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Environmental Sciences Ltd.

Towards Science-Based Lake Management Planning Approaches for Alberta

Workshop Proceedings

June 3rd, 2015

Alberta Environment and Parks

Spruce Grove Boardroom

Prepared for: North Saskatchewan Watershed Alliance and Alberta Environment and Parks
Job #: J150042

December 21, 2015

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December, 2015 HESL Job #: J150042

Mr. David Trew
Executive Director, North Saskatchewan Watershed Alliance
9504 49 St.
Edmonton, AB
T6B 2M9

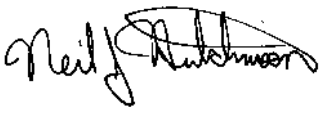
Dear David:

Re: Towards Science-Based Lake Management Planning Approaches for Alberta Workshop Proceedings

Please find attached our summary report of the June 3 workshop in Spruce Grove, the "*North Saskatchewan Watershed Alliance Lake Planning and Management Professional Development Day*". We have provided the individual presentations as Appendices to the main report and summarized the discussion points in the text by theme. There were a series of recurring themes and concerns over the course of the day and a wide ranging discussion from engaged participants. We have attempted to organize the discussion points by theme but there is some degree of repetition, as several points fit more than one theme. We also tried to preserve the flavour of individual comments as they captured the key concerns facing Alberta lake managers. The comments summarized herein therefore represent the opinions of the workshop participants and we all recognize that they may not necessarily reflect the policies or opinions of the North Saskatchewan Watershed Alliance, Alberta Environment and Parks or Hutchinson Environmental Sciences Ltd.

I thank you for your foresight and initiative in organizing this timely workshop and for your recent edits and recommendations relating to our draft report. I hope that our efforts provided useful information to inform development of the North Saskatchewan Regional Plan. I think that you captured the intent and timeliness of the workshop for the North Saskatchewan Regional Plan in your closing comment that "This is a golden opportunity to influence lake management in Alberta". We hope that our participation and this summary prove useful in the process.

Sincerely,
per: Hutchinson Environmental Sciences Ltd.



Neil J. Hutchinson, Ph.D. President
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Signatures

Report Prepared by:

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President

Workshop Sponsors

North Saskatchewan Watershed Alliance (NSWA)

Alberta Environment and Parks (AEP)

Hutchinson Environmental Sciences Ltd. (HESL)

Executive Summary

On Wednesday June 3, 2015, the North Saskatchewan Watershed Alliance (NSWA), Alberta Environment and Parks (AEP) and Hutchinson Environmental Sciences Ltd. (HESL) hosted the *"North Saskatchewan Watershed Alliance Lake Planning and Management Professional Development Day"* in Spruce Grove, Alberta. The aim of the workshop was to broach concerns, current issues and rationale behind the contemporary state of lake management in the North Saskatchewan Region in a pre-planning and educational session to inform the upcoming development of the North Saskatchewan Regional Plan.

The workshop consisted of a series of prepared presentations followed by discussions among the 23 participants. This document summarizes the main discussion points raised throughout the workshop. Presentations were made on:

- The history of lake management in Alberta: approaches, data and issues,
- The history of implementing Ontario's "Lakeshore Capacity Model",
- A review of approaches to lake management in 14 North American jurisdictions,
- Approaches to and case studies of lake classification, and
- A proposal to develop a risk-based classification system for the planning and management of Alberta lakes.

Discussions addressed the variety of concerns facing Alberta lakes and recognition that social concerns must be considered along with environmental concerns. Participants recognized the value of a systematic approach to classify lakes by use and risk, and using these classifications to inform planning and lake management activities. Lakes could be classified by:

- Lake Use - a high level goal such as "wilderness", "urban", "conservation", "recreation", and then
- Lake Health or "Current Risk" - to assign priority and need for management, e.g.,
  - lakes and watersheds with limited carrying capacity,
  - lakes and watersheds requiring restoration,
  - lakes and watersheds for which precautionary approaches (BMPs) are warranted
  - lakes and watersheds for which more information is required to focus monitoring programs.

Management could then consider the "Lake Use" and the "Risk" to that use and assign BMPs appropriate to each level of risk. For example:

- Lakes that are of high ecological value and not damaged at this point could be considered as candidates for "conservation".
- Lakes that are of moderate ecological value, but with some degradation, could be managed to prevent further degradation and improved through remedial actions.
- Lakes that are highly degraded or less sensitive to management initiatives because of unique characteristics could be less intensively managed because those efforts might not result in large improvements.
- Prudent watershed management to minimize further landscape degradation would be advocated in all cases

The Province of Alberta is currently developing the North Saskatchewan Regional Plan and this represents an opportunity to develop a lake management and planning system. What works for the North Saskatchewan Region may ultimately be applied across the Province. The workshop provided a useful discussion to inform the consideration of lake management approaches in the North Saskatchewan Regional Plan.

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Appendices

1. About the Workshop

On Wednesday June 3, 2015, the North Saskatchewan Watershed Alliance (NSWA), Alberta Environment and Parks (AEP) and Hutchinson Environmental Sciences Ltd. (HESL) hosted the *"North Saskatchewan Watershed Alliance Lake Planning and Management Professional Development Day",* in Spruce Grove, Alberta. The aim of the workshop was to broach concerns, current issues and rationale behind the contemporary state of lake management in the North Saskatchewan Region in a pre-planning and educational session to inform the upcoming development of the North Saskatchewan Regional Plan. Consideration was given to the importance of a systematic and well-defined approach to lake management, including a reason for prioritizing lakes for planning and management by creating a lake classification system. The workshop provided an opportunity to obtain a well-informed and practical understanding of the experience of other jurisdictions in implementing lake management programs, potential bases for lake classification systems, a review of their use in other jurisdictions and their potential applicability to the North Saskatchewan Region.

The workshop consisted of a series of prepared presentations followed by discussions among the participants. This document summarizes the main discussion points raised throughout the workshop. The comments summarized herein represent the preliminary opinions of the workshop participants and may not necessarily reflect the policies or opinions of the NSWA, AEP or HESL.

2. Presenters

Dave Mussell (AEP)	Introduction and Welcome
David Trew (NSWA)	An Overview of Lake Studies in Alberta
Neil Hutchinson (HESL)	Evolution of Lake Management Approaches: The Ontario Example
Tammy Karst-Riddoch (HESL)	Managing Shoreline Development on Inland Lakes: a Jurisdictional Review
Tammy Karst-Riddoch (HESL)	Screening & Classification Tools
Neil Hutchinson (HESL)	Case Studies in Classification
David Trew (NSWA)	Prototype Lake Classification Tool

3. Attendees

Ahmad Asnaashari	Alberta Environment and Parks
Alyssa Tuininga	Alberta Environment and Parks
Bruce Vanos	Alberta Environment and Parks
Chad Willms	Alberta Environment and Parks
Christine Geiger	Hutchinson Environmental Sciences Limited
Dörte Köster	Hutchinson Environmental Sciences Limited
Eleanor Kneffel	Alberta Environment and Parks
Hugh Sanders	Battle River Watershed Alliance
Jamie Bruha	Alberta Environment and Parks
Jana Tondu	Alberta Environment and Parks
Jennifer Regier	North Saskatchewan Watershed Alliance
Jon Sweetman	Alberta Innovates Energy and Environment Solutions
Laura Johnson	Alberta Environment and Parks
Marcel Macullo	Alberta Environment and Parks
Mary Ellen Shain	North Saskatchewan Watershed Alliance
Mathieu Lebel	Alberta Environment and Parks
Melissa Logan	North Saskatchewan Watershed Alliance
Richard Casey	Alberta Environment and Parks
Vanessa Swarbrick	Alberta Environment and Parks

4. Agenda

09:00—9:15 Welcoming Remarks - David Trew (NSWA), Dave Mussel (AESRD)

Introductions, Background, Provincial Initiatives and need for workshop

Morning Session - Background Materials

09:15—9:45 David Trew, NSWA

The state of our knowledge - Overview of watershed studies and lake eutrophication assessments in Alberta.

9:45—10:30 Neil Hutchinson, HESL

Overview of lake management planning in Ontario - Lessons Learned from 30 years of application by the Province of Ontario and District Municipality of Muskoka

10:30—11:00 Networking Break

11:00—11:45 Tammy Karst-Riddoch, HESL

What have others learned?-Review and analysis of approaches for managing lake shoreline development in 14 jurisdictions: Summary of HESL 2014 study prepared for Ontario Ministry of the Environment and Climate Change

11:45—12:00 Lunch-Facilitated Discussion- Neil Hutchinson

Key points participants gained from morning presentations

12:00-13:00 Lunch

Afternoon Session - The lake classification approach *How to focus resources within the North Saskatchewan Basin for the Regional Plan, and use of lake classification as a tool to identify lake types, determine lake management needs and manage competing interests.*

13:00-13:30 Tammy Karst-Riddoch

Summary of lake classification approaches from Ontario jurisdictional scan -what criteria were used and how are they defined?

13:30-14:00 Neil Hutchinson

Examples and case studies of lake classification approaches

14:00-14:30 David Trew

Proposal for a Risk-Based Classification system for Alberta Lakes - Range of lake types and ecoregions in the North Saskatchewan watershed

1430-14:45 Coffee

14:45 -16:00 All Participants: Facilitated Discussion - Elements of a Lake Classification System for the North Saskatchewan Regional Plan - Neil Hutchinson

Merits of a classification system

Problems with a classification system

Proposed criteria for classification by lake type

Proposed criteria for classification by management and use

16:00-16:30 Wrap up - Key points and Next Steps - David Trew and Dave Mussel

5. Overview of Alberta Lake Studies

Presenter: David Trew, NSWA. Presentation Provided as Appendix A.

5.1 Presentation Summary

- The regional planning process gives us the opportunity to improve lake management.
- History of AB lake studies:
  - Nutrient and algal bloom management have been long recognized in Alberta, and many comprehensive watershed and limnological studies have been conducted
  - First studies were triggered by shoreline development and cyanotoxicity issues;
  - The Pine Lake Study was the first to include agriculture stakeholders in the stewardship group
  - Many lake and watershed initiatives did not lead to concrete action because Alberta water and land managers were not effectively aligned to utilize the information
- AEP and NSWA have recently tested the BATHTUB model for nutrient modelling. Although it does well for simulating current conditions, it was developed for use outside of Alberta and so it would be useful to develop an AB model to improve the predictive capacity.
- Water quality modelling on Alberta rivers has been conducted extensively to support industrial and municipal regulatory processes. Point source discharges to rivers are relatively well understood.
- Jennifer Regier of NSWA has prepared a paper which compiles non-point source data on 108 Alberta streams and looks at spatial trends. It is available on the NSWA website.

Key Point
There are a lot of good data available, but there is no system in place to use them.

5.2 Discussion Points and Key Themes

- Need to set realistic management targets, because we will always have algae blooms; the question is how much can we decrease them through management? How do we minimize the potential for further degradation?
- Need to keep in mind the influence of climate change on algae blooms when setting management targets/goals. Increased internal P loading rates may result from declining lake volumes, and increased water/sediment temperatures.
- Observations suggest near-decadal oscillations in P and chlorophyll-a. Long-term monitoring is needed to capture cyclical changes in P and C*hl-a* that may be related to climate patterns, such as the Pacific Decadal Oscillation (PDO). There may be long enough records for some lakes to assess this observation further.
- The Alberta government has a mandate to reduce P inputs if there is a problem, but the classification system is needed to determine priorities and to focus efforts. We need to identify triggers to switch from a protective approach to a remedial approach.

