northeast shore of Lake Winnipeg
- 400 X 250ft
- Soil: Clay-loam
- pH: neutral
- Grade: gentle slope

You must provide the property owner with a project description, which includes the following:

- A description of the technique you have chosen
- The techniques benefits (provide supporting research)
- Estimated cost
- Ecological benefits, if any
- Any issues surrounding the use of your technique

Assessment

Assessment *for* Learning: Have students peer edit each other's reports prior to submitting them.

Assessment *of* Learning: Research reports on the shoreline erosion problem are collected and assessed using the rating scale provided.

Report Rating Scale					
1–poor	2–fair	3–satisfactory	4–very good	5–excellent	
Description of the technique is clearly identified and described					1 2 3 4 5
The benefits of the technique are identified using literature					1 2 3 4 5
The costs are identified and reasonably justified					1 2 3 4 5
The ecological benefits are clearly discussed					1 2 3 4 5
The issues associated with the technique are clearly discussed					1 2 3 4 5

Notes

Lesson: Changes in the Netley-Libau Marsh

Specific Learning Outcomes

- **SLO C6:** Estimate and measure accurately using Système International (SI) and other required standard units. Include: SI conversions, interconversion of units, significant figures.
- **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

- become familiar with the geography of the Netley-Libau marsh
- determine dominant vegetative types/plants found in the Netley-Libau marsh
- calculate changes in vegetative cover and decline (1979–2001) in the Netley-Libau marsh
- identify some of the probable causes associated with changes in the Netley-Libau marsh
- compare calculated results with the emerging plant community study *(see* Grosshans, R.E., D.A. Wrubleski, & L.G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, Winnipeg, MB: University of Manitoba, 2004. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.)

Teacher Background

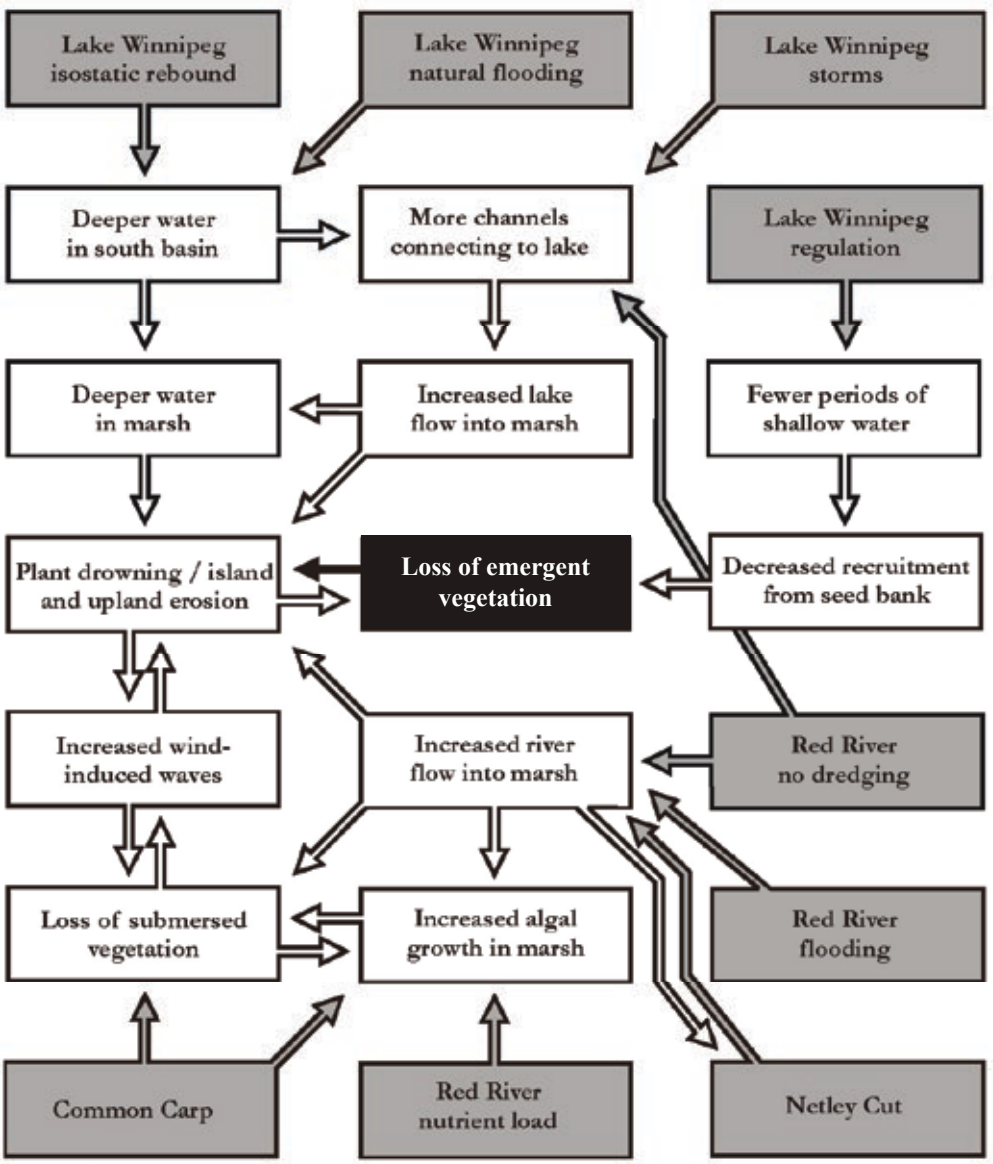
Marshes are the most productive type of wetlands and play an enormous role in the health of the planet and, in this case, Lake Winnipeg.

With the inception of agriculture, wetlands have excessively decreased throughout North America. Protecting existing wetlands and restoration efforts throughout the larger Lake Winnipeg basin are all crucial steps needed for a cleaner healthier Lake Winnipeg.

The Netley-Libau marsh is a remnant of glacial Lake Agassiz and one of the largest freshwater coastal wetlands in Canada. It is of significant importance as it lies at the mouth of the Lake Winnipeg's south basin where the Red River (contributor of 80 percent of nutrients entering Lake Winnipeg) enters the lake. Barrier Island, a narrow sand ridge, separates Lake Winnipeg from the marsh. The marsh is divided into two areas: east of the Red River and west of the Brokenhead River is the Libau side (Folsters Lake, Parisian Lake, Lower Devils Lake, Upper Devils Lake, Morrisson Lake, Oak Point Lake, Ramsay Lake, Hughes Lake, Passwa Lake, McKay Lake and Pruden Bay); west of the Red River is the Netley side (Goldeye Lake, Netley Lake, Cochrane Lake and Hardmans Lake).

In Canada, the marsh is designated as an important bird area (see <www.ibacanada.ca>), with over 100 species of birds. However, the Netley-Libau Marsh can hardly be called a healthy marsh, as it has undergone major geographical and vegetative changes over the last 40 years, reducing the marsh's productivity in reducing nutrients entering Lake Winnipeg.

In their study, Grosshans etal. demonstrate how changes in the marsh have led to a corresponding loss of emergent vegetation over the last 20 years.



Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 23. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

In September 2009, the provincial and federal government dedicated $1 million (see <http://news.gov.mb.ca/news/index.html?archive=2009-09-01&item=6794>) to help Manitoba waterways though the protection and restoration of wetlands. Funding is allotted to policy development and conservation easements. Of the $1 million, $300,000 is earmarked for the restoration of the Netley-Libau and Delta marshes.

Resources to Plan Your Teaching

Netley-Libau Marsh

- Netley Marsh Waterfowl Foundation
  www.lssd.ca/netleymarsh/
- Nature Manitoba: Netley-Libau Marsh Brochure
  www.manitobanature.ca/birder/iba.htm

General Wetland Resources

Ducks Unlimited Canada

- Teacher curriculum and corresponding student handbooks on wetland education
  www.ducks.ca/resource/teachers/lesson_plans/high.html
- The Wetland Centre of Excellence program offers support to high school students in wetland education through enrichment and action-based programs.
  www.ducks.ca/resource/teachers/classroom/index.html

Oak Hammock Marsh

- General Information
  www.oakhammockmarsh.ca/
- Program information for in class and on-site wetland education, as well as descriptions of teaching kits available for lending.
  www.oakhammockmarsh.ca/programs/educators/resources/index.html

The Three A's

Activate: Teacher-led class discussion on what is a wetland.

Suggested questions:

- What is a wetland?
- What is the role of a wetland? (Compare to a kidney)
- What are the types of wetlands?
- What are the parameters for designating each type?
- Where in Manitoba would you find these types?
- What is the natural succession of a wetland?
- How do the soil, plant, and animal communities differ in each type?
- What are some of the plants you would expect to find in a wetland?
- What are emergent plants?

Acquire and Apply: Introduce students to the study (see Grosshans, R.E., D.A. Wrubleski, & L.G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, MB: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.) Have students read the summary page of this publication, and underline the reasons the researchers identify as the main contributing factors to changes in the Netley-Libau marsh. After reading the summary and classroom discussion, have students fill out the Changes at Netley-Libau Marsh Worksheet.

Using the 2001 map and associated vegetative zone key, have students determine the dominant plant species, the distribution of vegetation, and the approximate total area for each type, and record their findings on a transparent graph sheet. For students to become familiar with the region, have them label the names of the streams, rivers, and lakes for the Netley-Libau marsh.

Once students are familiar with the geography, have them make rough calculations for the apparent changes in the region by comparing the 1979 and 2001 maps. These maps can be printed on transparencies so that students can overlay the images for more dramatic results. Using the transparent grid paper and corresponding legend, students can make rough estimates on changes for indicators of their choices (see BLM 2-5-5).

Changes in Netley-Libau Marsh, 1979–2001:

Indictor	1979	2001	Decline/Increase in %
Open Water	35%	51%	Decrease of:
Hard and soft-stem bulrush (schoenoplectus spp.)	13%	1%	Decrease of:

Table data reproduced from Grosshans, R.E., D.A. Wrubleski, & L.G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, MB: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 13. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

Have students write a summary paragraph describing how they think the changes to the Netley-Libau area will affect Lake Winnipeg.

Assessment

Assessment *for* Learning: Collect responses to questions and provide feedback, go through the answers to the questions as a class, or have students peer-review answers to questions.

Assessment *of* Learning: Have students submit completed maps and summary paragraphs, and assess responses according to clarity and use of the literature to justify any claims.

Summary

We used aerial photography combined with field observations to develop a detailed aquatic vegetation map for Netley-Libau Marsh in south-central Manitoba. This report describes the creation of a new geographically accurate map (georeferenced for use in a Geographic Information System - GIS), based on aerial photos taken in 2001, and construction of a detailed vegetation map for evaluating the changing state of Netley-Libau Marsh. This provides a basis for comparison with a 1979 vegetation map enabling a quantitative assessment of changes in the marsh over a 22-year period.

Comparisons between 1979 and 2001 reveal several significant changes in Netley-Libau Marsh. Loss of emergent vegetation and the erosion of separating uplands between adjoining water bodies has been extensive, resulting in the amalgamation and expansion of many marsh bays and ponds. Currently, half of the entire marsh (13,125 ha, 51%) is open water, compared to 35% (8,884 ha) in 1979. Cattail (*Typha* spp.) continues to be the dominant emergent plant in the marsh, showing little change between surveys. However, hard- and soft-stem bulrush (*Schoenoplectus* spp.) have declined ten-fold in abundance, from 3,247 ha (13%) to 317 ha (1%). The mixed river bulrush and sedge community, along with the wet meadow communities, have also declined in abundance. Plant communities at drier sites, however, have remained relatively unchanged.

Reasons for the observed changes in the marsh are not well known or understood, but change is not a recent development. Maps of the marsh from the 1920s to the present show a pattern of increasing open water area and loss of upland and island habitats. These changes are likely related to a number of factors, but the influence of Lake Winnipeg and the Red River are likely the most important.

Lake Winnipeg dictates water levels within Netley-Libau Marsh. Since the droughts of the 1930s and 1940s, water levels on Lake Winnipeg and the marsh have included few intervening dry periods. Without extended dry periods, to periodically allow the germination of new emergent vegetation, there has been a slow but consistent loss of emergent vegetation in the marsh. As this vegetation is lost, the protection that it provides for the soft sediments that make up island and upland habitats is also lost, and these habitats are slowly being washed away. The current management of Lake Winnipeg for hydroelectric production works to prevent low water levels on the lake and the marsh.

The Red River passes through Netley-Libau Marsh and it has likely contributed to some of the observed changes. High flow events on the river result in the erosion and collapse of weak points in the levees that border the river and other channels. Netley Cut, which was originally dredged in 1913, has been gradually eroded to a point where it now carries a substantial portion of the Red River flow into Netley Lake. The end of dredging on the Red River in 1999 has also likely contributed to the alteration of Red River flows through the marsh. High nutrient loads in the Red River, along with the arrival of common carp, may be contributing to enhanced algal growth and loss of submersed vegetation within the marsh. Loss of submersed vegetation results in the destabilization of bottom sediments and increased wind-induced wave action, which further helps erode island and upland habitats.

Without an ability to manage marsh water levels independently of Lake Winnipeg, only a prolonged drought will help restore the emergent plant communities of Netley-Libau Marsh. Dry conditions experienced in 2003 helped re-establish some of the emergent plant communities of the marsh, but the recent return to wet conditions may make this reversal short-lived.