- Municipalities have much land use authority, but limited technical expertise to support watershed decision -making, while Alberta Environment and Parks has expertise and the mandate to keep lakes healthy and clean. There has been a disconnection between the municipal staff who make the land decisions and the aquatic scientists at the provincial government level.

Key Point
We don't need to reinvent the wheel. There is expertise, as well as new and historical data that can be assessed using new statistical techniques.

6. Lake Management Planning in Ontario Review

Neil Hutchinson, HESL. Presentation Provided as Appendix B.

6.1 Presentation Summary

Neil presented a history showing how the "Lakeshore Capacity Approach" has evolved over 30 years in Ontario. The idea that each lake had a specific and predictable capacity (whether for phosphorus, angling pressure, wildlife habitat, etc.) came out of the 1970s and culminated in Ontario's "Lakeshore Capacity Study" which was published by the Ontario government in 1986. The trophic status component was based on modelling lake responses to phosphorus inputs from shoreline septic systems and was implemented as formal guidance by the Province in 2010.

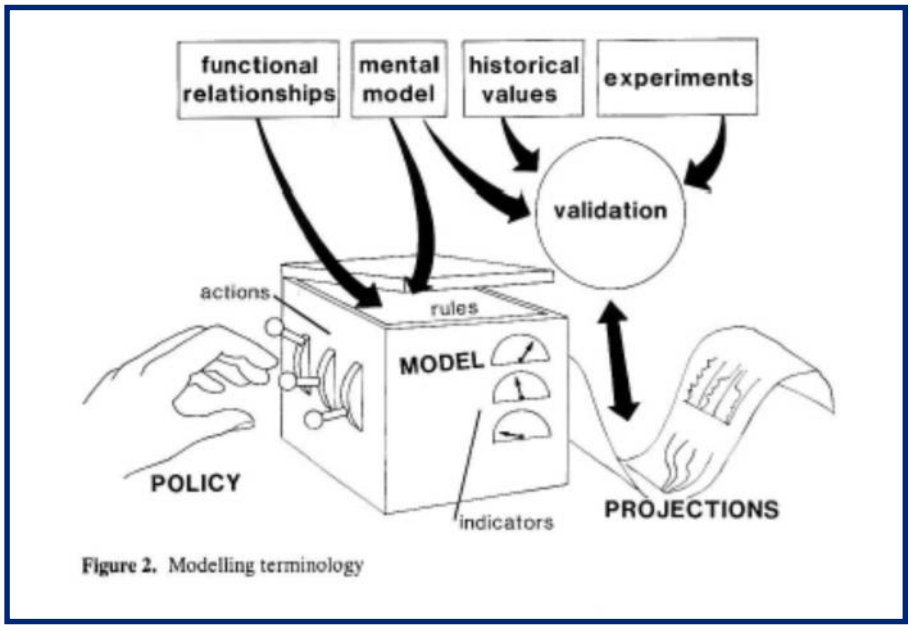


Figure 1. The 1980s Vision of Lake Management - Ontario's Lakeshore Capacity Study. (Downing et al. 1986)

The District Municipality of Muskoka (DMM) has been using variants of the Provincial trophic status model since the early 1980s to set and defend development capacities on over 160 lakes. Over the past 15 years, experience has shown that the model is not accurate enough to defend specific development capacities as a "line in the sand" but it did generally predict lake responses to nutrient enrichment. The DMM therefore used the model to "classify" lakes based on sensitivity and responsiveness to phosphorus loading and scaled Best Management Practices and development standards to lake sensitivity in their Official Plan policies.

Most recently, model inaccuracies, reflecting in part the influence of multiple stressors (climate change, hydrology and DOC changes, invading species, calcium decline) has led to the understanding that lake management needs to be based on more than phosphorus limits, that lakes need to be managed for a variety of reasons and that all lakes should receive a high level of protection via development standards, regardless of their sensitivity.

Key Point

Water quality is not the only lake management problem; social capacity and user conflicts are also important.

The DMM is therefore considering a lake management system based on:

1. Standard and protective BMPs for all lakes,
2. Regular review of the monitoring results (TP, D.O. and Secchi depth) from over 180 lakes against management "triggers" of TP > 20 ug/L, increasing trends in TP and occurrence of cyanobacterial blooms, and
3. "Causation" studies which require detailed review, enhanced monitoring and detailed lake specific modelling when "triggers" are exceeded.

6.2 Discussion Points and Key Themes

6.2.1 Management

- We need to understand what we can manage locally - such as land use practices and the nature and amount of shoreline development, and find ways to recognize and adapt to broader stressors such as climate change. We need to recognize the problem to determine the appropriate tool. We have information and tools, but they have limits. Models are best used as an educational tool, used to shape general impressions.
- Lake management guidance must be pragmatic and provide sensible advice to prevent degradation. Lake sensitivity relates to risk but depends on the stressor.
- Question - Is there a lot of animosity when lake management policies are enforced?
    - There is always initial push back, but over time people are educated to the importance.

- Management in Ontario has been systems-driven, not issue-driven, with a consistent approach introduced by the province in the 1980s through lakeshore capacity assessment, and formalized guidance in 2010.
- Municipalities generally implement lake planning and management under provincial guidance - such guidance needs to consider the available municipal resources.
- Municipalities are development authorities; the provincial government needs to provide the scientific knowledge to allow them to make good decisions.
- Although lake management in Ontario is routinely informed by spring overturn sampling, when lakes are isothermal and completely mixed, spring sampling is not representative in Alberta because the lakes are nutrient rich and exhibit large seasonal changes. It is therefore more difficult to classify lakes based on broad trophic state indicators.

6.2.2 Economics

- Land prices are high for lakeshore development but not for the farmland beside a lake. So the pattern sees a parcel of farmland bought and 25 trailers put on it. This increases human pressure on the lakes, which is exacerbated by the cars, ATVs, boats and newly needed docks to accommodate the trailer park.
- Ontario's more sophisticated lake management approaches were implemented by larger and wealthier municipalities with moderate development pressure (Muskoka, Sudbury). In Alberta, there are municipalities with low budgets, but with higher development pressure than in Ontario. Similarly there are ON municipalities with moderate development pressure and fewer resources, or low development pressure and no resources for lake management. One needs to recognize, however, that:
    - Municipalities benefit economically from development and lake tourism. Development pressure can bring the increased resources (though property and development taxes) needed to enhance lake management and planning if political will is there.
    - Lake management and classification systems must be able to recognize and accommodate differences in pressures and resources.

6.2.3 Naturalized Shorelines and Habitat

- Ontario's experience with the Lakeshore Capacity Study showed that smaller lots have greater relative disturbance compared to large lots. All sized lots have similar absolute disturbance envelopes based on the need for parking, lawn, a septic system and the building envelope, but larger lots end up with more undeveloped space and a smaller amount of disturbance. This increases resilience against various stresses by maintaining more terrestrial and littoral habitat, providing a "social buffer" between lots and reducing the number of lots on a lake.

- There is merit in setting minimum lot sizes for lake communities. This would also ease crowding, which is seen as a problem in Alberta.

Key Point

Lake planning and management must achieve stability between environmental, social and economic interests.

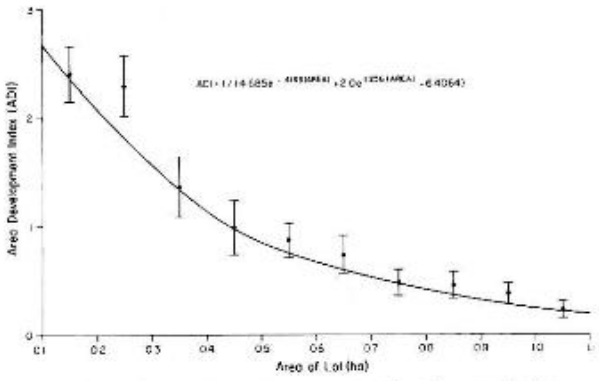


Figure 5. Relationship between the Area Development Index (ADI) and the area of the lot.

Figure 2. Habitat disturbance decreases as lot size increases.
From: Ontario Lakeshore Capacity Study (Downing et al. 1986).

7. Jurisdictional Review

Tammy Karst-Riddoch, HESL. Presentation Provided as Appendix C.

7.1 Presentation Summary

Tammy presented common approaches for managing shoreline development from a jurisdictional scan completed by HESL for the Province of Ontario in 2014. The scan included a detailed review of various scientific, policy and regulatory tools used by fourteen jurisdictions in Ontario, Nova Scotia, British Columbia and the northeast USA. The jurisdictions reviewed in the scan employed unique combinations of technical and planning tools depending on the primary focus of their management approach, but elements of one or both of two broad approaches were generally used:

1. Shoreline Management by Capacity - approaches that manage shoreline development by placing limits on the number of lots or development units based on different thresholds and densities

(Lakeshore Capacity Assessment, Lake Trout Policy and Recreational Carrying Capacity in Ontario only).

2. Shoreline Management by Mitigation – approaches that rely on the implementation of Best Management Practices (BMPs) including minimum development standards to mitigate impacts of shoreline development (e.g., storm water management, shoreline buffers, septic system design and maintenance, minimum development standards and soils assessment).

Lake classification/screening was commonly used to tailor capacity and mitigation tools to address a wide range of lake and watershed characteristics, local sensitivities, available resources and planning environments.

7.2 Discussion Points and Key Themes

7.2.1 Social Density

- Seguin Township (ON) uses a social capacity of 1 lot per 1.62 ha of lake surface area, but it is an arbitrary number based on recreational studies in central ON in the 1970s and its derivation is not known. It was thought to reflect crowding by boat users. It is still supported by Council and used as an Official Plan policy. The approach is considered as a parallel to municipal government requirements that developers set aside parkland in proportion to population of a new development. The proportion may be debatable but the intent is to allow recreational space.
- The Seguin Township example is based only on shoreline residences and does not consider usage by non-residents or multiple boats per residence.
- It is difficult to enforce social aspects. Seguin puts up speed signs and educates; it works, but is difficult to enforce.
- By requiring minimum lot size you attempt to control boating recreation.
- Seguin Township is willing to do anything to protect the environment, because councillors are for protection approach; there are more lakes, water quality is good and development pressures are lower.
- There is value for a capacity approach for Alberta's Municipal Districts. Social and recreational pressures are much greater on Alberta lakes and Councils would need hard numbers to stick to, that were based on a documented rationale, defensible and which were enforced.

Key Point

Social and recreational impacts have been approached by a combination of density limits ("capacity"), education and enforcement.

7.2.2 Economics

- People in charge of making decisions around the lake (municipalities) are seen to be more concerned with economic benefits versus environmental concerns.

- In the U.S. there is federal legislation, state legislation and enforcement is money driven, because if the state doesn't enforce legislation they don't get grant money from the federal Clean Water Act to support lake management.

7.2.3 Water Quality

- If water quality is really poor will people still want to use the lake recreationally?
  - The observations in Alberta are that water quality may impair swimming or drinking but does not deter boating. The only reason someone may stay off a lake is because it is unsafe due to human pressure (i.e., too many boats on a lake).
- Older lake residents (with a longer history at a lake) complain about changes in water quality.
- Existing development is often the problem, as old practices are "grandfathered" and are difficult to manage.
- Alberta Health Services (AHS) has a new program to issue advisories (e.g., blue-green algae blooms) for specific lakes with a history of algal blooms. The advisories are issued earlier in the summer and last longer than in the past.
  - Local municipalities view the postings from AHS as economic disincentives and the Association of Summer Villages of Alberta have petitioned to change the AHS messaging. There is a public communication issue at the moment. AHS is going to provide more educational postings to overcome fears. The postings aren't going to last as long and will provide contact/no contact warnings (don't go in the water, but you can use your boat in the water).
- Fish kills are increasing in intensity and duration. Although this may reflect water quality degradation there might be other factors influencing fish kills, such as declining lake levels.

8. Lake Classification

Tammy Karst-Riddoch, HESL. Presentation Provided as Appendix D.

8.1 Presentation Summary

Lake classification is an effective management tool because it is not a "one size fits all approach" and individual characteristics of the lake, watershed, existing development and social factors can be accounted for across a large area. Classification allows for planning decisions or the scaling of minimum development standards/BMPs to be determined objectively even if the initial selections of classification criteria are subjective. Importantly, classification schemes can be tailored depending on information and resource availability, which is especially important when attempting to classify a large number of lakes over large spatial scales, with variable data availability and often limited resources.

Three different approaches were presented that have been used successfully by Cariboo Region (BC), the State of Minnesota, and the City of Kenora to manage shoreline development, to illustrate the flexibility and usefulness of classification. The Cariboo Region approach classified lakes by water quality sensitivity and soil conditions to define the extent (distance from a lake) to which septic system and buffer guidelines apply,

and to determine siting and design requirements for septic systems. The State of Minnesota applied development restrictions, standards and BMPs that were tailored to lakes classified by their size/depth and existing development pressure (i.e., natural environment, recreational development and general development). The City of Kenora used a classification system within a single lake to establish 'restricted development areas' of the lake shoreline where larger frontages were required to limit crowding, protect scenic amenity and natural heritage features.

Key Point

Let's use the data we have, we know what we need to do, let's do it.
Do we need to have a crisis to do the right thing?

8.2 Discussion Points and Key Themes

- The Minnesota classification system was well regarded - it recognizes pre-existing lake uses such as wilderness, recreational and urban lake use categories.

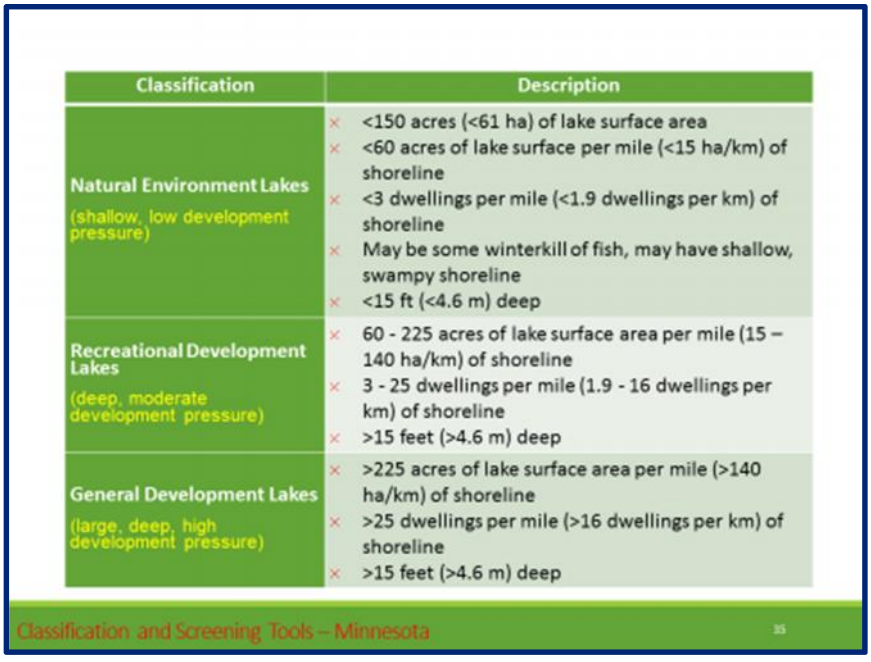


Figure 3. The State of Minnesota Lake Classification System.

8.2.1 Water Levels and Water Quantity

- Long-term decreases in water levels in AB should be considered in lake classification. Water levels in many small lakes have been in decline since 1974, which was the year of maximum snowfall and runoff. Many lakes have been declining steadily since then.
    - Fish kills, especially under ice, are influenced by this lake water level decline.
    - History shows that water levels are variable; it is said that in the 1790s early explorers walked across the North Saskatchewan River because it was so low.
- We have a poor understanding of the role of groundwater in lake water budgets and how changes in groundwater may influence lake levels, or the role of hydro-fracturing shale oil ("fracking") in the changes in groundwater or lake levels.
    - AEP limnologists are currently looking into groundwater recharge into lakes.
    - There has been a lot of work on groundwater and lake interactions completed in the Beaver River basin. This may usefully inform lake management plans.
- Right of accretion caused by water level fluctuations gives land owners the right to recently exposed land. This may result in a single lot being split in two, thus increasing human pressure. The development decisions are based on water level trends, but declining water levels will result in the use of new decision making criteria.
    - Municipalities allow cottage construction too close to former or on former shoreline causing hydrological modifications of landscapes, which has large impacts on surface water.
    - There are concerns with stream diversions in agricultural areas.
    - The consequences of these changes (diverting streams/rivers) are not well understood, No one has looked at these systematically.

Key Point

While water quality and social pressures are often the focus of lake management; water quantity, lake levels and water withdrawals are an increasing concern in some parts of Alberta and may require greater attention in a warming climate.

The role of groundwater in water level decline and lake budgets is poorly understood and seen as an important research need.

9. Case Studies in Lake Classification

Neil Hutchinson, HESL. Presentation Provided as Appendix E.

9.1 Presentation Summary

Neil presented a series of approaches to lake classification from Ontario. These were, by necessity, focussed on managing phosphorus, which has been the overwhelming lake management concern in Ontario for 40 years. Over this period of time, the toxicity of the pollutants that we must manage has decreased (chemical bans and phase outs, industrial effluent controls) but the number of sources has increased as we have moved from managing point sources, to watersheds, to continental air shed (acid rain) to the planet (climate change) and so, overall, management complexity has increased.

Most classification approaches were covered in Tammy's presentation. The diversity of ecosystems due to variable terrain, soils and climate in Alberta suggests that lake classification should begin with a consideration of "ecoregion" to understand how the fundamental and natural lake characteristics such as trophic status vary across the Province - classification of lakes might best begin with an ecoregion approach.

9.2 Discussion Points and Key Themes

- The presentation mentioned the use of "Phoslock" for sediment inactivation. A study on "Phoslock" which showed that it was toxic due to bioaccumulation in crayfish (in the journal PLOS 1) will be circulated.
    - Ontario did a series of toxicity tests showing no problems, so this study would be informative.

9.2.1 Approaches to Classification

- Minnesota's lake classification is very well regarded and respected, and it was one of the first jurisdictions to put a classification system together.
- What is the public going to accept as a classification system?
    - An ideal system will recognize the difference between people who own property on a lake, people who wish to acquire property and non-residents who wish to use the lake.
    - Lake users in Alberta need to have a say in lake classification system - user input into classification criteria and thresholds.
    - Classification may also need to consider messaging – how would you prefer your lake when you are recreationally using it? If you want to get people on board, you need the right message.
- A challenge in Alberta will be classifying lakes in the mountains/foothills region versus the rest of Alberta including boreal, parklands, and grasslands. Central Alberta lakes have a broad range of trophic status and a small sample size.
    - This speaks to the merits of classifying by ecoregion
    - A well designed monitoring program supports an adaptive classification system.

- The choice of reference lakes in a classification system will depend on and influence the management system and might change with the parameter you are interested in.
    - This returns to the question of "What are you trying to protect and what are your goals"?
- How far back do you go to obtain a baseline, how much variation do you need to consider when making your classification system?
    - Over many generations you get a creeping background level, because human perception changes.
    - These concerns speak to a paleolimnological approach to determining the reference condition and changes over time
- Clean lakes are now more desirable drawing in greater crowds that have a long-term potential to cause declines in water quality.
    - Distance from the city is a major factor in determining human pressure on lakes.
- Pigeon Lake has the highest property values because of perception. Wealthy people have property on it and people follow the trends.
    - There has been a 30% decline in property value on Pigeon Lake due to water quality issues.
    - Sylvan Lake has a very different flushing rate than Pigeon Lake so the water quality is better (more ground water, better water quality) thus they have maintained their property values compared to property on Pigeon Lake.

Alberta's "*Water for Life*" policy has gotten traction and considers the three pillars of sustainability (environmental, social and economic).

- It would be difficult to start from scratch and get people involved. Using the 3 pillars as a starting point will maintain that traction.

9.2.2 Intent of Classification System

- What is the intent of the classification system, what will it achieve for us?
- One of the purposes of the classification system is to try to acknowledge the current state of things and protect lakes that are in a pristine condition compared to those that are already impaired and used for recreation. If you don't have a classification like that, then all lakes are open for recreational use and development.
    - Classification outcomes should consider the difference between proactive versus reactive management, Proactive management can protect and prevent and reactive focuses on remediation
    - Do we want to modify people's behaviour around lakes or is the intent to develop a systematic approach to lake planning and management?
    - Behaviour modification is not an outcome of classification though a lake's classification may indicate where behaviour should be changed.
- Classifying lakes based on one use may be difficult, because they are multi-use systems.
- Three categories suggested: lightly impacted, in balance and out of balance
    - There is a desire to protect those lakes that are more pristine.
- One could set particular objectives for each classification, but a system can classify and set management objectives on an individual lake basis to determine if a stringent management system or a stringent mitigation system would be required. The purpose would be to identify lakes that require more protection.

- Intent
    - Make conservation/protection, management and restoration decisions
    - Limit development around lakes where necessary or setting development standards
    - Provide regional-scale advice
    - Focus on preventing further degradation versus remediation
    - Municipal Districts/Counties would like to know where their lakes stand in terms of risk
    - Select appropriate BMPs in the watershed based on risk/vulnerability.
    - Illustrate how our actions increase risk. We will be able to determine if certain activities will cause a lake to switch from one risk class to another.
    - Support appropriate development decisions by Municipal Districts/Counties.
    - Identify what the values are, what the risk to those values are, provide BMPs.
    - Help identify areas of concern.
    - Provide lake planning and management leadership.

Key Point

One must determine:
- the meaning and intent for the classification system,
- the categories for the classification system
- the criteria for assigning lakes to a category and
- the triggers for management actions within the classification system.

9.2.3 The Role of Education

- Education is a building block for how you make change so how do we revitalize our education program to initiate the change we need?
- Educational programs are one potential outcome of the lake management plan - they are a technique to address a problem that was identified through the classification process
    - In Ontario there is a dedicated program and website called “Dock Talks”. It is a provincial program where someone comes to you to discuss stewardship activities.
    - There is also the “Living by Water” initiative
    - Messaging is important, so wording around water quality that determines the quality of the lake experience may be useful
    - Alberta’s pressures are: development, land use, riparian zone impacts, and recreation.
- The real question is: how do we get people to change? Education alone is not enough to drive change; 10% of the population will adapt easily, 10% will refuse and 80% will need to be persuaded.
    - A by-law is a good way to get change to happen. It is about the tide changing and enforced legislation is a major part of that.

- Tickets and fines are not always effective deterrents because many may view these as "the cost of doing business" or "the cost of having fun".

10. Risk Based Classification System Prototype

David Trew, NSWA. Presentation Provided as Appendix F.

Key Point

A lake classification system is a tool to drive policy around lake usage. It can be used to:
- classify lakes for management of recreation or conservation,
- determine the sensitivity of a lake to disturbance and
- determine the resultant need for management.