We conclude that Netley-Libau Marsh resembles a shallow turbid lake more than a healthy coastal wetland. Any benefits to Lake Winnipeg which the marsh could provide as wildlife and fisheries habitat, and in removing and storing nutrients that would otherwise enrich the lake, have probably been degraded or lost.

Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

Student Handout: Changes at Netley-Libau Marsh Worksheet

1. Why are wetlands often considered to be the kidneys of Earth?

2. What techniques did the researchers of this study use to develop their hypothesis?

3. How does/can the Netley-Libau marsh contribute to a healthier Lake Winnipeg?

4. How has Netley-Libau marsh changed over the past 30 years?

(continued)

5. What are some of the factors contributing to the loss of emergent vegetation in the Netley-Libau marsh?

6. What can the changes in plant types teach us about Netley-Libau marsh? What do you think are the larger ecosystem implications of these changes in plant species?

7. What steps do you think government, scientists, and citizens should be taking to help deal with the unhealthiness plaguing the Netley-Libau marsh?

Sample Answers to the Changes at Netley Libau Marsh Worksheet:

1. Why are wetlands often considered to be the kidneys of Earth?

   Wetlands function as a natural filter, removing nutrients and contaminants and acting to prevent flood waters from soaking up runoff.

2. What techniques did the researchers of this study use to develop their hypothesis?

   Field studies combined with aerial photography.

3. How does/can the Netley-Libau marsh contribute to a healthier Lake Winnipeg?

   The Netley-Libau marsh provides an enormous service to the over 100 species of birds that breed and call the marsh home, helping to maintain the biodiversity of the region. The marsh acts as a filter for nutrients entering the lake. This is especially important as the Red River enters the lake here and is contributing over 80 percent of its nutrients, even though it only contributes 20 percent of the flow.

4. How has Netley-Libau marsh changed over the past 30 years?

   There has been significant erosion, increased open water, and changes in particular plant species.

5. What are some of the factors contributing to the loss of emergent vegetation in the Netley-Libau marsh?

   There are a number of reasons why the plant species at the Netley-Libau marsh have changed.

   - **Isostatic rebound, resulting in increased water levels in the south basin**
   - **Manitoba Hydro's Lake Winnipeg Regulation: the water is regulated within a four foot level; however, this has resulted in fewer low water cycles**
   - **Invasive species: carp (which destroy plants by pulling them out, resulting in vegetation loss and thus more turbidity and a decrease in water quality) and purple loosestrife (which chokes out endemic plant species)**
   - **Increased Flooding: Flooding along the Red River has increased, which results in more water entering the marsh (higher water levels/ less dry periods) and erosion, resulting in plant loss**

(continued)

6. What can the changes in plant types teach us about Netley-Libau marsh? What do you think are the larger ecosystem implications of these changes in plant species?
   - **Decreased genetic diversity among plant species**
   - **Increased nutrients entering the lake, resulting in eutrophication**
   - **Increased contaminants/toxins entering the lake, affecting the animal and fish populations/food chains and habitat health**
7. What steps do you think government, scientists, and citizens should be taking to help deal with the unhealthiness plaguing the Netley-Libau marsh?
   - **Increased funding for scientists/researchers into problems and plausible solutions for the Netley-Libau marsh**
   - **Increased public education on the benefits of wetlands**
   - **Increased public education**

Student Table

Changes in the Netley-Libau Marsh, 1979–2001			
Indictor	1979	2001	Decline/Increase in %

Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 7. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

(continued)

BLM 2-5-6 (continued)

Table 1. Interpretation key of vegetation signatures for colour infrared aerial photographs modified from Grosshans *et al.* (2005).

Vegetation Zone	Colour	Texture	Location/Comments
Open water	Blue/black	Smooth, rippled in some areas from wave action	Very dark and distinct
	White to green/white		Shallow water or reflections off water will often appear white to green/white
Sand (beaches, exposed)	White, usually quite bright	Smooth, flat appearance	Mostly devoid of vegetation, so appears bright white
Mudflat	White to blue/white, to greeny black	Navy/greeny black and white patches	Found bordering water, disturbed areas
Bulrush *(Schoenoplectus)*	Dark deep red, brick red to dark navy, to browny red	Blurry appearance and patchy; open water patches due to sparseness	Found in water, along water's edge, or deeper water areas; sparse patches appear as shadowed areas on open water
Cattail *(Typha)*	Medium to deep red	Smooth to grainy; pock marked appearance from open water, and inter-mixed patches of deadfall	Found mainly bordering open water to low water-filled areas; also borders whitetop, giant reed grass as well as sedges/rushes
Giant reed grass *(Phragmites)*	Pink to dark pink	Grainy to lumpy, shadows along edges gives depth to these patches appearing almost three-dimensional on photos, and much higher than surrounding areas with stereoscopes	Found bordering water, upland areas, cattail and whitetop; often a thin ring of cattail between giant reeds and water; also borders sedges and rushes, grasses, grasses with forbs.
Sedges and rushes *(Carex, Eleocharis, Juncus)*	Dark red to dark pink	Appears flatter on photos, does not have three-dimensional appearance as cattail does; with stereoscope appears flat	Usually occurs around/near whitetop areas, as well as cattail and fen grasses; also borders reed canary grass, grasses, and forbs; found in wet, waterlogged areas
Whitetop *(Scolochloa festucacea)*	White, to pale/light pink to green (shallow water)	Fine mottled appearance, white or green patches from open water areas	Often found bordering cattail, wet meadows, and giant reed patches; also borders fen grasses, sedges/rushes, and grasses

Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 9–11. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

(continued)

Table 1. Continued

Willows	Burgundy, maroon to dark red	Lumpy, gravelly, dotted patches	Uplands, dikes, along river channels; borders and surrounds sedge patches
Reed canary grass	Dark pink to browny red, a darker pink than Whitetop	Grainy lumpy appearance, to smooth	Usually occurs between whitetop and grasses/forb areas; also occurs next to cattail and giant reed; is a wet meadow grass, found where soils are moist to wet
Salt flat species *(Hordeum, Puccinellia)*	Cream, brown to browny red	Flat smooth texture, low flat appearance with use of stereoscopes	Occurs all over, but usually associated with mudflats, whitetop, sedges/rushes and fen grasses; occurs in grass/forb areas as well
Grasses (> 75% cover)	Light pink, light brown, to cream	Flat smooth texture, often more light pink to cream and not as patchy as Grasses/forbs	Low prairie areas found bordering wet meadows of whitetop, reed canary grass and sedges/rushes; slightly moister areas than grass/forbs
Grasses and forbs (< 50% forb cover)	Pink, light brown, gray and cream	Flat smooth texture, often patchy and mixed light pink, brown, gray to cream	Low prairie areas near wet meadows of whitetop, fen grasses and sedges/rushes; transition to upland areas of prairie grasses; presence of forbs cause mixed patches of browns and grays
Prairie (> 50% forb cover)	Medium pink to dark pink	Smooth to grainy	Upland areas, borders grasses and forbs, woodlands, cultivated fields and hayfields
Hayed grasses and forbs	White light green, to light pink	Lined, pinstriped, and patchy; can see haybales as large dots if already cut; hayed, fallen dead grasses and forbs appear white to light green	Low prairie areas which are hayed; often intermixed with grasses/forbs, as well as prairie; borders wet meadows and low prairie areas alike; many sedge/rush meadows are hayed as well
Grazed (prairie and shrubs)	Dark pink, cream, brown and gray	Smooth texture, patchy mixed dark pink, cream, brown and gray	Occur near and intermixed with woodlands while bordering cultivated areas and hayfields; patchy cream colors and browns from grazing

(continued)

BLM 2-5-6 (continued)

Tabled 1. Continued

Cultivated	White, yellow, brown, gray, beige, yellow-green, red to pink; quite variable	Lined, pinstriped, patchy or smooth to grainy; can see rows of crops	Human disturbance is very distinct; found upland on higher ground
Trees (trees and shrubs)	Burgundy, maroon to dark red	Lumpy, patchy, gravelly with shadows; cauliflower appearance; tall, three-dimensional appearance with stereoscope	High upland areas, borders next to prairie, grass/forbs, and cultivated fields; willow bluffs appear as smaller, lumpy, dotted areas surrounding small cattail and fen grass marshes
Disturbed	Browny-gray, gray to white; light green	Smooth to grainy appearance; freshly disturbed bare soils and deadfall appear white to light green	Disturbed areas very distinct; usually found in grass/forb areas, or near trees

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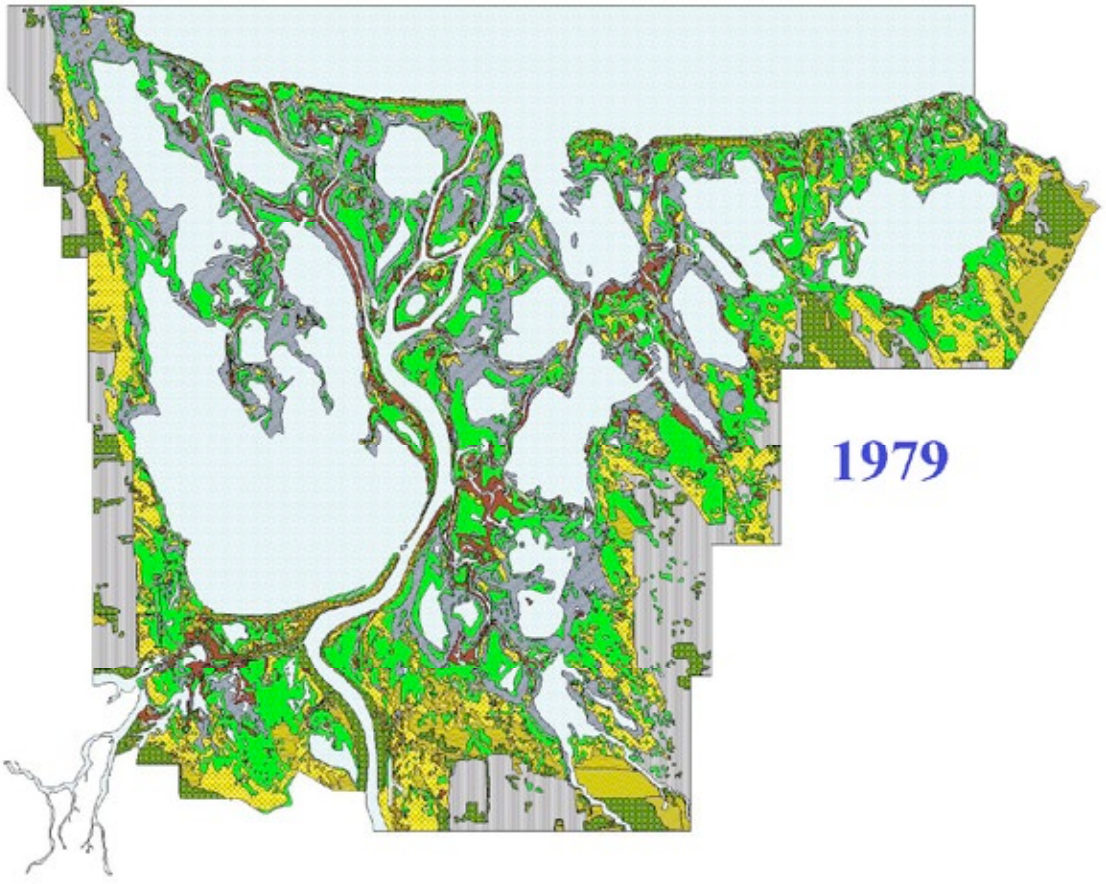

Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 14. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

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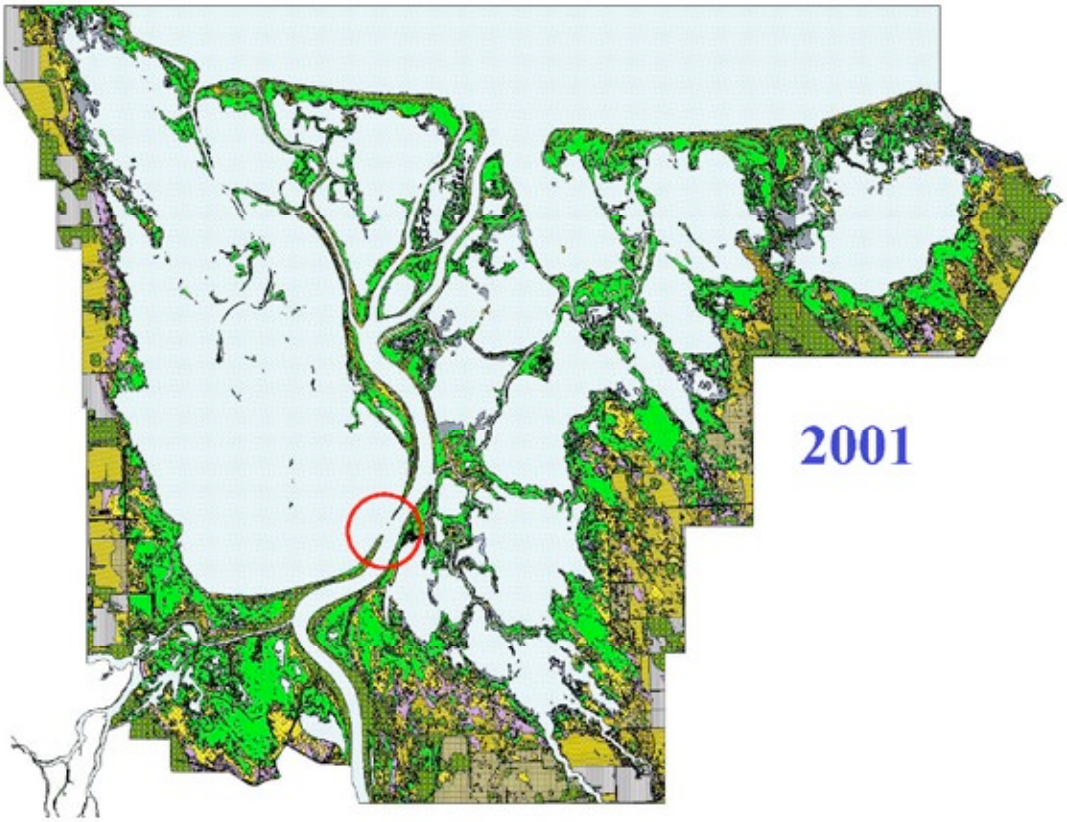
BLM 2-5-6 (continued)



Source: Grosshans, R. E., D. A. Wrubleski, & L. G. Goldsborough. *Changes in the Emergent Plant Community of Netley-Libau Marsh between 1979 and 2001.* Winnipeg, Canada: Delta Marsh Field Station (University of Manitoba) Occasional Publication No. 4, 2004. p. 15. Available online at <www.gov.mb.ca/waterstewardship/iwmp/netley/documentation/netley_libau_marsh_report.pdf>.