10.1 Presentation Summary

David introduced a prototype classification system, criteria and scoring to distinguish:

1. Lakes and watersheds with limited carrying capacity and/or requiring restoration
2. Lakes and watersheds for which precautionary approaches (BMPs) are warranted
3. Lakes and watersheds with high conservation value

Low, moderate and high risk thresholds were proposed for criteria including "Watershed Factors", "Shoreline Factors", "Water Quality", "Hydrology/Morphometry" and "Biodiversity"

Key Point

Education provides the means to make effective long-term change and build support for lake management.

Discussion Points and Key Themes

- A systematic approach such as a classification system is a means to an end. It provides a systematic, objective and defensible approach to lake management as opposed to responding to crisis or public pressure. A robust, data-driven classification system is required to be able to use this as a planning tool. GIS will be a valuable tool.
- A purely technical classification system may not suit all needs. Other categories to consider include "Ecosystem Goods and Services ", "Recreational Value", "Value of Investment", etc.
- There are many factors which require a lot of data. Some people thought that this could be an issue while others thought that data for the proposed factors were readily available. There were several questions raised by the classification scheme.

- Do we need that many different criteria, or can we simplify several metrics into one that could do the job?
- Let's simplify the process. Good things can be done without classification.
- If you have an opportunity to create a classification system, you should do it.

- How much work would creating a classification system be?
  - You can do a "coarse scale" analysis with the data we currently have. Things like depth and watershed area are readily available. Drone technology offers a means for cost-effective data acquisition and has recently been tested by NSWA. High resolution ortho-rectified imagery and land cover data sets are available.

- Classification should consider hydrologic attributes: water levels, water level decline and water withdrawals.
  - Need to consider if and how much water withdrawal is sustainable for Alberta lakes.
  - Need to quantify the rate of water level decline.
  - The classification system could act as a tool to inform water licensing under the *Water Act.*
    - If a lake is high risk based on hydrologic attributes then the Province could stop issuing water licences.
- It might be best to look at the percent of water withdrawal that is acceptable. People have issues when you give a specific number, but are more comfortable with percentages.
- The importance of hydrology could be recognized in form of priority, where hydrology is only one part of the classification system, but if a lake is identified at high risk, the resultant licensing restrictions trump any other needs (e.g., economic).
- Fish and Wildlife officials are looking at a policy with regards to water withdrawals and they are currently discussing it in terms of centimetres.

10.1.1 Components of a Classification System

- How do we classify and prioritize? How do we identify the most sensitive lakes?
- Should consider risk to biota (endangered species, fish, birds, mammals), economics, and human use/pressure.
- Potential Metrics for classification by human pressure
  - Distance to nearest urban centre
  - Amount of shoreline development measured as units/km
  - 1st and 2nd tier development
  - Disturbance per km of shoreline (data could be obtained by drone survey)
  - Percent of wetland by type of wetland
    - could use Ducks Unlimited GIS layer
    - Municipalities are encouraged to get wetland drainage maps
  - Percent drained wetlands
  - Recreational pressures need to be quantified.
    - Could consider marina slips + boat docks + parking spots (or "horse power/ hectare")

- Multiple accounts analysis is used by the mining industry - it weights different classification criteria or design choices and then alters the weighting and importance of each to see which criteria have the most influence on the risk classification. This approach could be used to compare social, economic and environmental criteria.
- Suggest two levels of classification criteria:
    - Lake Use (high level goal e.g. wilderness", "urban", "conservation", "recreation")
    - Then Lake Health or "Current Risk" to assign priority and need for management
        - lakes and watersheds with limited carrying capacity
        - lakes and watersheds requiring restoration,
        - lakes and watersheds for which precautionary approaches (BMPs) are warranted and
        - lakes and watersheds for which more information is required to focus monitoring programs.
- Management could then consider the "Lake Use" and the "Risk" to that use and assign the levels of BMPs for each level of risk.
    - District of Municipality of Muskoka approach - best management practices are scaled to low, medium and high risk lakes.
    - Lay out BMPs and expectations for each risk level.
        - With highly degraded systems, it's more about preventing further degradation and realizing that improvements won't be seen for decades.
        - BMPs can be implemented to prevent further degradation.
    - Need to take new development and existing development into consideration.
        - Muskoka has a permit system that includes redevelopment (e.g., the municipality can impose BMPs and conditions for environmental improvement on a building permit application).

10.2 Summary

Key Point - Lake Classification Triage

Lakes that are of high ecological value and not damaged at this point will be conserved.

Lakes that are of moderate ecological value will be managed to prevent further degradation and start remedial actions.

Lakes that are highly degraded because of unique characteristics may not respond easily to management efforts

- The North Saskatchewan Regional Plan (NSRP) needs to have language to describe the purpose of the classification system.
- Need a framework to increase buy-in by other stakeholders and Municipal Districts
- The province needs to increase leadership and move from providing suggestions to implementation and enforcement. Planners need to consider what is appropriate for the NSRP and keep in mind that provincial leadership is soon to follow.

- Next steps:
  NSRP lakes team to ensure that lakes in the NSRP are being properly managed
  - Need to refine the classification system,
  - Additional considerations
    - How to get the data,
    - Are there some criteria that should be collapsed, or
    - Are there more criteria that should be considered to make it more robust?

11. Alberta Lake Management Concerns to Consider in a Classification Scheme

Workshop participants raised a variety of concerns during different discussions over the course of the day and these are summarized in this section.

11.1 Social

- Overcrowding is an issue in Alberta
- Wakes are another issue for Alberta lakes. Wakes from boats are meant to be surfed on and boats are designed to make large wakes. Wakes as high as 5 feet have been observed coming into shore and are so large they can flip a docked boat over
  - Wakes are particularly detrimental to soft shorelines and shoreline nesting birds
  - Waves may be due to different reasons on different lakes, either boats or wind.
- "Private" docks are used by non-residents (day-use for their boats, further degrading shoreline)
  - Need to balance concerns of residents with public right to water access.
- The Alberta government promotes the purchase of boats.
- There needs to be management of recreational activities. Stereo systems on the boats and the behaviour of boaters create social problems.
- Can managers enforce certain size boats on certain lakes?
  - At one point, Ontario and other jurisdictions considered "boating capacity" by allocating certain amounts of lake area to boats of a certain type (canoes, rowboats, sailboats, water skiers, power boats). But this cannot be controlled, and boats get bigger and faster so setting a "boat capacity" is not really feasible by this means.
  - Some US reservoirs limit the number of boats allowed via public boat launches and assign users a time slot.
- Restrictions aren't enforced because nobody has the capacity to do so.
- What about the First Nations people? There may be different sensitivities and expectations from this group.

11.2 Environmental

- There is a need to communicate the importance of riparian health/shoreline vegetation to cottage owners.
- Wakes from boats are flooding and overturning the nests of shore-breeding birds such as western grebes.

- Marinas have been approved and built adjacent to sensitive shoreline nesting areas.

11.3 Economic

- Property values can decrease due to deteriorating water quality
- Lakeshore development is a source of revenue for municipalities; need to balance economic with other (environmental, social) needs
- Water withdrawals from lakes are important for certain industries; need to balance with other needs

12. Summary Remarks

- The lake classification and management system does not have to be perfect.
- Let's not make it too complex to start with:
    - start simple, get BMPs in place and focus on what we need to do
- Education and behaviour should not be the only focus - we need strong leadership that is based on science and enforcement of planning decisions
- Consider a nested classification approach
    - Three levels of classification :
        - Lake use/future direction
        - Current risks and priorities of management
        - Resultant classification matrix showing low, medium and high risk lakes with BMPs for each based on factors increasing the risk

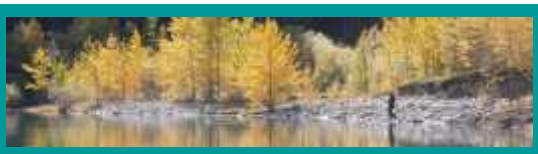
Key Point - Our Opportunity

Development of the North Saskatchewan Regional Plan presents a golden opportunity to develop a lake management and planning system.

What works for the North Saskatchewan Region may ultimately be applied across the Province.

We can get it right.

Appendix A. Presentation - Overview of Alberta Lake Studies



Overview of Lake Studies in Alberta

David O. Trew, P. Biol
June 3, 2015

A NEW OPPORTUNITY

- Extensive lake surveys, monitoring, research, knowledge in Alberta - but lake management largely "ad hoc" to date
- New call by NSRP – RAC:
  - Develop Lake Management Strategy (Policy)
  - Classify Lake Carrying Capacities (Technical)
  - Classify and prioritize lakes for Protection, Management, Restoration (Technical)
  - Address growing recreational pressures…

International Lakes Research

- International Society of Limnology (SIL) - 1922
- OECD eutrophication research on drinking water reservoirs and lakes in Europe – 1960s
- OECD world-wide lake eutrophication research program - 1970s
- United Nations "International Biological Program" (1970s) – aquatic science methods
- International Assoc. for Great Lakes Research -1975
- North American Lake Management Society - 1980)

Canadian Research

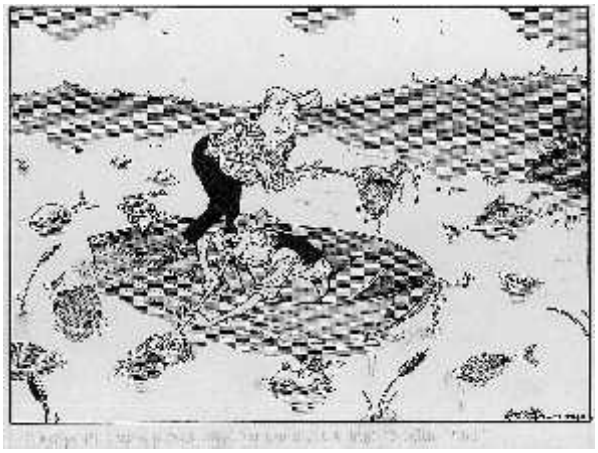
- Fisheries Research Board of Canada – extensive publication record on fisheries and limnology
- Ontario Conservation Authorities (1948) – pioneered watershed research and management
- Experimental Lakes Area – Canada (1970s+)
  – Lake fertilization and acidification experiments
- Ontario MoE - Shoreline Capacity Studies (1970s - 1980s) – applied phosphorus modelling
- Okanagan lakes – aquatic weed research (1970s)
- BC - Salmonid Enhancement Program (1970s)

Alberta Lakes Information Fisheries Research

- Dr. R. B. Miller (U. of A. 1940-50s)
  - "Preliminary Biological Surveys of Alberta Watersheds"
  - Original manuscripts at Fish + Wildlife HQ
- Dr. M. Paetz and Dr. J. Nelson (U. of A. 1960s)
  - Published "Fishes of Alberta" (1970)
- Fisheries Biologists (1960s and 1970s) collected lake information in support of fisheries management
  - Paetz, Stenton, McDonald, Hunt, Bishop, Thompson, Radford, Kraft, Makowecki, Crutchfield

Alberta Limnological Research

- Alberta Geological Survey gathered basic lake chemical data (1950-60s)
- Canada Land Inventory (1960s and 1970s)
  - Sport Fish Capability Surveys – many Alberta lakes sampled
- University of Alberta
  - Drs. J. Kerekes, M. Hickman, D. Gallup, J. Nursall and P. Gorham – conducted detailed lake research (1960s – 1980s)
  - Drs. E. Prepas and D. Schindler (1980s-2000s)
- Canadian Wildlife Service, U. of C.
  - Rocky Mountain National Parks lakes – Dr. R. S. Anderson (1960s -70s)



Starting in the 1970s…

- Strong industrial and municipal pollution control measures implemented to improve Alberta rivers
  - Industrial and municipal wastewaters regulated
- Concerns arise about water pollution in Alberta lakes
  - Much academic research occurring but lack of systematic lake planning and management tools
- Formation of AENV 1971 (Hon. W. Yurko)
  - Spoke about the need for lake protection at Symposium on Western Canadian Lakes (U of A)
- Provincial Shoreline Development Regulation (1977)
  - Froze development at 15 key lakes until municipalities completed "lake management land use zoning bylaws" for each lake.

Hon. William Yurko, Minister of Environment (Nov 16, 1972)

- "I think we might all agree that a Symposium on the Lakes of Western Canada is timely. Here in Alberta, intensifying industrial and agricultural activities have not left our lakes unaffected…problems such as fluctuating and receding lake levels, deterioration of water quality, shoreline erosion, silt deposition and competing usage are increasing in magnitude and scope. These problems have gone on far too long and have reached proportions which now dictate that a concerted effort by different levels of government is required to preserve the quality and character of our lakes……"

Development prohibited at 15 lakes

- "Regulated Lake Shoreland Development Operation - Regulations" proclaimed August 24, 1977 pursuant to sections 21, 23 and 25 of the Land Surface Conservation Reclamation Act
- No further development allowed at Baptiste, Gull, Garner, Island, Isle, Lac La Biche, La la Nonne, Lac Ste Anne, Moose, Muriel, Nakamun, Sandy, Skeleton, Sturgeon and Wizard
- Regulation repealed in 1986, after last land use bylaw completed

Regional Approach to Lake Management

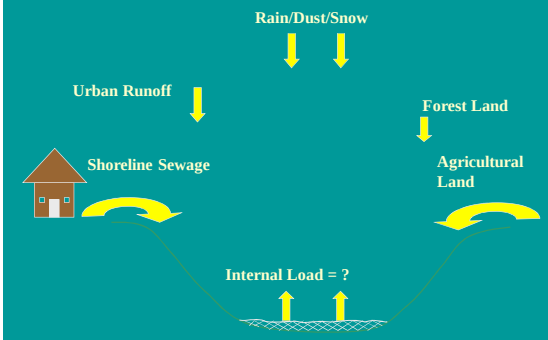
- After 1976 no GOA - led "regional" approaches to recreational lake management
- GOA – pursued much detailed work on individual lakes, or small clusters of lakes, (e.g. Cold Lake - Beaver River Water Management Study 1983)
- Exception: WC-LRTAP program. This was an interprovincial lake acid-sensitivity mapping program during the late 1980s and early 1990s. Alberta then developed the Acid Deposition Management Framework (ADMF) for the regulation of acid forming gas emissions
- Some municipalities now well engaged in lake management work (e.g. Parkland County)

Lake Watershed Studies in Alberta

The Baptiste Lake Study 1976-79

- Crisis at lake: too much development already
- GOA needed a "model" to predict effects of watershed development
- Intensive study of lake and watershed nutrient sources, phytoplankton ecology, hydrology, paleolimnology

Phosphorus Sources



The Vollenweider phosphorus model (1969)

$$[TP] = \frac{L}{\bar{z}(\sigma + \rho\omega)}$$

[TP] = TP Concentration
L = Annual P-Loading
z = Mean depth
ρ_w = Flushing rate
σ = Sed. Coeff

Dillon and Rigler Model (1974)

$$[P] = \frac{L(1 - R_p)}{z \cdot \rho_\omega}$$

- P = Spring [TP]
- L = Areal P-load
- R_p = retention coeff.
- z = mean depth
- ρ_ω = flush. rate

Chapra Model (1975)

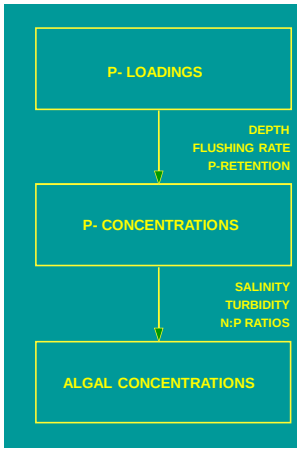
$$P = \frac{L}{(\upsilon + q_s)}$$

- P = Steady state [TP]
- L = areal P-load ($mg \cdot m^{-2} \cdot yr^{-1}$)
- υ = P-settling velocity
- q_s = areal water load ($m \cdot yr^{-1}$)

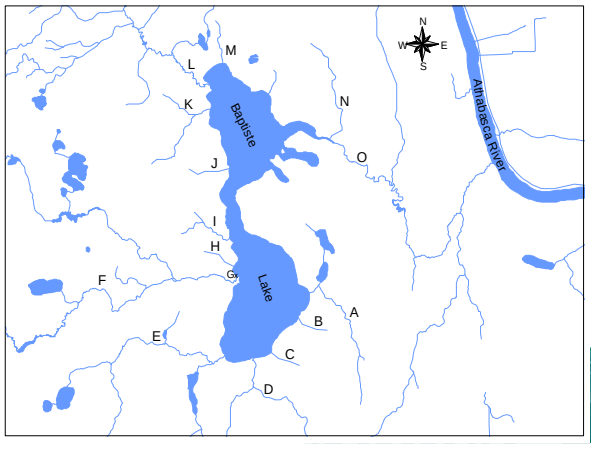
Rast and Lee Model (1978)

$$[P] = \frac{[P_i]}{(1 + \sqrt{\tau_w})}$$

- P = steady state [TP]
- P_i = mean influent [TP]
- τ_w = hydraulic residence time

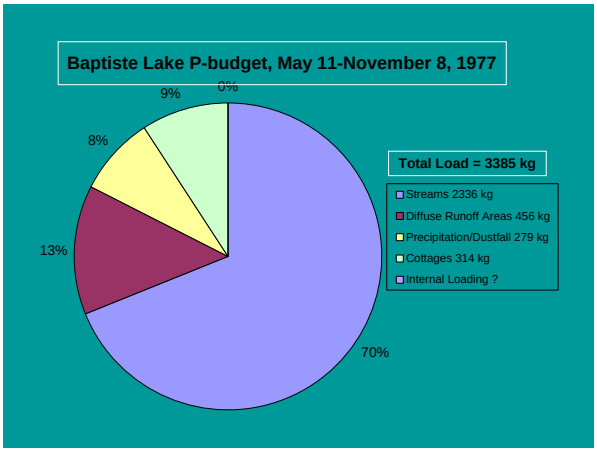


Develop the phosphorus modeling sequence for use in Alberta



Phosphorus Analyses!

- Pollution Control Division Lab - Clover Bar 1970s
- Early 1970s [TP] Det. Limit (200 ug/L)
- Mid 1970s [TP] Det. Limit (50 ug/L)
- Late 1970s [TP] Det. Limit (20 ug/L)
- [TP] Det. Limit >1981 (MacIntyre - 2 ug/L)

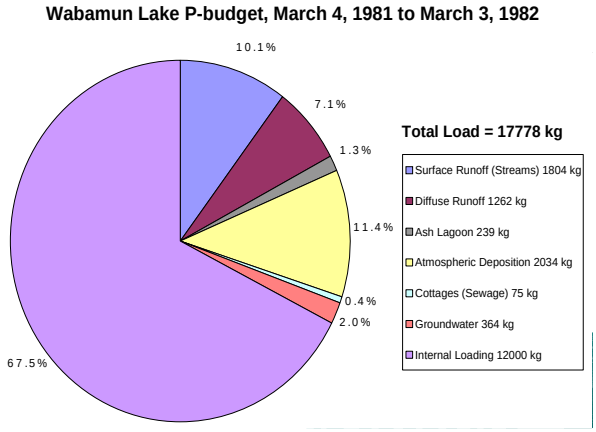


Management Decisions

- Agricultural impacts not pursued
- Whispering Hills Subdivision was approved

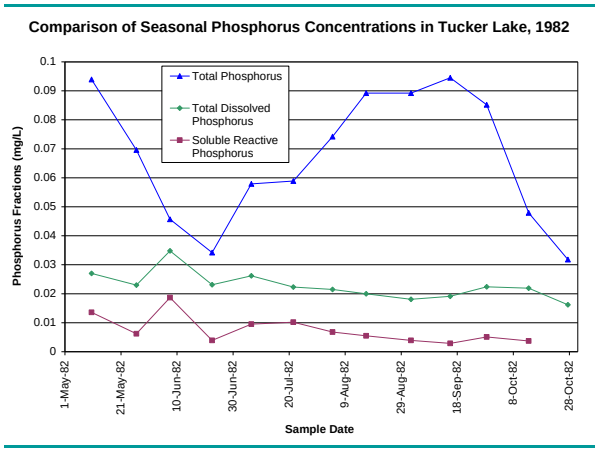
Lake Watershed Studies

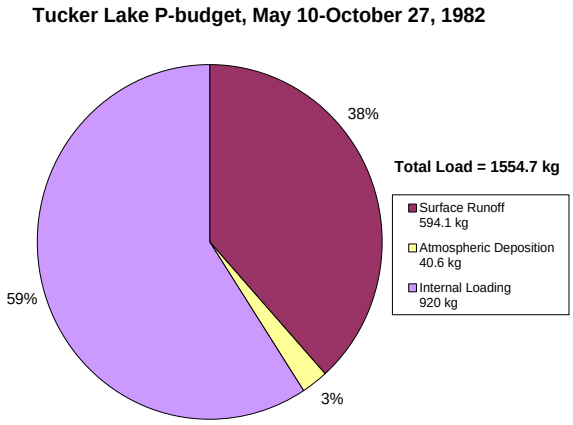
1. Baptiste Lake (1976-78)
2. Wabamun Lake (1980-81
3. Tucker (1981)
4. Pine Lake (1992)
5. Lac Ste Anne (1997)
6. Lake Isle (1997)
7. Lesser Slave Lake (1991-93)
8. Gull Lake (1999)
9. Pigeon (2013)



Management Decisions

- Agricultural impacts not pursued
- Internal loading not pursued
- Shoreline development continued
- Watershed Management Plan not Implemented





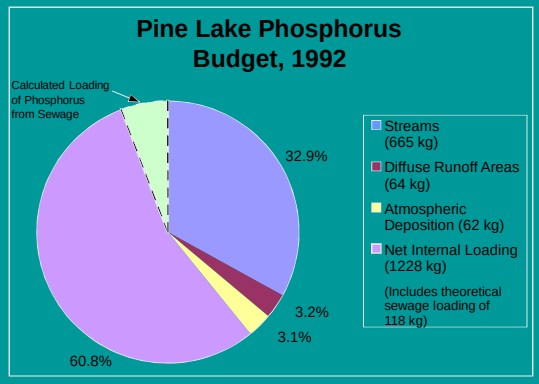
Management Decisions

- Internal loading not pursued
- No water withdrawals allowed from Tucker Lake – Cold Lake Beaver River Water Management Plan implemented by AENV
- Industrial development continued in the region

Pine Lake (1991)

- Extensive algal blooms
- Complaints from resort and cottage owners
- Advisory committee formed
- Watershed and lake research