Essential Question 3

How are Social and Economic Activities Affecting the Health of Lake Winnipeg?

Essential Question 3: How are Social and Economic Activities Affecting the Health of Lake Winnipeg?

Introduction

There are so many different social and economic perspectives when it comes to Lake Winnipeg. Some of the perspectives are best covered by the whole class, so students can discuss the impact of poor stewardship on the livelihood of communities that live on the lakeshore. Another goal in this section of the course is to have groups of students explore one perspective in depth, and then teach the rest of the class about what they have learned by using a town hall scenario.

Resources to Plan Your Teaching

- CEC Manitoba website
  www.cecmanitoba.ca/index.cfm?pageID=1

  ``The Living Earth.`` *The Sharing Circle* (Season 16, Episode 6).
  This episode of the *Sharing Circle* explores the Indigenous view of the Earth and how this view contributes to the understanding of the health of Lake Winnipeg, The Boreal Forest, and the entire planet.

  > "As the world teeters on the brink of environmental collapse, this story examines people who respect the indigenous world view that the Earth is our mother, the rivers lifeblood flowing in her veins, and the plants and animals our brothers and sisters. By looking at the world this way, these people help preserve the environment around them and across the planet, and therefore hold the key to humanity's survival."
  > (Retrieved from <www.thesharingcircle.com/shows.html>)

The episode highlights Sophia Rabliauskas and the effort her community is leading to protect the northeast shore of Lake Winnipeg.

Notes

Lesson: The Living Earth

Specific Learning Outcome

- **SLO D2:** Integrate knowledge from various disciplines beyond the natural sciences, as necessary, in order to complement and represent the scientific world view. *Examples: the arts, mathematics, language arts, social studies…*

Teacher Background

There are many First Nations and Métis communities located within the Lake Winnipeg area, several of which are along the shorelines of the lake. Aboriginal people have a connection to the land and water that goes beyond simply appreciating its usefulness. In this lesson, students explore Aboriginal perspectives of the lake and its watershed.

The Three A's

Activate: Show students a map of the Lake Winnipeg watershed, and identify the many First Nations/Métis communities that lie within the watershed. Ask students how these communities may be affected by the health of the lake.

Acquire and Apply: Show students episode 6, season 16, of *The Sharing Circle*. The episode is about the Poplar River First Nation and the efforts they are going through to have the eastern shoreline of Lake Winnipeg declared a UNESCO World Heritage site.

Probing Questions

Have students discuss the following questions in small groups.

Questions

1. In the episode, the Elders say that the youth are losing touch with the environment. Do you think that youth, in general, are losing touch with their natural environment? What is your evidence to support your ideas?
2. In the episode, Sophia talks about the importance of the Boreal Forest as a natural filter of the lake. What do you think she means, and do you agree?
3. Do you think that the east side of Lake Winnipeg should become a UNESCO World Heritage site and be protected from logging and development? Do First Nations and Métis support the idea? Support your argument.

Have students complete an exit slip responding to the following:

> *The east side of Lake Winnipeg should/should not (circle one) become a UNESCO world heritage site because….*

Assessment

Assessment *for* Learning: Review responses in the exit slip, and provide comments on students' use of evidence.

Lesson: Agricultural Operations

Specific Learning Outcomes

- **SLO A4:** Analyze a controversial issue in the context of science as a community endeavour. Include: activities within the scientific community and potential influences beyond the scientific community.
- **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 C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*
- **SLO C16:** Compare diverse perspectives and interpretations in the media and other public information sources. *Examples: how various media treat scientific information and/or issues…*
- **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 investigate diverse perspectives on hog farming issues, and be introduced to the proceedings of the Clean Environment Commission by participating in a town hall.

Teacher Background

In 2008, the Province of Manitoba passed *Bill 17: The Manitoba Environment Amendment Act*, which banned the construction or expansion of large swine barn operations in southern Manitoba, the Red River Valley, a Special Management Area, and the Interlake. This bill was the result of a report produced by the Clean Environment Commission of Manitoba (CEC). The CEC is an arms-length organization that investigates and provides advice to the government on issues related to the environment. The commission is responsible for holding public consultations on proposed development projects where non-governmental organizations, concerned citizens groups, and private citizens, as well as the developers and local businesses, can present their cases to the commission. The commission then compiles the information and creates a report with a recommendation to the government.

Participating in the commission is the right of every citizen of Manitoba, and knowing the process and how to create a submission is an important part of being able to participate in the decision making of some of the more heated issues about the environment. In the following lesson, students prepare a CEC submission for a fictitious hog barn proposal in an area outside the banned area.

Resources to Plan Your Teaching

- CEC Manitoba website
  www.cecmanitoba.ca/index.cfm?pageID=1
- The following site provides a step-by-step description of the CEC process and the requirements for putting together a submission to the commission.
  www.cecmanitoba.ca/UserFiles/File/Participants%20Handbook.pdf
- Environmental Sustainability and Hog Production in Manitoba
  www.cecmanitoba.ca/File/Hog%20Production-%20Final%20Report2.pdf

The following is a list of resources to assist educators with media literacy, critical thinking, and diversity.

Applicable Bibliographies at Manitoba Education Library:

- Media Literacy Bibliography (2001):
  www.edu.gov.mb.ca/k12/iru/library_publications/bibliographies/media_literacy_2001_10.pdf
- Antiracism Bibliography (2001):
  www.edu.gov.mb.ca/k12/iru/library_publications/bibliographies/antiracism_2001_12.pdf
- Manitoba Education Library Catalogue:
  www.edu.gov.mb.ca/k12/iru/

Manitoba Education Website Resources:

- Literacy with ICT website: Professional Learning Experiences for Educators
  www.edu.gov.mb.ca/k12/tech/lict/let_me_try/le_teachers.html
  The following learning experiences would be applicable:
  1. Bogus Websites
  2. Internet Literacy 2: Evaluating Web Content
- Manitoba Education, Citizenship and Youth. *A Continuum Model for Literacy with ICT Across the Curriculum*. Winnipeg, MB: Manitoba Education, Citizenship and Youth, 2006.
  www.edu.gov.mb.ca/k12/tech/lict/resources/handbook/lict.pdf
- Diversity website for educators:
  www.edu.gov.mb.ca/k12/diversity/educators/what.html
- Social Studies Learning Resources (Annotated Bibliography):
  www.edu.gov.mb.ca/k12/learnres/bibliographies.html#social
- ELA Learning Resources (annotated bibliography):
  www.edu.gov.mb.ca/k12/learnres/bibliographies.html#ela

Other Web Resources

- MediaSmarts.ca
  http://mediasmarts.ca/
  A Canadian not-for-profit charitable organization for digital and media literacy. This website has resources for educators and students to support their learning about digital and media literacy. A search on the MediaSmarts.ca website using the keyword *bias* returns many resources for teaching about bias, stereotyping, and prejudice found in multiple types of media (print, online, television, radio, etc.).
- Critical Thinking Compendium
  http://critical-thinking.iste.wikispaces.net/
  Resource for teaching critical thinking and Internet literacies.
- Diigo.com
  https://groups.diigo.com/index
  Diigo is a social bookmarking site that provides a tool for people to pool their findings. Search using the keywords *critical thinking* to find resources submitted by users.

Scenario

On Wednesday, September 24, 2008, the Government of Manitoba passed *Bill 17: The Manitoba Environment Amendment Act,* which banned swine barn construction or expansion in most of eastern Manitoba. The bill established a permanent moratorium on the construction of new or expanded swine barns in southeastern Manitoba, the Red River Valley, a Special Management Area, and the Interlake. Bill 17 was the result of a report produced by the Clean Environment Commission of Manitoba called *Environmental Sustainability and Hog Production in Manitoba*, which states "…while we did not focus our investigation on Lake Winnipeg, we were always cognizant that most of the surface water in Manitoba ultimately flows through that lake." (p. 13)

Taiwan Salt is proposing a 80,000-head hog barn facility in the Minnedosa region of Manitoba.

> **Notice of Environment Act Proposal**
>
> Manitoba Conservation has received a proposal pursuant to the *Environment Act* from the following operation, and invites public participation in the review process:
>
> "Taiwan Salt" has filed a proposal to construct and operate an 80,000 head hog barn facility in the Minnedosa region of Manitoba. The operation will create 20 new full-time jobs, provide a local client for grain and feed supplies, and put thousands of dollars into the local community, beginning with the construction of a new recreational facility for the town.

The Three A's

Activate: Read a few headlines taken from local and national newspapers that have to do with the construction of hog barns. Try to gather a selection of headlines that balance the view.

Acquire and Apply: Talk to students about CEC Manitoba and its role in ensuring there is public participation in decision making when it comes to the environment. Go over the CEC process for a hearing, and provide some recent examples that can be found on the CEC website. Invite individuals who may have submitted and presented to the commission to talk about their experience, and how and why they may have decided to participate.

Provide students with the scenario, and split students into pairs or groups that represent different stakeholders. Use the cards provided, each one describing a different stakeholder group and some beginning resources.

Hold a commission hearing where each group provides a submission and gets to present at the hearing, and then have the class also act as the commission and develop recommendations and a final report.

Ask students to think critically about why these stakeholder groups have taken their respective positions, and evaluate their potential motives and biases. The Manitoba Education document *A Continuum Model for Literacy with ICT Across the Curriculum* describes critical thinking as "using criteria and evidence to assess the worth or validity of information and to make reasoned judgements. These judgements include distinguishing fact from opinion and interpretation, evaluating information and ideas, identifying perspective and bias, and considering the consequences of decisions and actions." (14)

Assessment

Assessment *for* Learning: Provide feedback to students on their participation in a town hall.

Assessment *of* Learning: Assess the report using the attached rating scale.

Submission for the Clean Environment Commission of Manitoba on a proposed large operation hog barn in the Minnedosa area by Taiwan Salt.

Requirements

As a stakeholder in the proposed development, prepare a submission addressing concerns or supporting information about the project impacts to the Clean Environment Commission by referring to the Participants' Handbook (note the CEC also examines issues associated with the methodology and scope of the environmental assessment and the adequacy of

the proponent's consultation program; however, neither of these are described in this scenario).

The submission must include the following:

- The name, address, telephone, FAX, and/or email of the participant
- A description of the particular interest of the participant (1 page)
- A clear and concise statement of the position taken by the participant (approximately 5 pages)
- A list of all documents to be relied upon (this includes websites, interview transcripts, or any other sources of information used to create the submission)
- A list and CVs of the expert witnesses to be relied upon, and a justification of why they would be good witnesses

Assessment Rating Scale									
The submission is: 1–poor 2–fair 3–satisfactory 4–very good 5–excellent									
Appropriately formatted	1	1.5	2	2.5	3	3.5	4	4.5	5
Highlights clearly the interests of the participant	1	1.5	2	2.5	3	3.5	4	4.5	5
Clearly and concisely describes the position of the participant	1	1.5	2	2.5	3	3.5	4	4.5	5
Includes an accurate bibliography of the sources of information	1	1.5	2	2.5	3	3.5	4	4.5	5
Clearly justifies why expert witnesses would be called upon	1	1.5	2	2.5	3	3.5	4	4.5	5

Notes

Spokesperson:

_____

(create a name)

Organization:

Manitoba Hog Producers
(representative organization for the many hog producers of Manitoba)

Resources:

Manitoba Pork Council
www.manitobapork.com/

Canadian Pork Council
www.cpc-ccp.com/index-e.php

Canadian Swine Breeders Association
www.canswine.ca/

Spokesperson:

_____

(create a name)

Organization:

Taiwan Salt
(international corporation, which was originally involved in one market in Taiwan, that has now branched out into many different markets, including animal production)

Resources:

Maple Leaf Foods
www.mapleleaf.com/en/#/entrance

Big Sky Farms
www.bigsky.sk.ca/

Spokesperson:

_____

(create a name)

Organization:

Policy Now Canada
(independent research institute concerned with issues of economic and social justice)

Resources:

Canadian Centre for Policy Alternatives
www.policyalternatives.ca/

Frontier Centre for Public Policy
www.fcpp.org/index.php

Spokesperson:

_____

(create a name)

Organization:

Local farmer
(local and small grain farmer with a family of four who lives close to the proposed site of the hog barn)

Resources:

Stop the Hogs
www.stopthehogs.com/index.htm
On this site, there are many editorials and testimonials from local farmers arguing both sides of the issue.