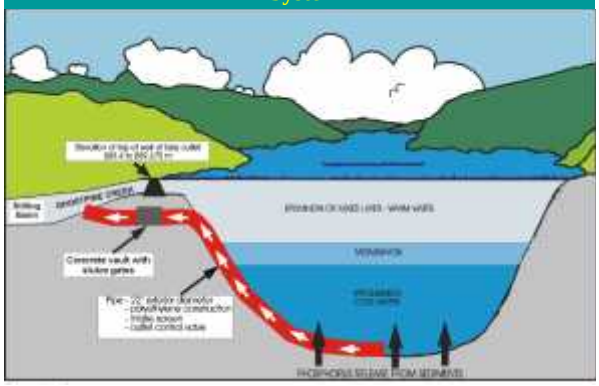
Pine Lake Phosphorus Budget, 1992



Management Decisions

- Agricultural impacts were pursued – AAFRD staff engaged succerssfully
- Shoreline sewage management improved
- Hypolimnetic water withdrawal system installed
- Pine Lake was a 'turning point' in lake management thinking in Alberta

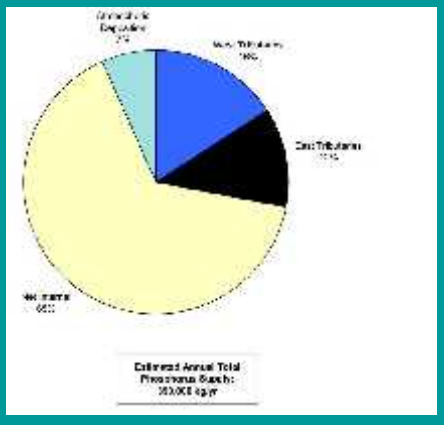
Cross-Section of Pine Lake Showing Withdrawal System



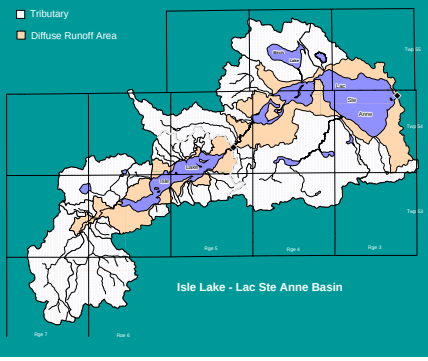
Hypolimnetic Withdrawal System

Pipeline then weighted and fed out from shore and joined to vault with control valves.

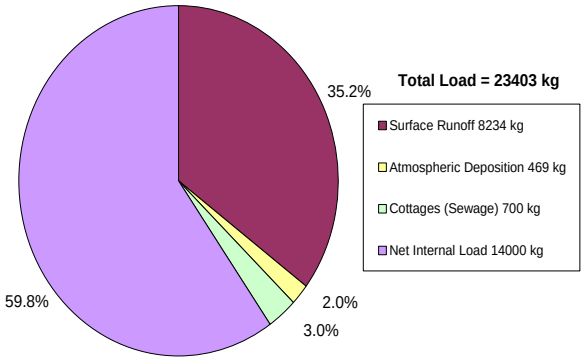
Lesser Slave Lake (1991-93)



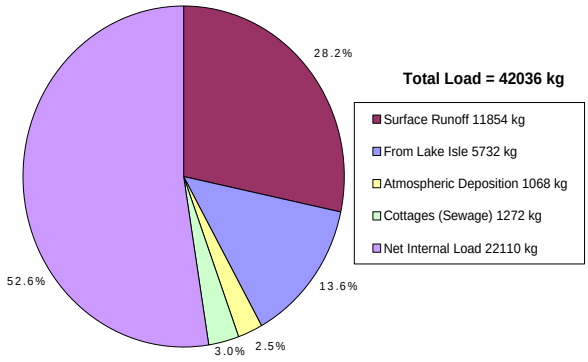
Lac Ste. Anne and Lake Isle



Isle Lake P-budget, March 1 to October 31, 1997

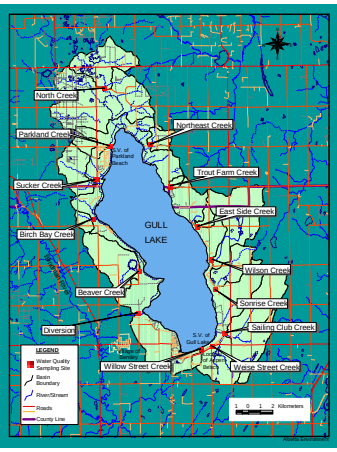


Lac Ste. Anne P-budget, March 1 to October 31, 1997



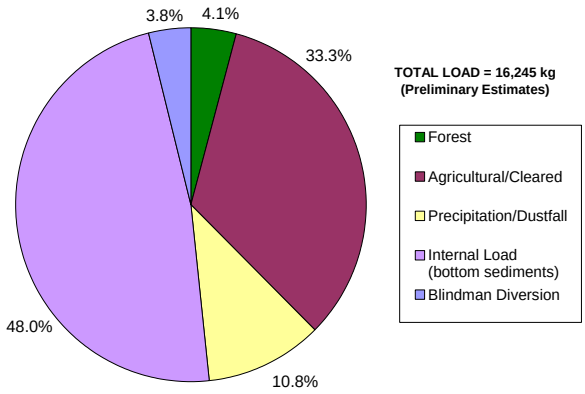
Management Decisions

- Agricultural impacts not pursued
- Internal loading not pursued
- Shoreline development continued



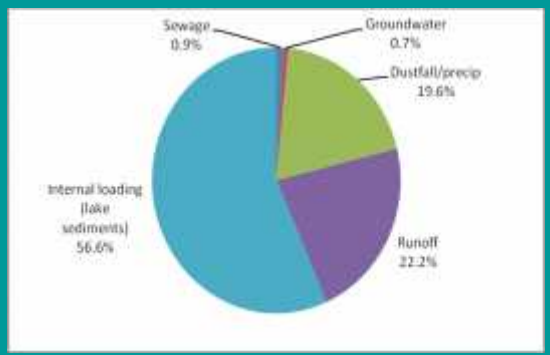
Location of Water Quality Sampling Sites on Streams in the Gull Lake Study Area, 1999-2000

Gull Lake P-Budget, 2000



Management Decisions

- Agricultural impacts not pursued
- Internal loading not pursued
- Shoreline development continued



Applied Lake Studies: AENV, U of A.

- Sampling methods and laboratory methods
- Extensive lake water quality surveys
- Nutrient budgets, [TP] – [Chl a], relationships salinity effects
- Phytoplankton primary production
- Algal bioassays + limno corrals
- Phytoplankton taxonomy, cyanotoxicity
- Sediment P-release
- Modeling with Bathtub and Flux
- LTLN, Provincial Parks Network, Volunteers
- Trend Analyses
- Surface water hydrology, some groundwater work

Summary

- Central Alberta rivers have improved since 1980s - as a result of applied wastewater treatment research and strong regulations
- Water quality in most lakes has not improved and remains poor or threatened – even though though much applied research is available
- Accountabilities for "lake management" need to be resolved
- Lake water quality plans must be integrated into current land use planning.

Recent NSWA Lake Work

- Bathtub Modelling (with AESRD)
- Nutrient Compilation for Alberta Streams
- Aerial Riparian Assessments
- Wabamun and Mayatan Lake Planning Projects

Lake Modelling with "BATHTUB"

1. Pine (1992)
2. Lac Ste Anne, Lake Isle (1998, 2014)
3. Baptiste (2006)
4. Lac St Cyr (2013)
5. Mayatan (2014)
6. Pigeon (2014)
7. Lesser Slave Lake (2015)
8. Wabamun (2015)

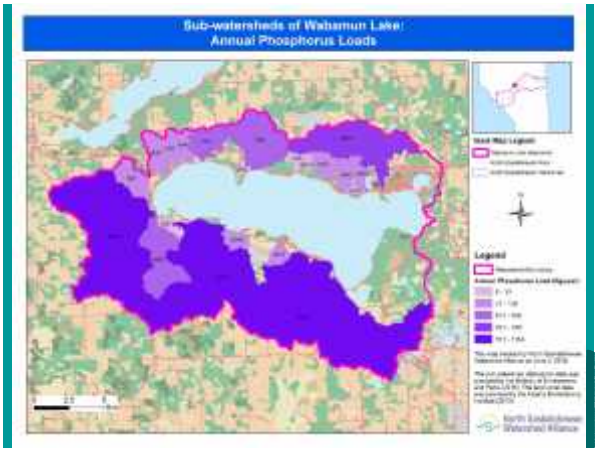
BATHTUB - Calibration

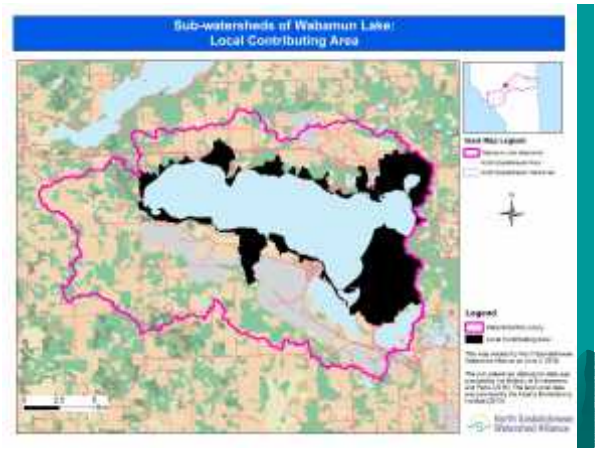
- Steady state model: predicts summer averages
- TP can be simulated well
- Single year calibrations are difficult
- Best to use long term hydrologic context (Inflows over 10, 20, 40 years)

Variable	#	Selection +Description
Conservative Substance	0	Not Computed *
Total Phosphorus	8	Canfield & Bachman (1981), Natural Lakes $0.162\ (Wp/V)^{0.458}$
Total Nitrogen	4	Bachman (1980), Volumetric Load $0.0159\ (Wn/V)^{0.59}$
Chlorophyll-a	4	P, Linear $B = K\ 0.28\ P$
Transparency	3	Secchi vs. Total Phosphorus, CE Reservoirs $S = K\ 17.8\ P^{-0.76}$
Longitudinal Dispersion	2	Constant-Numeric – Fixed Dispersion Rate D = 1000 KD
Phosphorus Calibration	1	Decay Rates – Apply calibration factors to sedimentation rate *
Nitrogen Calibration	1	Decay Rates – Apply calibration factors to sedimentation rate*
Error Analysis	1	Consider Model Error and Data Error *
Availability Factors	0	Ignore *
Mass Balance Tables	1	Use predicted segment concentration to calculate outflow and storage terms
Output Destination	2	Excel worksheet *

BATHTUB

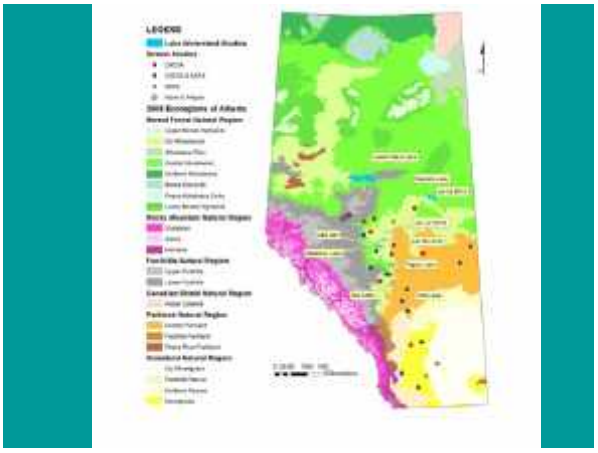
- Bathtub designed for U.S. reservoirs: not all model features applicable to Alberta Lakes
- Calibration process provides educational value
- Predictive capacity is reasonable, but caution required
- Consider developing an "Alberta Lakes Model"





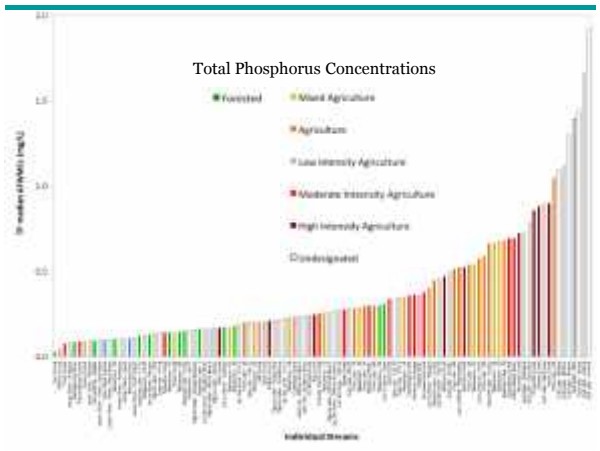
Compilation of Stream Nutrient Data for Alberta

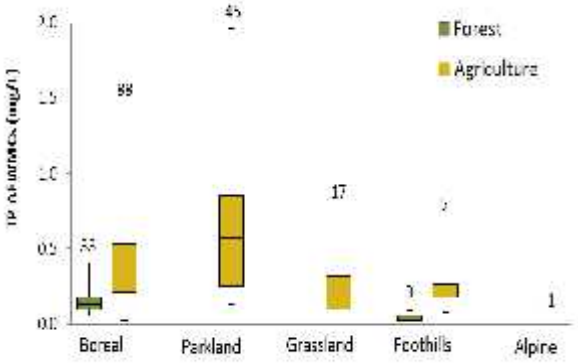
Number of Streams = 108



Studies Compiled

Study	Year(s) sampled	Stream Tally	Streams per Study	Stream Years	No. Sample Days
Lake Watershed Studies					
Baptiste Lake (Trew et al. 1987)	1977-1978	6	6	12	400*
Wabamun Lake (Mitchell 1985)	1980-1981	14	14	28	1030
Lac La Nonne (Mitchell & Hamilton 1982)	1981	1	1	1	16
Pine Lake (Sosiak & Trew 1996)	1989 & 1992	8	8	15	134
Lesser Slave Lake (Noton 1998)	1991-1993	7	7	7[a]	67
Baptiste Lake (Cooke & Prepas 1998)	1994-1995	0	4	10	1400*
Lac Ste. Anne & Lake Isle (Mitchell 1999)	1997	12	12	12	100*
Gull Lake (Mitchell & LeClair 2003)	1999	12	12	12	109
Lac La Biche (Neufeld 2005)	2003-2004	6	6	6[a]	126
Wabamun Lake (Emmerton 2008)	2008	2	7	7	61
Pigeon Lake (Teichreb 2014)	2013	7	7	7	54
Stream Studies					
Sakwatamau Two Creek (Munn & Prepas 1986)	1983	2	2	2	600*
CAESA (Anderson et al. 1998)	1995-1996	24	25	51	840*
AESA (Lorenz et al. 2008)	1999-2006	7	22	22[a]	3040
TOTAL		**108**	**133**	**192**	**~8000**



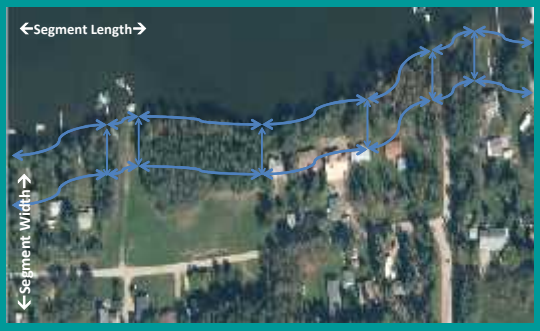


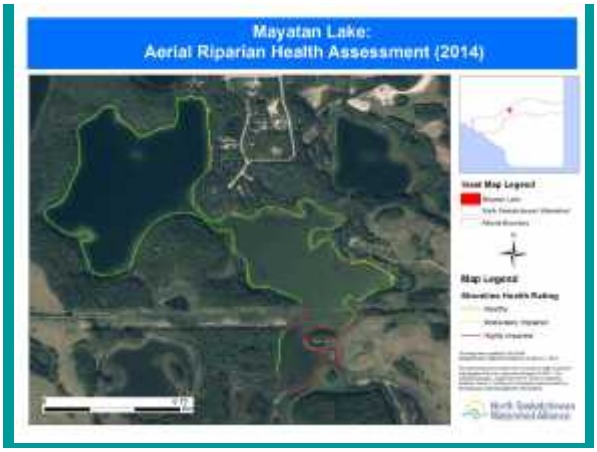
Lake Riparian Management Zone Assessments

Riparian Management Area

Aerial Image and GIS data

Assessment Segments





A NEW OPPORTUNITY

- Extensive lake surveys, monitoring, research, knowledge in Alberta - but lake management largely “ad hoc” to date
- A new request by the NSRP – RAC
- AEP staff urged to:
  - Develop Lake Management Strategy (Policy)
  - Classify Lake Carrying Capacities (Technical)
  - Classify and prioritize lakes for Protection, Management, Restoration (Technical)
  - Address growing recreational pressures

Prototype Lake Classification Tool

- Seven Characteristics to Assess
  - Watershed Condition
  - Shoreline Condition
  - Water Quality Condition
  - Hydrology and Morphometry
  - Biodiversity
  - Economic Considerations
  - Social Considerations

Prototype Lake Classification Tool

- Low total scores denote lakes and watersheds with high conservation value
- Moderate total scores denote lakes and watersheds requiring careful management to prevent further degradation
- High Moderate total scores denote lakes and watersheds with “questionable” capacity for further development – or requiring restoration

Uses of the Lake Classification Tool

- Identify priority lakes for conservation, precautionary management or restoration
- Inform lake management decisions by MDs
- Inform water management decisions by GOA
- Provide regional scale oversight
- Select and apply appropriate BMPs based on lake and watershed condition
- Identify monitoring and research needs

Appendix B. Presentation - Lake Management Planning in Ontario - Review

Hutchinson
Environmental Sciences Ltd.

Evolution of Lake Management Approaches : The Ontario Example

Purpose

Describe Ontario's history of lake management

Describe its shortcomings for intended use through three examples of implementation

Propose alternative management approaches to protect recreational water quality and other lake attributes

Background
Ontario's "Lakeshore Capacity Study – 1986

- Ontario Lakeshore Capacity Simulation Model
- one "black box" would quantify all necessary relationships and guide development by "capacity"

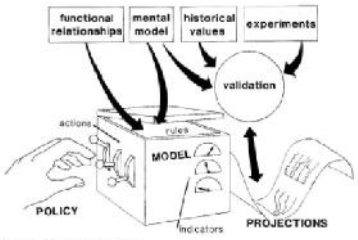


Figure 2. Modelling terminology

Background
Ontario's "Lakeshore Capacity Study – 1986

- a "black box" model of acceptable limits to development on recreational lakes
  - Microbiology, Land Use, Fisheries, Wildlife, **Trophic Status** and Integration components
- Only the trophic status model was implemented by MOE
  - Formal acceptance in 2010.

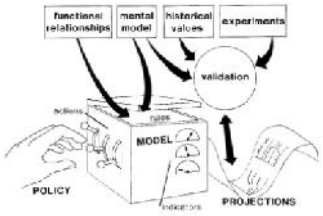
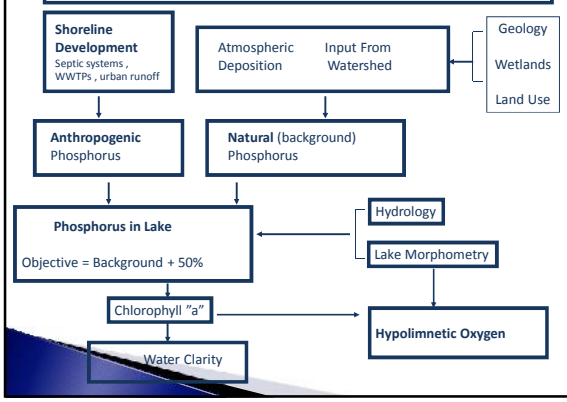


Figure 2. Modelling terminology

Ontario's "Lakeshore Capacity" Trophic Status Model



Ontario's "Lakecap" Approach

Manage phosphorus loading by

-Modeling lake response to development
-Setting nutrient limits based on septic system loading

"Planning by Plumbing "

-Assumption that all phosphorus is mobile and will move to lake
-- discredited by research

-Enforcing development capacities in the Official Plan
-a regulated limit to the number of shoreline septic systems
-No recognition of Best Management Practices to reduce impact in LakeCap (they are mentioned but no credit for reduction is applied)
-- no explicit consideration of other attributes

- Approach is based on, and reliant on the Lakeshore Capacity Trophic Status Model

In Ontario
Lake Management = Development Capacity

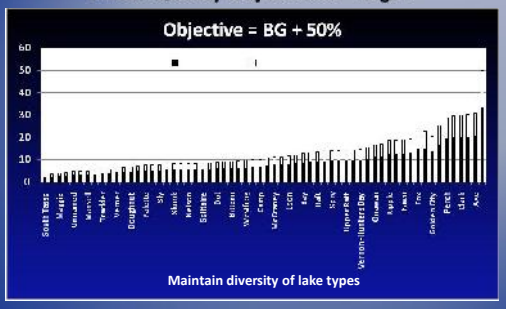
Province sets the approach and developed the "tool"
- whole watershed phosphorus model
- Policy framework ("LakeCap")

Municipalities implement it by Official Plan or "as needed"
- larger, more organized municipalities have resources to do formal implementation and public will to do so

Many "unorganized" municipalities "ad hoc" or rely on the Province
– small budget, few resources for lake management
- low development pressure
- large watersheds, cannot undertake sophistication required

HESL 7

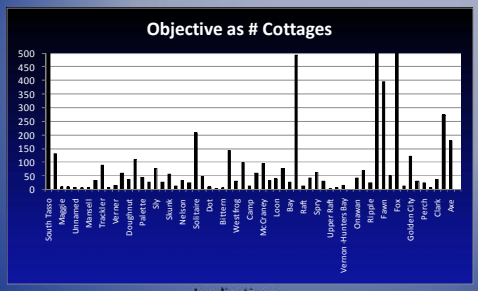
Translate Natural Phosphorus Concentration to a Water Quality Objective or Target



Hutchinson, N.J., B.P. Neary and P.J. Dillon. 1991. Validation and use of Ontario's Trophic Status Model for establishing lake development guidelines. Lake and Reserv. Manage.7(1):13-23.

HESL 8

Translate Target Concentration of BG + 50% to "Development Capacity"



Implications
124 cottages is "acceptable"
125 cottages is "over capacity"
Does the model/approach support this precision ?