(continued)

Spokesperson:

_____

(create a name)

Organization:

Protect Homer
(an organization concerned with the welfare of hogs)

Resources:

www.humanefood.ca/about.html

Spokesperson:

_____

(create a name)

Organization:

Lake Winnipeg Research Consortium
(an organization composed of the many researchers of Lake Winnipeg)

Resources:

Lake Winnipeg Research Consortium
www.lakewinnipegresearch.org/

Spokesperson:

_____

(create a name)

Organization:

Lake Winnipeg Foundation
(an organization made up of individuals who have a passion for restoring and maintaining the health of Lake Winnipeg and its Watershed)

Resources:

Lake Winnipeg Foundation
www.lakewinnipegfoundation.org/ourhistory.html

Spokesperson:

_____

(create a name)

Organization:

Manitoba Association of Cottage Owners

Resources:

Lake Winnipeg Foundation
http://macoman.com/

Newspaper Articles Headlines:

Calling for change at hog barn

The Stonewall Argus and *Teulon Times*

Hog Barns Are Here; So is the Smell

Norquay North Star
February 18, 2004

Mega hog barns: Not in our back yard!

CBC, Broadcast Date: Oct. 11, 2000

Family farms vs. factory farms

CBC, Broadcast Date: Nov. 21, 1993

Won't back down from hog-farm fight,
Group plans to challenge province's agriculture rules

By: Carol Sanders
Winnipeg Free Press
26/10/2009

Protect Water, Stop Calling Names

Letter to the Editor
Ted Muir
General Manager
Manitoba Pork Council

Winnipeg Free Press, Aug 27, 2003

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.

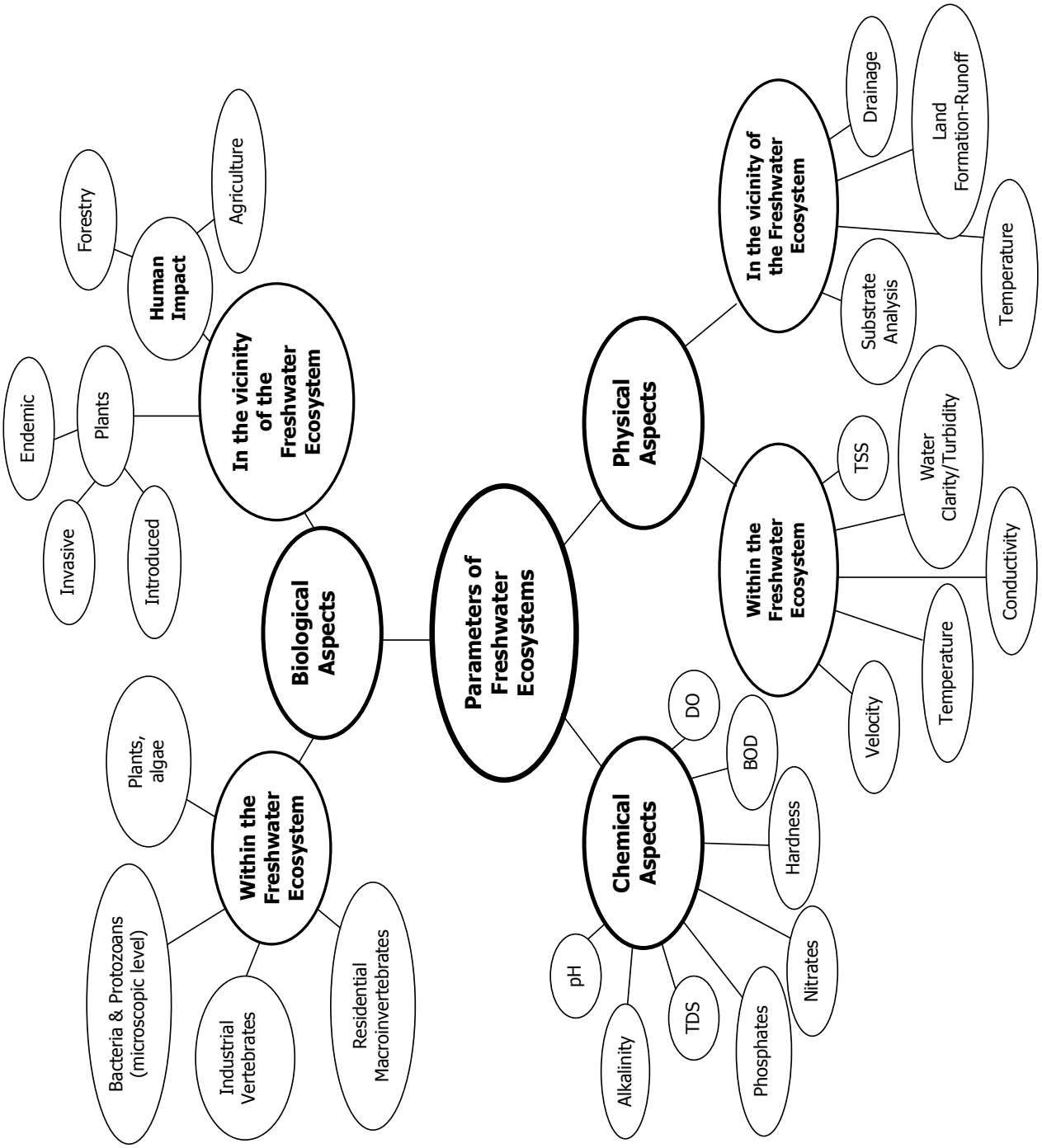
Using the cluster diagram (BLM 4-1-1), have students identify some questions they would like to answer while examining each of the parameters of a freshwater ecosystem. Establish one of these questions as an inquiry assignment that will be conducted during the course.

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.

(continued)

- 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?

(continued)

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.

(continued)

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**.

(continued)

> 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?

(continued)

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?

(continued)

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.

Essential Question 5

How Can Biotic Parameters Indicate the Health of Lake Winnipeg?

Essential Question 5: How can biotic parameters indicate the health of Lake Winnipeg?

Introduction

The biological condition of an aquatic environment is an indicator of watershed health. Aquatic organisms and communities reflect the cumulative conditions of watershed components. Healthy aquatic ecosystems reflect healthy watershed conditions. A biotic condition assessment for identifying healthy watersheds examines the presence, numbers, and condition of aquatic organisms and communities in a body of water. Environmental toxicologists, ecologists, and limnologists have used the biota of an area to indicate the health of the ecosystem. The lake ecosystem is no different. The presence of invasive species, the absence of toxin-sensitive invertebrates, the presence of low-oxygen tolerant macroinvertebrates, and population increases in toxin-tolerant macroinvertebrates are indications that an aquatic ecosystem has been disturbed. Some species are sensitive to specific toxins, and can be used as indicators for these poisons.

Resources to Plan Your Teaching

- CIER Species-at-Risk Tool Kit

Macroinvertebrates Keys

- Carlson, W., N. Trautmann, & the Environmental Inquiry Team. *Watershed Dynamics, Student Edition.* NSTA Press: Arlington, VA, 2004.
- Protocol 6 Simplified Stream Biota Test (SSBT) and Protocol 7: Index of Biotic Integrity using Aquatic Invertebrates are two analytical tools that can be used to evaluate the water quality of a stream.
- Ducks Unlimited Canada. *Key to Common Wetland Invertebrates; Marsh Monsters posters.* Winnipeg, MB: Oak Hammock Marsh Interpretive Centre/ Ducks Unlimited. Available online at <www.ducks.ca/ohmic>.
- Project WET (Macroinvertebrate Mayhem activity)
- Manitoba Waterways Project. Available online at <http://home.cc.umanitoba.ca/~lewthwai/mwp>. (information included on pp. 26–29)
- Arizona Water Education for Teachers. Healthy Water, Healthy People: Water Quality Educators Guide. "Benthic Bugs and Bioassessment," pp. 154–162; "Invertebrates as Indicators," pp. 174–180.

- **Fort Whyte Alive Centre**
- Beyond Books Institute of Alberta. "How to Monitor Aquatic Invertebrates," 1999–2001.
- "Key to the Major Invertebrate Species of Stream Zones." North Dakota Wetlands Discovery Guide, Photocopy booklet, USDA Soil Conservation Service, Figure B-11.
- "Protocols for Measuring Biodiversity: Benthic Macroinvertebrates in Fresh Waters" by D.M. Rosenberg, I.J. Davies, D.G. Cobb, & A.P. Wiens. Winnipeg, MB: Department of Fisheries and Oceans, Freshwater Institute.
- "Water on the Web." Available online at <www.waterontheweb.org>.
- "Freshwater Macroinvertebrates Protocol." GLOBE, 2003.
- Sharpe, William E., William G. Kimmel, & Anthony R. Buda. "Biotic Index Card." Penn State Sustainable Forestry Teacher Resource Center.
- "The Alabama Watershed Demonstration Project—Biotic Indicators of Water Quality." Available online at <www.aces.edu>.
- Volunteer Stream Monitoring Partnership. "Guide to Volunteer Stream Monitoring." University of Minnesota Water Resources Center.
- University of Wisconsin. "Water Action Volunteers—Volunteer Monitoring Factsheet Series." University of Wisconsin, 2003.

Lesson: Prokaryotes in Lake Winnipeg

Specific Learning Outcomes

- **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 C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*

Objectives

Students will describe the characteristics of cyanobacteria by completing an Internet scavenger hunt.

Teacher Background

Cyanobacteria, sometimes called blue-green algae, are a domain of prokaryote. They lack a cell nucleus. Unlike plants, where photosynthesis takes place in specialized organelles called chloroplasts, cyanobacteria photosynthesis takes place inside the cytoplasm. Some of the filamentous cyanobacteria contain specialized heterocysts, which can fix nitrogen directly from the air.

Cyanobacteria may be single-celled or multicellular. Multicellular cyanobacteria can form filaments, sheet, or hollow balls. Certain types of cyanobacteria may produce toxins.

In Lake Winnipeg, cyanobacteria cause problems with recreation activities such as swimming and commercial activities such as fishing.

Good Internet sources for definitions include the report *State of Lake Winnipeg: 1999 to 2007 Highlights,* issued in June 2011, and the definition of cyanobacteria in the *New World Encyclopedia*.

Resources to Plan Your Teaching

- Lockhart, Lyle. "Algal Blooms in Lake Winnipeg." *Lake Winnipeg Foundation Newsletter,* November 2005. Available online at <www.lakewinnipegfoundation.org>.
- Hiriart-Baer, Véronique. "Tracking the phosphorus sources in Lake Winnipeg: A possibility?" *Lake Winnipeg Foundation Newsletter,* Fall 2007. Available online at <www.lakewinnipegfoundation.org>.

- Levésque, Lucie, & Elaine Page. *State of Lake Winnipeg: 1999 to 2007 Highlights.* Winnipeg. MB: Environment Canada, Manitoba Water Stewardship, June 2011. Available online at <www.gov.mb.ca/waterstewardship/water_quality/state_lk_winnipeg_report/pdf/state_of_lake_winnipeg_rpt_technical_low_resolution.pdf>.
- New World Encyclopedia. "Cyanobacteria." Available online at <www.newworldencyclopedia.org/entry/Cyanobacteria#Health_risks>.
- Lake Winnipeg Research Consortium. "What's So Special about Blue-Greens?" *Lake Winnipeg Research Consortium Newsletter* 1.1, March 2008. 7. Available online at <www.lakewinnipegresearch.org/pdf%20files/LWRC_enews_Mar08_final.pdf>.

The Three A's

Activate: Play a cyanobacteria matching game. Create pairs of matching cyanobacteria cards using pictures obtained from the following website: <www-cyanosite.bio.purdue.edu/images/images.html>.

Distribute the cards randomly around the classroom, and ask students to find their matching cyanobacteria. Have pairs examine the pictures, and discuss how cyanobacteria share characteristics of both bacteria and plants.

Acquire and Apply: Have students read 'So what's so special about blue-greens?" on page 7 of <www.lakewinnipegresearch.org/pdf%20files/LWRC_enews_Mar08_final.pdf>.

Provide an overview of the morphology of a generalized cyanobacteria. Point out the characteristics of cyanobacteria that make it a prokaryote. Highlight how bacteria cells differ from other cell structures because they do not have a nucleus. Because of this, genetic material is loose in the cell in the gel-like cytoplasm. Except for the protein-producing ribosomes, bacteria do not have organelles (specialized cell structures that have specific functions).

However, bacteria do have cell walls and cell membranes. Cyanobacteria harvest the energy contained in sunlight and turn it into food (sugars) using the same process of photosynthesis found in higher plants.

Have students complete the Cyanobacteria Scavenger Hunt.

Assessment

Assessment *for* Learning: Collect student responses to the cyanobacteria scavenger hunt, and provide feedback.

See <www.cyanosite.bio.purdue.edu/images/images.html>.

Distribute the cards randomly around the classroom, and ask students to find their matching cyanobacteria. Have pairs examine the pictures, and discuss how cyanobacteria share characteristics of both bacteria and plants.

Student Handout: Cyanobacteria Scavenger Hunt

Answer the following questions about cyanobacteria using the recommended web resources.

1. Create a biologically accurate picture of one species of cyanobacteria. Identify the magnification of the diagram. You can find images of cyanobacteria at the following website: www-cyanosite.bio.purdue.edu/images/images.html

2. What are the causes of the overproduction of cyanobacteria in the Lake Winnipeg ecosystem? You can find an overview of the cause of algae blooms at the following website: http://dunnottar.weebly.com/overview.html

(continued)

3. How do cyanobacteria harm an aquatic ecosystem? You can find information on harmful algal blooms at the following website: www.cdc.gov/nceh/hsb/hab/default.htm

4. What morphological qualities do cyanobacteria have that help them out-compete phytoplankton in high nutrients in low light conditions? You can find information on the health risks of cyanobacteria at the following website: www.newworldencyclopedia.org/entry/Cyanobacteria#Health_risks

5. What is a cyanoHAB? You can find information on cyanoHAB at the following website: www.cdc.gov/nceh/hsb/hab/default.htm

Lesson: Understanding Algae

Specific Learning Outcomes

- **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.

Objectives

Students will identify the morphological differences between cyanobacteria and algae by comparing biological diagrams.

Teacher Background

Algae are non-vascular, aquatic plants that are capable of photosynthesis. Algae includes seaweed and many unicellular organisms. Many species of algae can be found floating or swimming as plankton in the water column, and macroscopic algae can often be found in the sand on beaches, but some algae are plants that grow together and form areas of thick vegetation that can look like underwater forests.

We can also eat some types of algae, and many commercial products contain forms of algae. The following are four of the most common algal products used in commercial products:

1. **Agar:** Agar is a gelatin-like substance that can solidify liquids that was first used in China in the 17th century. It is used as a thickener in foods like soup, yogurt, and ice cream.
2. **Diatomaceous earth:** This is a product that is made from diatoms, which are fossils of planktonic algae. It can be used as a filtering agent, an abrasive, and even as a pesticide-free ant killer.
3. **Carrageenan:** Carageenan is a colloid made from brown algae that is used in dairy and bakery products as a stabilizer or emulsifier.
4. **Alginic acid:** This is found in kelp plants along the Pacific coast, and is also used as a stabilizer or emulsifier in a variety of products, such as table syrup, orange drinks, and ramen noodles.

The Three A's

Activate: Bring in some food products that contain algae products (anything that contains agar would do, as it is a product of red algae). Show students each of the products one at a time, and then ask them what they have in common. Tell them they all contain algae. Have students discuss the natural environments in which they have observed algae, and describe what they looked like.

Acquire and Apply: Explain to students the different divisions of phytoplankton present in freshwater systems.

Explore the morphology of sample species in each of the different divisions. Assign students different freshwater algae species, depending on the slides you have available, or have each student observe algae species in a prepared culture. Have students prepare a large-scale drawing of their assigned algae. Students can compare the morphology of algae to the cyanobacteria studied previously using a compare and contrast frame.

Have students conduct the identification and quantification of a phytoplankton lab.

Identification and Quantification of Phytoplankton

This laboratory exercise is courtesy of Kent Simmons, University of Winnipeg.

Introduction

While it is useful to examine a few representative species within each group of algae, that exercise will not acquaint students with the difficulties of identifying algae collected in water samples from lakes, rivers, and streams. Also, knowing the algae is only half the problem. The other half is being able to quantify the number of algae in a known volume of water. This lab is designed to teach students how to recognize the major algal groups and to demonstrate one quantifying method.

Objectives

1. To illustrate techniques in identifying freshwater phytoplankton to family.
2. To develop student skills in reporting algal morphology.
3. To demonstrate one method of quantifying algae.

Phytoplankton Identification

This portion of the lab will concentrate on algal identification. The criteria you will use are sometimes based on the characteristics of algal divisions. Just

as often, they are based on the following: morphological traits that are true most of the time; colour that only indirectly reflects pigment composition; and developing a sense of logic and a process of elimination to help you in your identifications. In this lab, we will only classify the algae to family (where possible). Once you are able to get the organism to the level above genus, generic recognition is usually straightforward but species determination can be extremely difficult. Although there are several classification schemes available, we will use the scheme outlined by G.W. Prescott in *The Algae of the Western Great Lakes Area*.

You will be provided with a taxonomic key of all the divisions (classes, order, and families) of freshwater phytoplankton found in central and southern Manitoba. As well, each group of students will have a water sample. The first exercise will be to devise a relative abundance profile for the algae in your sample. Each student should make a wet mount of the water sample and record the numbers of algal/family present in the sample. Before submitting the results of your work, you should combine your results with those of the rest of the group. The results should be reported in the form of a histogram. This is a qualitative description of what is in your sample. You are not describing how many algae are present in a known volume of water, only how many are present relative to the other algae present.

Algal Morphometry

This section of the lab exercise involves determining some of the morphological features of the algae that may be important in estimating such parameters as lake productivity. This exercise may appear tedious, but it is issued on a regular basis in labs associated with determining water quality. There are three portions to this part of the lab:

a. Calibration of an ocular micrometer
b. Drawing two algae to scale
c. Calculating the surface area, volume, and surface-to-volume ratios of the cells

a. Calibration of an Ocular Micrometer

The ocular micrometer is a disc of glass upon which is ruled a series of equally spaced lines. Compound microscopes have ocular micrometers; however, the scale on the ocular micrometer changes with total magnification, and thus has no absolute value. Therefore, the ocular micrometer does not have units, and it needs to be calibrated prior to use. To determine the actual size of each unit on the scale, we must first calibrate the ocular micrometer with a stage micrometer. The stage micrometer is a microscope slide with a scale etched on it. The distance between the lines of the scale is exactly 10 microns.

When it is mounted on the stage, one can determine the number of microns represented by one scale division of the ocular micrometer.

- Remove the left ocular lens and insert the ocular micrometer (have the 10x objective lens in place). Look through the ocular and observe the scale.
- Place a stage micrometer on the stage. Focus on the scale using the right ocular.
- Using both oculars, rotate the left ocular until its scale is superimposed on the stage micrometer scale. Line up the tops of both scales at the same point.
- How many divisions of the ocular scale correspond to 1 division (10 microns) on the stage scale? What is the diameter of the field of view (microns)? Complete the calibration chart for your microscope.
- Remove and clean the stage micrometer.

b. Drawing Algae to Scale

- Once you have calibrated the ocular micrometer, you can now draw algae to scale. On the next two pages are grids and data tables. Make a wet mount of your lake sample, select two algae, and complete each page with a diagram and description of each alga.
- Using the calibrated micrometer, estimate the long axis of your alga in microns. Make an entire side of the grid slightly larger than the length of the alga. For example, if you determined the alga to be 12 microns long, then designate the grid scale to be 15 microns. Each subunit on the grid would then be 15 divided by the total number of subunits (19) or 1.4 microns.
- Draw the alga to fit the scale.
- Calculate the magnification of your drawing: $\frac{\text{drawing size (microns)}}{\text{actual size (microns)}}$
- Select the most appropriate geometric configuration, and calculate the surface area, volume, and surface-to-volume ratio. Complete the table that accompanies the grid.

c. Quantitative Estimate of an Algal Population

In the first exercise, you determined the type and relative abundance of an algal population. This may be all the information you are asked to obtain but generally it is insufficient. What you are missing is the number of algae per volume (usually mL) of water. This information is essential if you wish to know the productivity status of the lake. If slightly more sophisticated techniques are applied, quantitative information may also be obtained. In this portion of the lab, you will use one technique to determine the number of cells/mL. The technique employs a Palmer counting chamber. This chamber, when covered with a cover slip, holds exactly 0.1 mL of water.

Method:

Place a clean cover glass in position over the counting chamber, and slightly tilt the slide. Be certain there is firm contact between the chamber and the cover slip.

With a Pasteur pipette, add the sample via the lower entry port.

The total area of the chamber is 250 mm^2. Determine the area of the field of view from your calibration chart.

Count the number of algae (in each family) in 10 different fields of view (at 10x). Determine the average number of algae/family/field of view.

The density of each family of algae (D) in the water sample can be determined as:

$$D = N \times \frac{\text{area of chamber}}{\text{area of field of view}} \times \frac{1.0}{0.1}$$

$$D = N \times \frac{2500}{A}$$

A is the area of the field of view (in mm^2), where D is the number of cells of each family/mL of water, N is the average number of organisms/field in each class after 10 fields were counted. A is the area of the field of view (in mm^2).

Report your results in the form of a histogram (bar graph) in which the y-axis is the number of cells/mL.

Assessment

Assessment *for* Learning: Provide students with feedback on their use of the microscope and creation of wet mounts.

Algal Record

Sample Number_____ Sample Date_____

Sample Location _____

_____

Organism Identification_____

Organism Dimensions (microns) _____

Cell Volume _____ Cell Area_____ SA: Volume ratio _____

Magnification _____ Name of Identifier_____

Lesson: Lake Productivity

Specific Learning Outcomes

- **SLO C1:** Identify questions to investigate what arises from practical problems and issues.
- **SLO C2:** Clarify problems and refine testable questions to facilitate investigation. *Examples: develop a testable question appropriate to circumstances; define and delimit the kind and number of inquiry pathways…*
- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures…*
- **SLO C4:** Demonstrate work habits that ensure personal safety, the safety of others, and consideration of the environment. *Examples: application of WHMIS, proper disposal of chemical or biological specimens…*
- **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 investigate ways to measure the primary productivity of a lake by conducting a simulation experiment.

The Three A's

Activate: Show students a jar of water and a second jar that is filled with algae. Ask them how we could measure the difference in algal growth between the two jars. Then ask students to imagine the two jars are lakes, and ask them how we could compare the difference in algal growth between the two lakes.

Acquire and Apply: Explain eutrophication to students, and tell them how it is a measure of the productivity of a lake. Discuss some issues associated with eutrophication that are specific to Lake Winnipeg.

The Measurement of Primary Productivity

This laboratory activity was provided courtesy of Kent Simmons, University of Winnipeg.

Teacher Background

The Winkler method is often used to measure biological oxygen demand. Biological oxygen demand (BOD) is a measure of the oxygen used by microorganisms when breaking down the organic material in a water source. When there is a large amount of organic waste in a water source, the BOD will be high because there is a large amount of bacteria in the water. As the waste material decreases, so will the BOD. When the BOD is high, there is also less dissolved oxygen in the water because the bacteria are consuming the oxygen. Low dissolved oxygen will affect fish and other aquatic animals that cannot survive in low oxygen environments.

The following lab is an exploration of the effect light limitation has on the biological oxygen demand of a water source. This is especially important in the Lake Winnipeg context because of the highly turbid water in the southern basin. Cyanobacteria can adjust to low light conditions because they have a vacuole that helps them navigate the water column. Thus, under high turbidity, cyanobacteria can move to better light conditions and out-compete other species of algae.

The beauty of the Winkler method is that once students have an idea on how it measures biological oxygen demand in a water source and they have conducted one guided experiment to explore the effect of light limitation on BOD, they can then design their own experiment to look at other parameters that may affect BOD by changing some of the variables.

Resources to Plan Your Teaching

The Manitoba Waterways project also has a description of the Winkler method that is not so detailed or as complicated. Students can follow this method and then submit their findings to the Waterways site.
http://home.cc.umanitoba.ca/~lewthwai/mwp/mainpage.html#contents

Laboratory

How does the productivity of a water column change with depth?

Procedure

Day 1

1. Divide students into groups of five, and have each person obtain a 300 mL glass bottle (you can use an Erlenmeyer flask or other glass bottle that can be sealed) and rinse well with distilled water. Obtain at least 2.5 litres of the sample water (this will be either water collected from a field trip or a culture created by your teacher to simulate Lake Winnipeg water).
2. Carefully siphon the water into the glass bottles. Place the siphon on the bottom of the bottle and fill it so it is overflowing. Place a stopper on the bottle, and turn it upside-down to get rid of excess water in the well. Set the bottles up as follows:

Bottle	Treatment
1	Fill with water, initial sample
2. Dark	Fill with water, cover with aluminum foil
3. Light	Fill with water

3. Place the dark and the light bottles in front of a light source, as directed by your teacher, and leave them overnight.
4. Remove the stopper from the initial sample bottle and pipette 2 mL of manganous sulfate into the sample. Be sure to insert the tip of the pipette below the surface of the sample.
5. Pipette 2 mL of alkaline iodide into the same sample. Again, be sure to insert the tip of the pipette below the surface of the sample. A manganous hydroxide precipitate will immediately form.
6. Stopper the bottle and shake the sample by inverting the bottle several times. Keep all three sample bottles at the same temperature.
7. Make a wet mount slide of the sample water used for the experiment, and draw and identify some of the organisms that you observe.

Day 2

8. Obtain your bottles. Fix the dark and light bottles by following steps 4, 5, and 6.
9. Determine the absolute amount of dissolved oxygen in all the samples by filling a burette with a standardized thiosulphate working solution (or PAO), and obtain a bottle of starch solution.

10. Remove the stopper from the BOD bottle and **CAREFULLY** pipette 2 mL of concentrated sulphuric acid (H_2SO_4) into the sample. **YOUR TEACHER WILL PERFORM THIS STEP FOR YOU. CONCENTRATED SULPHURIC ACID IS EXTREMELY CORROSIVE! YOUR TEACHER SHOULD BE WEARING GLOVES AND EYE PROTECTION.**

11. Stopper the bottle and shake the sample by inverting the bottle several times. The precipitate will dissolve and the sample will turn a clear yellow-gold as free I_2 is formed.

12. Using a graduated cylinder, remove a 50-mL sample and pour it into a 250 mL Erlenmeyer flask.

13. Titrate this sample with the thiosulphate solution in your burette until a pale straw colour is reached. Remember to continually swirl the solution in your Erlenmeyer flask during the titration process. Also, set the flask on a sheet of paper to enhance the colour change.

14. To help you accurately identify the endpoint of this titration, introduce one or two drops of starch solution into the straw-coloured sample. The sample should turn purple in colour.

15. Continue to titrate, **drop by drop**, until the purple colour disappears. At the endpoint in your titration, all the free iodine has been converted to sodium iodide by the addition of sodium thiosulphate. The volume of sodium thiosulphate (in mL) used to titrate your 50-mL sample is approximately equivalent to the concentration of dissolved oxygen (mg/L) in your original sample. Your teacher will show you how to convert mg/L to mL/L.

16. Calculate the gross and net productivities and the respiration rate for your samples using the following equations:

    Gross Productivity =
    [Light Bottle (mL O_2/L)—Dark Bottle (mL O_2/L)]/time in hours.

    Net Productivity =
    [Light Bottle (mL O_2/L)—Initial Bottle (mL O_2/L)]/time in hours.

    Respiration rate =
    [Initial Bottle (mL O_2/L)—Dark Bottle (mL O_2/L)]/time in hours.

    Gross Productivity =_____ (mL O_2/L)/hr

    Net Productivity =_____ (mL O_2/L)/hr

    Respiration =_____ (mL O_2/L)/hr

17. Plot the net productivity (mL O_2/L)/hr versus light intensity (%) for the samples.

Probing Questions

What was the effect of light limitation on biological oxygen demand? How would this finding be important in the Lake Winnipeg situation?

Extension

Now that the students have the basic procedure for the Winkler method, they can design their own experiment using their own questions. Have students, in pairs or groups, develop a testable question they would like to explore.

Examples

How does the temperature affect biological oxygen demand?

How does the pH affect biological oxygen demand?

From the testable question, students can now develop a procedure that would examine a different parameter other than light and dark.

Assessment

Assessment *for* Learning: Provide students with feedback on their lab skills using a checklist.

Assessment *of* Learning: Assess the lab report using a rubric.

Notes

Lesson: Macroinvertebrates as Indicators of Water Quality

Specific Learning Outcomes

- **SLO C2:** Clarify problems and refine testable questions to facilitate investigation. *Examples: develop a testable question appropriate to circumstances; define and delimit the kind and number of inquiry pathways…*
- **SLO C3:** Design and conduct an investigation to answer a specific scientific question. *Examples: materials necessary, independent/dependent variables, controls, testable hypothesis or prediction, methodology, safety considerations, appropriate sampling procedures….*
- **SLO C4:** Demonstrate work habits that ensure personal safety, the safety of others, and the consideration of the environment. *Examples: application of WHMIS, proper disposal of chemical or biological specimens…*
- **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 C11:** Synthesize information obtained from a variety of sources.

Objectives

Students will identify macroinvertebrates found in local water sources, and determine water quality based upon their presence or absence.

Teacher Background

Assessment of water quality for life can be done by looking at the macroinvertebrates that are found in a body of water. Tolerance to conditions in and of the water varies from species to species, and the relative abundance of different groups is a good general indicator of water quality.

Students can collect benthic invertebrate samples from small streams in an area. Samples could be collected from upstream and downstream reaches of a

creek or stream and benthic invertebrate abundance, community composition, and diversity could be compared among all sites. The benthic invertebrate data would complement any water quality information (i.e., DO, pH, water clarity, temperature, nutrients, ions) that the students may be collecting at the same locations along the stream of interest. The organisms can be easily identified by types and often by species. There are many good invertebrate resources available and keys that are relatively simple to use.

Resources to Plan Your Teaching

Macroinvertebrates Keys

- Carlson. W., N. Trautmann, & the Environmental Inquiry Team. *Watershed Dynamics Student Edition.* Arlington, VA: NSTA Press, 2004. Protocol 6 Simplified Stream Biota Test (SSBT) and Protocol 7: Index of Biotic Integrity using Aquatic Invertebrates are two analytical tools that can be used to evaluate the water quality of a stream.
- Ducks Unlimited Canada: Key to Common Wetland Invertebrates; Marsh Monsters posters—Oak Hammock Marsh Interpretive Centre/ Ducks Unlimited
  www.ducks.ca/ohmic
- Project WET (Macroinvertebrate Mayhem activity)
- Manitoba Waterways Project
  http://home.cc.umanitoba.ca/~lewthwai/mwp/
  (information included on pp. 26–29)
- "Benthic Bugs and Bioassessment" (pp. 154–162), "Invertebrates as Indicators" (pp. 174–180): Healthy Water, Healthy People Water Quality Educators Guide"
- FortWhyteAlive
- "How to Monitor Aquatic Invertebrates." Beyond Books Institute of Alberta, 1999–2001
- "Key to the Major Invertebrate Species of Stream Zones." *North Dakota Wetlands Discovery Guide—Photocopy Booklet*, USDA Soil Conservation Service, Figure B-11
- "Protocols for Measuring Biodiversity: Benthic Macroinvertebrates in Fresh Waters" by D. M. Rosenberg, I.J. Davies, D.G. Cobb & A.P. Wiens. Winnipeg, MB: Department of Fisheries and Oceans, Freshwater Institute
- "Water on the Web"
  www.waterontheweb.org
- "Freshwater Macroinveretebrates Protocol" GLOBE, 2003

- "Biotic Index Card" by William E. Sharpe, William G. Kimmel, & Anthony R. Buda. Penn State Sustainable Forestry Teacher Resource Center
- "The Alabama Watershed Demonstration Project: Biotic Indicators of Water Quality"
  www.aces.edu
- "Guide to Volunteer Stream Monitoring" Volunteer Stream Monitoring Partnership, University of Minnesota Water Resources Center
- "Water Action Volunteers—Volunteer Monitoring Factsheet Series" Spring 2003 University of Wisconsin

The Three A's

Activate: Using web resources, create a matching game where students must try to match adult macroinvertebrates with their larval stage.

Acquire and Apply: Have students look at the key to identify the macroinvertebrates present in a water source. Using the samples collected from a local water source, have students practise by identifying different macroinvertebrates.

Discuss the importance of each macroinvertebrate as an indicator of water quality, and design a plan on how your class could quantitatively evaluate the water quality using macroinvertebrates (e.g., the class could decide that each group must use the same amount of sample and count the number of different organisms in 10 different fields of view, and then average them).

Alternately, the class could use protocol 6 or 7 in *Watershed Dynamics*. (Carlson W., N. Trautmann, & the Environmental Inquiry Team. Watershed Dynamics Student Edition. Arlington, VA: NSTA Press, 2004. Protocol 6 Simplified Stream Biota Test [SSBT]).

Based upon the class results, have students write their own conclusions.

Assessment

Assessment *for* Learning: Provide students with feedback on their participation in the discussion.

Assessment *of* Learning: Collect the individual conclusions students draw to the results collected by the class.

Notes

Lesson: Fish Populations

Specific Learning Outcomes

- **SLO C11:** Synthesize information obtained from a variety of sources.
- **SLO C13:** Quote from or cite sources as required, and reference sources according to an accepted practice.
- **SLO C14:** Communicate information in a variety of forms appropriate to the purpose, audience, and context. Include: technical science writing (*e.g., proposals, laboratory reports, research reports…*); popular science writing (*e.g., magazine articles, comics, short stories, poetry…*).
- **SLO C15:** Use bibliographic and electronic research tools to collect information on a selected topic. *Examples: keyword searches, search engine navigation, databases…*

Objectives

Students will identify some of the fish species found in Lake Winnipeg, explain the habitat and food web of one species, and discuss the impact of nutrient loading on their selected fish species.

Teacher Background

There are 56 fish species found in Lake Winnipeg. They all have their own habitat parameters, and thus will be affected differently by different stressors on the lake. Students will be responsible for selecting one fish species from the lake, and conducting a research project that examines the habitat requirements of the fish and how high nutrient levels in the lake may affect it.

The Three A's

Activate: Ask students to name as many fish species they know to exist in Lake Winnipeg.

Acquire and Apply: Choose one fish species, and provide an overview of how that species may be affected by high nutrients in Lake Winnipeg.

Provide students with the following scenario:

A Grade 8 class is currently studying the Lake Winnipeg ecosystem and the effect high nutrient levels could have on the different organisms in the lake. The class does not have time to cover the fish species in the lake, and the teacher would like the class to create a web page, *PowerPoint* presentation, or bulletin board about the different species found in the lake and how they could be affected by high nutrient loading. Your job is to contribute

to the presentation by selecting one fish species to research, and creating a presentation providing the following information:

- Fish species common name
- Fish species biological name
- Description of habitat requirements
- Description of where this fish fits in an aquatic food web
- Description of sensitivities to fluctuations in the environment

Lesson Modification: If you are in a First Nations community, have students visit the Centre for Indigenous Environmental Resources website (see <www.ppw.ca>). The First Nations Fish Habitat Program has a number of resources. Using this workbook allows students to take a modified but proactive and local approach to the lesson above (see <www.ppw.ca/WorkArea/showcontent.aspx?id=1848>).

Assessment

Assessment *of* Learning: Assess the presentation using a rubric.

SAMPLE PROFILES

Lake Winnipeg Stewards Questionnaire

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Allan Kristofferson

2. **What is your occupation in relation to Lake Winnipeg?**

   I am the Managing Director of the Lake Winnipeg Research Consortium Inc. (LWRC).

3. **How did you come into your current occupation/work? (What is your educational background? Where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg.)**

   Very little is known of Lake Winnipeg from a scientific perspective. Having had a close connection with Lake Winnipeg since my childhood, I saw an opportunity to increase our scientific understanding of the lake, so, along with a number of others with interest in the lake, we formed the Lake Winnipeg Research Consortium in 1998. The goal of the LWRC is to facilitate multidisciplinary research on the lake, and to promote educational opportunities for students where possible. Upon retirement from the Federal Fisheries Department, I became the Managing Director. I earned a B.Sc. in Zoology and a M.Sc. and Ph. D. in Ichthyology (study of fishes) from the University of Manitoba.

4. **Are there any early life experiences that drew you into your current work?**

   I grew up in Gimli on the shore of Lake Winnipeg. Commercial fishing was an important part of the community, and I became interested in fish as a result. I wanted to pursue a career that involved fish and fishing, so, after studying biology at the University of Manitoba, I became a fisheries biologist.

5. **How did you become involved in working on Lake Winnipeg issues?**

   I started working on Lake Winnipeg with the Provincial Fisheries Department in the early 1970s, and went on to complete my M.Sc. on lake whitefish in the lake. Following that, I became employed with the Federal Fisheries Department and spent 30 years working on Arctic char fisheries in the Canadian Arctic. I became aware of the development of problems with water quality in Lake Winnipeg by talking to commercial fishers that I knew. I wanted to get involved in this and was nearing retirement, so I and others formed the LWRC.

6. **Please describe a typical day on the job.**

   I conduct my business from an office in Gimli. My job is to ensure that the entire operation runs smoothly. On a typical day, this includes dealing with funding issues, crew and vessel requirements, science needs, educational programs, preparing presentations, and, on occasion, interviews with media and others.

7. **What do you like about your job?**

   It gives me a sense of satisfaction that I am doing something that will help to deal with the challenges facing the lake and the people who rely on it for business and pleasure.

8. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   The activity I am involved in will give us a better understanding of what is happening within the lake. Scientific information that is produced as a result of our work will provide everyone (e.g., government and private citizens) with the ability to make better decisions about what is done in the watershed and how it affects the water quality in the lake.

9. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   I think the biggest issue surrounding Lake Winnipeg is the lack of awareness by most of the 6.6 million people who live in its watershed of the serious nature of this eutrophication issue. Many are not aware of a problem at all, and many of those who know there is a problem do not understand its nature. We need to educate these people so that they will change their behaviour in order to reduce their nutrient inputs to the watershed.

10. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen, etc.)?**

    First and foremost, everyone needs to know and accept that they are part of the problem. They need to understand the nature of the problem so that they will know what they need to do differently to help turn it around, and they must be willing to do so. People have different interests. Those interested in science can pursue a career that will put them in a position to get involved in the science directly. There is much we do not yet understand, and the more we understand, the better we will be able to protect the lake from this and future threats. There is a need for more education (teaching), more outreach (media), support of government (civil service, politicians), etc.

11. **Please add any other information you feel relevant to our young people learning about Lake Winnipeg.**

    Lake Winnipeg is so very important to so many people. We each have a responsibility to protect it, whether we are directly affected by its problems or not.

12. **Please add any other information you feel relevant to young people wanting to obtain careers working in science.**

    Young people wanting to obtain careers in science should become aware of the many different types of careers available, such as in government, academia, and private industry. This will provide information on the type and extent of education needed to secure a particular position of interest. Talking with those involved in such careers will help, and obtaining summer employment within a particular career will be very valuable in giving students "hands-on" experience in what it is actually like before they make a career choice.

13. **Please add any additional information you feel is relevant.**

    Don't rush a career choice, but don't be afraid to switch if the first choice is not what you expected. Above all, once you have found a career of interest, be positive about your ability to achieve the level of expertise necessary to do an excellent job, and enjoy all aspects of it. That way, it won't seem like work!

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Dr. Eva Pip

2. **What is your occupation in relation to Lake Winnipeg?**

   Research scientist

3. **How did you come into your current occupation/work? (What is your educational background? Where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg.)**

   I have a B.Sc. (Hons) and Ph.D. from the University of Manitoba, and I also held a post-doctoral fellowship from the Natural Sciences and Engineering Research Council of Canada (NSERC). My doctoral thesis was on freshwater ecology/physiology, and focused on how water chemistry is linked to aquatic community composition and structure. However, none of my mentors or supervisors were interested in Lake Winnipeg.

4. **Are there any early life experiences that drew you into your current work?**

   Yes, I have always been interested in aquatic organisms, and I think that this started when I began collecting shells when I was five years old. This grew into a lifetime obsession.

5. **How did you become involved in working on Lake Winnipeg issues?**

   I always loved this lake, and I was saddened to see how it was being neglected and abused.

6. **Please describe a typical day on the job.**

   When I am out on a sampling day in the field: I wake up at about 4:30 a.m., load up my truck with my equipment and canoe, and head out. Sampling needs to be done regardless of the weather, as the lake will not wait for anybody. It is very pleasant when the day is nice, but not so good when it is pouring and the bugs are bad. I spend the whole day visiting my sampling sites, collecting water samples and specimens, and recording measurements such as temperature, pH, oxygen concentrations, underwater light intensities, etc., in my waterproof field notebook. I will typically take 15 minutes to eat my lunch, which is always a cheese sandwich and a thermos of tea—my standard field lunch for the past 50 years! I come back to the lab when it is already dark. I have to unload my samples and put them away in the fridge or freezer. If there are bacterial samples such as E. coli to analyze, these must be inoculated onto media immediately, since they cannot be stored, and put away into the incubator to grow so they can be counted and identified later. Then I head home (I live in eastern Manitoba) and usually arrive back at around midnight. If I am sampling farther away, such as around the north basin of the lake, I will sleep in my truck overnight. During winter, I spend my days in the lab going through the samples I have collected, together with my students and research assistants. We do a lot of water chemistry: we analyze for basic things like nitrogen, phosphorus, alkalinity, chloride, sulphate, total dissolved solids, suspended solids, as well as metals such as cadmium, copper, and lead. We also look at the toxins produced by blue-green algae, and we do a lot of work on the plants and, particularly, the snails and clams that are found in the lake, as they tell us a lot about the health of the lake. Some years, we also sample the lake in winter. This involves going out all day on a snowmobile with a dogsled attached and cutting holes in the ice, through which we can lower our sampling equipment. There have been a few times when I have fallen through the ice, but have lived to tell about it.

7. **What do you like about your job?**

   I love being outdoors, and I love being able to find out new things that nobody has known before.

8. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   I believe that *somebody* has to be an advocate for Lake Winnipeg, since the politicians and other people who are supposed to be doing it, are definitely ***not*** doing it! Personally, I take care of the lake by refusing to have a cottage. In the 50 years that I have been working in this business and the thousands of cottages that I have observed, I firmly believe that it is not possible for a cottage to have no adverse impact on the environment. It is wasteful and greedy to have two residences when much of the world's population has none, and cottages are usually located in places where the environment is the most vulnerable and fragile.

9. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   The biggest issue is public apathy. If more people took the time to educate themselves about the impact that their actions have on the lake, and if more people expressed their concerns to their government, maybe we could see some changes. But for many things, it is already too late. For example, we can never put back all the species that have already disappeared from the lake.

10. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen, etc.)?**

    Get informed about the things that we are doing that are harming the lake. Start making changes in your own life/family/school.

11. **Please add any other information you feel is relevant to our young people learning about Lake Winnipeg.**

    Our young people, ultimately, are the only hope that Lake Winnipeg has. The older generations have blown their chance.

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Dr. Gordon Goldsborough

2. **What is your occupation in relation to Lake Winnipeg?**

   I am a member of the Department of Biological Sciences at the University of Manitoba. I am a wetland scientist, interested in the dramatic ecological changes that have occurred in the Netley-Libau marsh located on the south shore of Lake Winnipeg.

3. **How did you come into your current occupation/work? (What is your educational background? Where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg.)**

   I received B.Sc. (Honours) and Ph.D. degrees from the University of Manitoba, did a post-doctoral fellowship at the University of Alberta, and taught at Brandon University before coming to the University of Manitoba in 1996, as Director of the University's Delta Marsh Field Station adjacent to Delta Marsh and Lake Manitoba. My doctoral advisor, who had a major hand in my decision to go into my field of study, was Dr. Gordon Robinson, who is also a member of the Department of Biological Sciences at the University of Manitoba.

4. **Are there any early life experiences that drew you into your current work?**

   I took an undergraduate-level course in biology of algae, which, at that time, was a required course that I did not expect to enjoy, but did so immensely. On the basis of that experience, I changed my career plans (which at one time were to go into forestry) to instead become an aquatic ecologist.

5. **How did you become involved in working on Lake Winnipeg issues?**

   I was asked by Dr. Frank Baldwin (a retired medical scientist living near the Netley-Libau marsh) to look into the dramatic ecological changes in the marsh that he had witnessed through his many years of experience there. We were shocked at what we found, and were gradually drawn into further studies that are still ongoing today.

6. **Please describe a typical day on the job.**

   Every day is different—that's what I enjoy most about my job, along with the flexibility that it affords (basically, I decide what I do each day; it is generally not dictated to me by others). One day might be teaching classes of university students. Another might be attending a meeting of scientists or resource managers. Yet another might be leading a public meeting relating or giving a public presentation. Still another might be spent in an airboat cruising around a marsh. And another might be spent hunched over a computer keyboard, analyzing data, and writing scientific articles or applications for research funding.

7. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   I am interested in healthy coastal wetlands because, when they do their job, they remove nutrients and therefore prevent them from passing into the lake. By restoring the ecological function of the Netley-Libau marsh, we can reduce the impacts of the Red River on water quality in Lake Winnipeg.

8. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   Lake Winnipeg is the "end of the pipe" for an enormous watershed covering several Canadian provinces and American states. Getting participation from all the relevant stakeholders will be crucial to the restoration of Lake Winnipeg. Therefore, I think that wider public education about the Lake Winnipeg issue, and the watershed concept in general, is critically important.

9. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen, etc.)?**

   Lake Winnipeg water quality is affected by the contaminants put into water flowing into it from the watershed. Anything that people can do to reduce their consumption of water, and therefore their production of "gray water" containing contaminants will help. Every citizen should take part in a personal water audit to track their own water consumption and, where

possible, strive to reduce it. Every litre of water that is not consumed is one less litre of contaminated water entering Lake Winnipeg.

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Gregg J. Brunskill

2. **What is your occupation in relation to Lake Winnipeg?**

   During 1968–74, I was a limnologist studying Lake Winnipeg, from the Fisheries Research Board/Freshwater Institute in Fort Garry. I am now a retired chemical oceanographer, having worked on the coastal seas of northern Australia, New Guinea, and Indonesia.

3. **How did you come into your current occupation/work? (What is your educational background? Where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg.).**

   Undergraduate, B.A. 1959–63, Augustana College, Sioux Falls, South Dakota, Major in Biology, Minor in Chemistry.

   Graduate, Ph.D. 1963–1967, Cornell University, Ithaca, N.Y., Major in Biogeochemistry, Minors in Geology and Psychology. Thesis in Limnology and Geochemistry

4. **Are there any early life experiences that drew you into your current work?**

   Mostly serendipity. I grew up in western South Dakota, where there isn't much water. The newspapers thought Lake Erie was dying, to they gave us money to find out what was happening in the Canadian Great Lakes.

5. **Please describe a typical day on the job.**

   I gather the eggs, water my gardens, pick sweet corn and watermelons and mangoes and jackfruits and passionfruits, read and listen to music. I am now retired, living on a rural property in north Queensland, Australia. While I was working on Lake Winnipeg in 1969, it was a rough job, trying to get all the people and equipment to work on the CGS Bradbury, running 24 hrs/day, mostly in rough weather.

6. **What do you like about your job?**

   I like adventure, creating new ways to measure the natural world processes, trying to understand how the world works, and seeing exotic corners of the world. Hnausa, Berens River, George Island, Grand Rapids are exotic places that interested me on Lake Winnipeg. I also learned that I liked working on big ships, and that I didn't get seasick.

7. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   I have several publications that help explain how Lake Winnipeg operates, and I continue to be involved in the Lake Winnipeg Foundation affairs.

8. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   Reduce agricultural runoff of farm wastes and industrial toxic substances to the Red, Assiniboine, Saskatchewan, and Winnipeg Rivers. Protect the fishery, and the scenic values of the shorelines.

9. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen etc)?**

   Study geology, physics, chemistry, biology, environmental economics, Manitoba history, and even limnology. Support the Lake Winnipeg Foundation at <www.lakewinnipegfoundation.org/>.

10. **Please add any other information you feel is relevant to our young people learning about Lake Winnipeg.**

    Allan, R.J., & G.J. Brunskill. "Relative atomic variation (RAV) of elements in lake sediments: Lake Winnipeg and other Canadian lakes." *Interactions between sediments and freshwater: Proceedings of an International Symposium, Amsterdam, September 6–10, 1976.* Ed. H.L. Golterman. The Hague: Junk & Wageningen, PUDOC, 1977. 108–120 (print).

    Brunskill, G.J. *Rates of Supply of Nutrients, Nitrogen and Phosphorus to Lake Winnipeg,* Manitoba, Canada: Int. Ver. Theor. Angew Limnol. Verh., 1973. 18:1755–1759.

    Brunskill G.J., Elliott S.E.M., & Campbell P. *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. v +23

    Brunskill, G.J., & B.W. Graham. *The offshore sediments of Lake Winnipeg.* Can. Fish. Mar. Serv. Manuscr. 1979. Rep. 1540: v + 75.

    Brunskill, G.J., D.W. Schindler, S.E.M. Elliott, & P. Campbell. The attenuation of light in Lake Winnipeg waters. Can. Fish. Mar. Serv. Manus, 1979. Rep. 1522: v + 79

    [Note: all of these publications should be available at the Freshwater Institute Library in Winnipeg.]

11. **Please add any other information you feel relevant to young people wanting to obtain careers working in science.**

    Study geology, physics, chemistry, biology, environmental economics, and even limnology in a good university, and find good people to work with in research projects.

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   My name is Lyle Lockhart.

2. **What is your occupation in relation to Lake Winnipeg?**

   I am retired. I came to be interested in Lake Winnipeg because of my work as a Research Scientist at the Freshwater Institute (1971–2001).

   Since 1995 we have spent most of our summers fixing up an old cottage at Ponemah and so I had both professional and personal interests in the lake.

3. **How did you come into your current occupation/work? (What is your educational background—where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg).**

   I completed a B.A. (1965) and M.Sc. (1967) in biology and Ph.D. (1971) in biochemistry (University of Western Ontario) and was offered work at the then quite new Freshwater Institute here on the U of M campus. Biochemistry is a mixed discipline with quite a lot of chemistry and relatively little biology but I already had the biology part. My work at the Freshwater Institute was on the presence of contaminants in water and aquatic organisms and the biological effects on those aquatic organisms. I was an adjunct professor at U of M and taught an undergraduate course in Environmental Toxicology along with graduate students.

4. **Are there any early life experiences that drew you into your current work?**

   I grew up near the north shore of Lake Erie and was always interested in that. I used to ride my bike to Port Stanley and fish from the pier there; I could usually fill my tin bucket with perch in a couple of hours. On moving to Winnipeg, I was surprised how little scientific interest there seemed to be in Lake Winnipeg but I had almost no opportunities to work on it until the 1990s.

5. **How did you become involved in working on Lake Winnipeg issues?**

   I had a small project on effects of the Pine Falls pulp mill on the reach of the Winnipeg River from Pine Falls to Traverse Bay. The results were quite striking and I wanted to extend the work into the lake. My first opportunity to do that came in 1994 with a geological cruise of the Namao.

6. **Please describe a typical day on the job.**

   I don't have to go to work any more. Usually I spend a good bit of time on scientific literature in two areas, material relevant to Lake Winnipeg and to Evolution in general. And on other hobby interests.

7. **What do you like about your job?**

   Being retired is one of the best times of life as long as health holds up. For the first time, I can study whatever I want, not something that I have been able to find research money to do.

8. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   I have been working a lot of volunteer hours for the Lake Winnipeg Foundation. I was one of its founding directors and served as chair of its education committee. Now I am chair of its scientific committee. I hope soon to be able to give up that role and just be a member of the foundation and the science committee and avoid everlasting meetings. I want to spend more time getting relevant literature catalogued and onto our embryonic website (see <www.lakewinnipegfoundation.org>).

9. **What do you think is the biggest issue surrounding Lake Winnipeg?**

   There are several issues for the lake. I usually group them into biological ones, chemical ones, physical ones, and political/economic ones. Probably the most serious immediate biological issues are the algal bloom that seems to becoming both larger and more frequent and the invasions of the lake by new species. The algal problem is related to the chemical inputs, particularly of phosphorus which in turn are related to changing precipitation patterns and ever-growing land drainage networks. Most of the physical/chemical/biological problems of the lake are related to political and economic issues that arise from having so many different jurisdictions with different interests involved in managing the watershed.

10. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen etc)?**

    I think young people should try to experience a lake if they can. If they experience it, I hope they will come to both love and respect it. The key is the value they place on the lake. All the rest will flow from the kinds of values they form, not just about the lake but about the planet as a whole. As far as formal education goes, pretty well any of the sciences will be helpful regardless of the careers they follow.

11. **Please add any other information you feel relevant to our young people learning about Lake Winnipeg.**

    Young people have the most freedom to form positive values about the environment in general and about a big features of our environment here, namely Lake Winnipeg and the other lakes and rivers - water in general. Young people do not yet have entrenched economic interests that may compromise the values they place on the environment. If there is a conflict between our environment and our incomes, we adults tend to make choices that favour our incomes. If young people already have strong environmental values, I hope they will choose economic activities that are consistent with those early environmental values.

12. **Please add any other information you feel relevant to young people wanting to obtain careers working in Science**

    I hope young people will be able to obtain fairly broad educational experiences. I was once asked by a Winnipeg city MLA whether his riding was in the Lake Winnipeg drainage. It never occurred to me that an elected MLA would not be aware of where the rivers and sewers end up. He told me he had never thought about it before. That is the problem. I often give public talks about the problems with Lake Winnipeg and many Manitobans are surprised at the extent of the watershed that drains into Lake Winnipeg. Something must have been lacking in our education about geography. We all need to think about the consequences of our actions and childhood seems a good time to learn that.

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Greg McCullough

2. **What is your occupation in relation to Lake Winnipeg?**

   Geographer (doing remote sensing of algae in the lake, and studying geomorphology and hydrology of nutrient transport from the watershed)

3. **How did you come into your current occupation/work? (What is your educational background-where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg).**

   I did a B.Sc. in 1968–71; then worked with a landscape architecture and planning firm for a while, then with Fisheries and Oceans Canada for 19 years studying hydrology and sediment and nutrient transport in lakes and streams; then did an M.Sc. in remote sensing, then a Ph.D. in geomorphology/limnology and now do all of these things as a research associate at the University of Manitoba. That's the bare bones description of my education so far.

   My first and greatest influence was Bob Newbury—a civil engineer who taught me geomorphology and the importance of finding work that is both a joy and a service. And then Bob Hecky—a limnologist from whom I began to learn just how complex and fascinating every lake is (if you happen to be that way bent).

4. **Are there any early life experiences that drew you into your current work?**

   I'd like to say my early playing in puddles, which would be true. But also, chance. I started my B.Sc. in geology, which I very early on grew bored by. And then I found geomorphology and I was off.

5. **How did you become involved in working on Lake Winnipeg issues?**

   I was mid-thesis and found opportunities for grants to do remote sensing research on the lake. I jumped in because I could see the value of the work to understanding the lake, and felt that by the time I finished my Ph.D., someone else would be doing it. So I took a few years longer to write up my thesis. Lake Winnipeg paid for it, and has been helping pay for me ever since. (I do have another job, but still find time for a lot of Lake Winnipeg research.)

6. **Please describe a typical day on the job**

   Could be a day on the computer analyzing the relationships between numeric data recorded by satellites and concentrations of cyanobacteria sampled in Lake Winnipeg. Or analyzing data sets for environmental factors other than nutrient concentrations that might have affected the relative size of algal blooms in different years—either could occupy days. Or it could be a day on the Namao tending (usually cantankerous) equipment that measures optical properties of lake water and sampling water for chlorophyll and associated parameters at various stations through the day, followed by sub-sampling and filtering the water—preparing subsamples to be sent to various labs for analysis when we return. It could be a day driving around to suppliers picking up hardware—hose, valves, wood, bottles, filter paper, whatever—to make up the sampling gear and building weather-proof housing for equipment and all the rest that has to be done to get ready to do that sampling. And then, there are meetings… Or it could be a day answering email—that's today!

7. **What do you like about your job?**

   I love figuring out how things work. But by things, I mean mostly rivers, lakes, the sea—and all of the processes that go on in them. And I enjoy being outside, whether on a ship or beside a stream. Field work is a way to get paid to do what I would do anyway if I had the money.

8. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   I don't think of myself as a steward (sounds too much like something out of Lord of the Rings, where the stewards were failed protectors) but I'll try to answer. The simplest part is that I have developed a capability to monitor the lake using satellite data; that's a tool that we can use to monitor the lake in the future, a way to measure the response of the lake to whatever mitigation strategies we undertake to "fix" it. At the other end of things, I also study relationships between climate, flooding and nutrient loading to Lake Winnipeg's tributary rivers. We may understand a lot about how the lake has changed in response to increased nutrient loading, but we are a long ways from understanding watershed processes well enough to be sure we can lower that loading (other than from urban sewage—that we do know how to do). I hope that my research will contribute to better understanding those processes… and through that, contribute to decisions that will have to be made to control them.

9. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   Nutrient loading. Support decisions to remove phosphorus from sewage—not just in Winnipeg, but in every community. Lobby governments to quit adding phosphorus to your water supply (it's added to reduce deterioration of water lines. Push them to find another way.) Personally: learn where you contribute phosphorus to the watershed—dishwasher detergents, car washes, lawn fertilizers, others—many of those are optional; you can choose to not used them. Most of all, learn about it. Read the Lake Winnipeg Stewardship Board's report—they had lots of ideas. Some you can do, some you can promote.

10. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen etc)?**

    Pretty much what I wrote above. For a future scientist: there are pieces to the puzzle we still haven't figured out. Everything I wrote above seems to do with urban life; yet most of the nutrient loading to Lake Winnipeg comes from the land. We can suggest phosphorus runoff mitigation strategies that may contribute a little, but there is so much more to learn. Lots of room for science, some applied, some pretty basic.

11. **Please add any other information you feel relevant to our young people learning about Lake Winnipeg.**

    Remember that it's a pretty complex ecosystem. It's not dying; it's changing. We may or may not be able to reverse that change, but if not, we can still try to manage it. To do either needs knowledge, and time.

12. **Please add any other information you feel relevant to young people wanting to obtain careers working in Science.**

    Better be into this for the love of it; the kind of environmental research I do won't likely make you rich.

Lake Winnipeg Stewards Questionnaire

1. **What is your name?**

   Sue Watson

2. **What is your occupation in relation to Lake Winnipeg?**

   Research Scientist with Environment Canada

3. **How did you come into your current occupation/work? (What is your educational background-where/what did you study? Who were your mentors/teachers? This is to help students from a variety of backgrounds and educational levels identify with individuals involved in Lake Winnipeg).**

I obtained a B.Sc., and M.Sc. at McGill University in the 1970s. The graduate work focused on Lake Memphremagog, a trans-boundary lake spanning the Vermont/Quebec borders with similar, albeit less severe, issues with inputs of nutrient-rich water at the south end. This lake has several basins, and exhibits a nutrient gradient and associated changes in the species of algae and abundance that predominate. There were frequent summer blooms in the more shallow south basin, which received the majority of nutrient inputs from the southern river inflow and some of the embayments, and a gradual clearing of the water column towards the deeper areas in the north. Similar to Lake Winnipeg, I worked on an interdisciplinary team to understand the causes and correctives of this problem. I continued on at McGill for two more years, working as a research assistant for Dr. J. Kalff, and analyzing the samples he took from a series of African lakes, which we published. Following a 15-year period when I stayed home and raised a family (although stayed peripherally involved in research via co-authored publications), I went on to obtain a Ph.D. at the University of Calgary, where we were living at the time. I specialized in the ecophysiology of algal species outbreaks—i.e., how individual species are able to grow to excess and dominate a community to the near exclusion of others (a 'bloom'). I focused on algae which are both photosynthetic (fix energy from the sun) and bacterivorous (acquire energy and nutrients by ingesting bacteria as an alternative resource). I became intrigued in the chemical ecology of these and other algae, and why they produce compounds such as taste-odour causing volatile metabolites and toxins. This was the focus of an NSERC Post Doctoral Fellow at the University of Calgary, which was followed by placement with Environment Canada, working on this issue. I initially was located at the University of Calgary as an adjunct faculty member and government scientist, where I conducted research into algal outbreaks, chemical ecology, and nutrient-management related issues in southern Alberta and the mountain parks. As more and more of my work involved the Great Lakes, I relocated to Burlington and now work at CCIW. I work with many different levels of government, industry (including the drinking water industry), academia, and local stewardship groups in Canada, the US, and other countries (including Australian and European partners), as well as academic partners. Recently, Environment Canada has become involved in multidisciplinary research and assessment of Lake Winnipeg and surrounding drainage systems (e.g., Lake of the Woods), which is a major component of our present work.

4. **Are there any early life experiences that drew you into your current work?**

   A love of the outdoors, water, and a healthy curiosity (which often gets me into trouble!).

   I chose to have a family and then challenge myself by launching into a Ph.D. at age 40—it is never too late to set and achieve goals.

5. **How did you become involved in working on Lake Winnipeg issues?**

   Recently, Environment Canada has become involved in multidisciplinary research and assessment of Lake Winnipeg and the surrounding drainage

systems (e.g., Lake of the Woods), which is a major component of our present work. I have also been working for some time with scientists at the Freshwater Institute on other water quality related issues.

6. **Please describe a typical day on the job**

   There is no such thing! I work on Lake Ontario and embayments, Lake Erie, the St. Lawrence River, Sudbury district lakes, prairie lakes, Lake Winnipeg, and Lake of the Woods, and this requires a lot of management and, often, lab and field work, meetings, and much travelling. I also supervise many students and young people at summer work—term employees, interns, and grad students.

7. **What do you like about your job?**

   The different partners and students, the variety and challenge of the different water bodies we work with, and the opportunity to travel and see Canada and other countries in the world and share ideas and learn about issues in these places. We often share many environmental problems.

8. **Why are you a steward of Lake Winnipeg/how do you take care of the lake?**

   It is a vital and living ecosystem and a major source of fresh water for Canada. It is now recognized as the 6th Great Lake and, as such, is the most impaired, with more severe water quality problems and over-enrichment of nutrients than even Lake Erie. It is imperative that remedial action is taken, which first requires the identification of the key sources of nutrients and other contaminants and a basin-wide effort to work together in this initiative following a scientifically based action plan.

9. **What do you think is the biggest issue surrounding Lake Winnipeg? What can we do?**

   Non-point-source nutrient inputs from the watershed (notably agriculture), historic complacency, the water level regulation by the numerous hydro dams that have fundamentally changed the flushing rates of the lake, allowing more nutrient and sediment deposition to the bottom and accumulation of internal reserves. This high nutrient input has resulted in the recent increased frequency of severe algal blooms and impaired food-web function.

10. **What advice/tips would you give to young people wanting to be proactive on the issues surrounding Lake Winnipeg (as a future scientist, Manitoba citizen, etc.)?**

    Become involved and informed, learn about the key issues and why nutrients are a problem, participate in local restoration projects (e.g., wetland restoration, tree planting, practices, and environmentally friendly lifestyle, such as using less water, gas, and hydroelectricity; eating locally; reducing garbage and landfill material; initiating composting, and understanding the potential impacts of garden and other fertilizers, etc.)

11. **Please add any other information you feel relevant to our young people learning about Lake Winnipeg.**

    Get active and move to restore and protect your lake! It is a precious and badly battered local and national resource. Join the local groups at <www.lakewinnipegresearch.org> and <www.lakewinnipegfoundation.org>.

12. **Please add any other information you feel relevant to young people wanting to obtain careers working in science.**

    Keep pushing yourself past your comfort zone and challenging yourself—this is the only way to grow and really experience life to its fullest. Take opportunities as they arise! One can always find a reason why not to, and allow oneself to slip into a routine while life and careers pass you by. There is not such thing as a final choice—i.e., even if you take a graduate degree in one area, you can always change course afterwards and follow a completely different (or related) path.

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