HESL 9

Analysis

HESL staff have completed four large and complex watershed modelling projects in the past 6 years

-District of Muskoka : ~ 550 lakes
-City of Greater Sudbury : ~350 lakes
-Seguin Township: ~ 80 lakes
-City of Elliot Lake: ~30 lakes

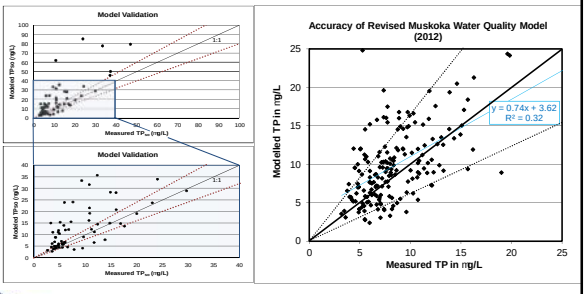
We have consistently concluded that the model accuracy does not support the intent of its implementation by the Province
-Some government users share our conclusions

The model is not calibrated to shallow, non-stratified eutrophic lakes

The prediction of phosphorus concentrations in the model is empirically derived, based on a small set of lakes in Muskoka-Haliburton

HESL 10

Model Results



HESL 11

Model Error

- Sudbury

	All Lakes		Lakes with >20% Error		Lakes with >40% Error	
	-ve error	+ve error	-ve error	+ve error	-ve error	+ve error
N lakes	14	52	6	38	4	30
Mean % Error	-22	96	-40	128	-48	154
Median % Error	-15	73	-42	101	-47	118

- Muskoka

Table 17. Predictive Error of the MWQM (n=206 lakes)

	+ Error	- Error
Mean Error (%)	52.7	-25.0
Median Error (%)	38.4	-22.9
n =	134	72
n >20% Error	100	42
n >40% Error	64	17

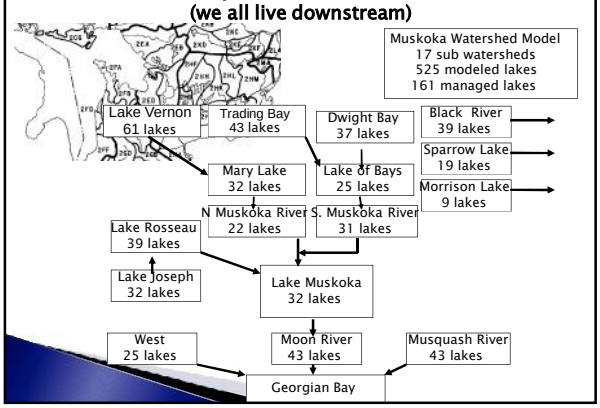
HESL 12

Potential Sources of Model Error

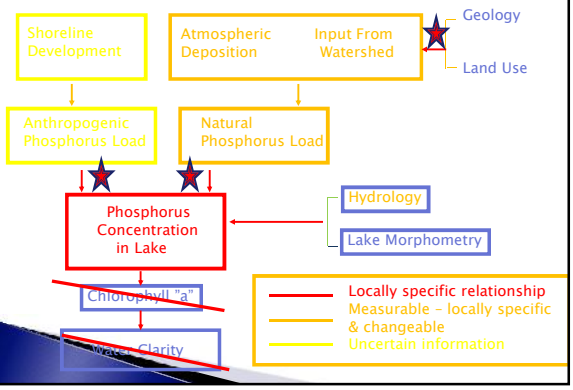
- Unknown shallow or anoxic lakes,
- Unusual hydrological characteristics (e.g., flow-through lakes that have lower or negligible phosphorus retention),
- Complex lakes with hydrologically distinct basins,
- Lakes with characteristics outside the range of those for the calibration lakes upon which the model was developed and calibrated,
- Poor quality data or insufficient years of measured phosphorus data to confidently determine the long term mean (not an issue in Muskoka),
- Inaccurate shoreline development counts and occupancy rates,
- Attenuation of septic system phosphorus by soils (LakeCap assumes that 100% of the phosphorus from septic systems that lie within 300m of the shoreline of a lake moves to the lake, but recent scientific studies show much of this phosphorus is attenuated by soils),
- Inaccurate estimation of wetland area, and
- High concentration of dissolved organic carbon (DOC)

HESL 13

The model is complex – whole watershed orientation (we all live downstream)



The Model contains Uncertainty or Variance



Points of Model Uncertainty or Variance

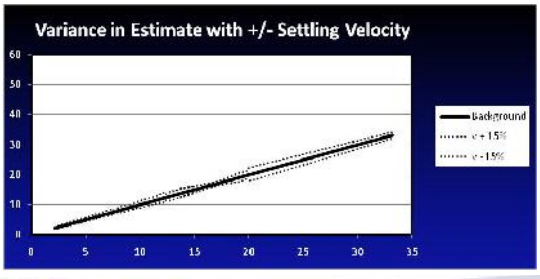
7.2 = anoxic settling velocity in m/yr
- calibrated from mass balance for one lake

12.4 = oxic settling velocity in m/yr
- average value from a series of calibrations

Highly specific or average derivation of key parameter in phosphorus prediction
It will vary between lakes – but model uses 2 values

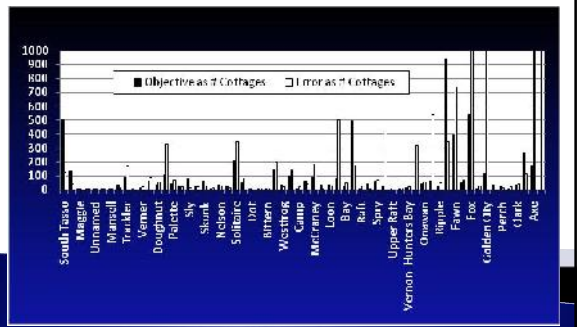
What happens if you vary it ?
Implications of error can be applied to other sources as well

Implications of Model Error

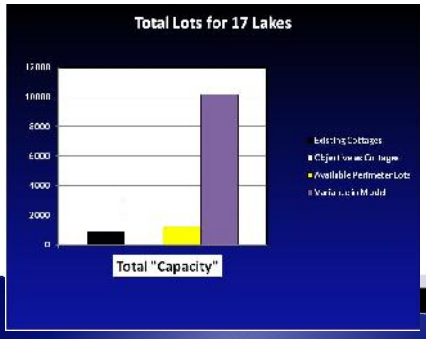


What if settling velocity error was +/- 15%?

Implications of Model Error



Implications – Error >>> "Capacity"



Model – Conclusions

The LakeCap model does not provide accurate predictions of phosphorus concentrations due to multiple sources of error.

Specific thresholds or capacities developed using the model cannot be defended on the basis of model accuracy.

We need to trust model output to defend its use to set capacity

Capacity demands a defensible "line in the sand" – a set lakeshore capacity that can be defended at the OMB

We have a "ribbon in the sand" and it is very broad

Experienced MOE practitioners admit the same problems

MOE can go on refining the model

BUT

Municipalities need a tool they can implement and defend

HESL 20

So What ?

- Recognize that development can degrade trophic status
- Recognize that variance >> specific capacity estimates
- Acknowledge where assumptions are not supported
- Manage nature of lake and development vs "capacity"

- Ask ourselves what it is we are trying to manage

HESL 21

So What ?

- Ask the right questions
- Lakeshore Capacity Asks
  - How much phosphorus is acceptable ?
  - How green can my lake become ?
  - How many users are acceptable ?
- Is growth the question ?
  - Or is better management of growth the question?

These lakes have lots of "capacity"

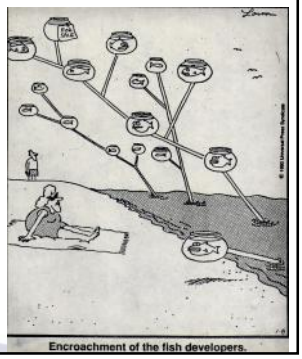
HESL

Why Manage Lakes ?

Why Plan for Lake Development ?

Why Set Development Capacities ?

It's a matter of perspective



Encroachment of the fish developers.

What Are We Trying to Manage?

- Water quality ?
- Social Crowding?
- Local economy ?
- A "wilderness" experience or perception of nature?
- Ecological attributes?
- Boating Density or Intrusion ?

Does the goal determine the approach or can we find an approach that meets all goals ?

HESL 24

Planners and People Like Stability?

- Stable Ecological Environment
  - Water quality
    - Prevent observable aesthetic changes
  - Aquatic life
  - Wildlife and waterfowl habitat
- Stable social and aesthetic environment
  - Protect recreational opportunities
  - Buffer uses and users
- Stable economic environment
  - Protect property values
  - Maintain employment opportunities

Ontario's "Lakecap" Approach

Science Heavy – Requires precise and repeatable assumptions and relationships to maintain stability

Planners and People Like Stability

But science adapts to change
- in assumptions
- in the environment
- in better data
- in better understanding

Science is Unstable and Improved Scientific Understanding is at Odds with Planning Stability and Public Desires

Recognize What the Model and Lakecap Can Do

- Indicate the level of sensitivity of a lake to nutrient enrichment - model
- Indicate state of phosphorus concentration – monitoring
- Guide development policy
  - Management requirements (development controls) scaled to sensitivity score
- Indicate when a lake has more phosphorus than is healthy
- Be the basis for planning and stewardship programs

Conclusions – Revised Approach

- the model does not provide estimates of absolute phosphorus concentrations in individual lakes that could be defensibly used to set and defend specific lake capacities in planning policy, BUT
- the model can be used and defended in the context of
  - a) estimating potential loads of phosphorus to the lake from natural and human sources and
  - b) assessing the relative responsiveness of a lake to loadings
- lake monitoring data can, and should be, used to inform planning policy
  - - in the past, we have used it only to check model accuracy

Conclusions
Revised Approach – 2014 (CGS)

- We took those elements of the model that worked best to develop a sensitivity-based lake classification system to inform planning policies
- Based on
  - two criteria from the model +
  - Three "triggers" from monitoring program

Recommended Approach

- Criterion 1 "Threshold".

Is existing phosphorus load to the lake >50% greater than the natural or "background" load ?
  - - where "load" is the potential contribution to the lake from all human sources.

	Criterion 1. Threshold	
	Over Threshold	Under Threshold
Phosphorus Load	≥BG+50%	<BG+50%

  - Advantage – Policy does not rely on inaccurate predictions of TP concentration in lake

Recommended Approach

Criterion 2 "Sensitivity"

Does the lake have a High or Low Responsiveness to phosphorus loading.

- Where "responsiveness" is the relative change in the lake to a standard load per unit area of lake surface (1cottage/1.6 ha)

•A lake has "High Responsiveness"
- if the standard areal phosphorus load causes concentration to increase by >50%

•A lake has "Low Responsiveness
- " if the standard areal phosphorus load causes concentration to increase by <50

	Criterion 2. Responsiveness	
	High Responsiveness	Low Responsiveness
Change in phosphorus concentration with a standard aeral phosphorus load	≥ 50%	<50%

HESL 31

Result

Management Classification Matrix for Planning Policies

Advantage – Policy does not rely on inaccurate predictions of TP concentration in lake

	P Load ≥BG+50%	P Load <BG+50%
High Responsiveness	Enhanced	Moderate
Low Responsiveness	Moderate	Standard

HESL 32

Management Classification for Planning Policies

"Enhanced" management is recommended for lakes that:

- have a phosphorus load that could cause them to exceed ≥BG +50% and have high responsiveness to phosphorus loads.

"Moderate" management is recommended for lakes that:

- have a phosphorus load that that could cause them to exceed BG +50% but have low responsiveness to phosphorus loads, or
- have a phosphorus load that would not cause them to exceed BG +50% but have high responsiveness to phosphorus loads.

"Standard" management is recommended for lakes that have a phosphorus load that would not cause them to exceed <BG +50% and have a low responsiveness to phosphorus loads.

HESL 33

Linking Classifications to Planning Policies

The classifications are implemented into planning policy by linking increasing lake sensitivity with increasingly stringent site specific management techniques and Best Management Practices to mitigate the potential for phosphorus loading.

	Lake Classification		
Management Techniques	Enhanced	Moderate	Standard
Vegetated Buffers	X	X	X
Shoreline Naturalization	X	X	X
Soil Protection	X	X	X
On-Site Storm Water Control	X	X	
Limit Impervious Surfaces	X	X	
Enhanced Septic Setback	XX	X	
Septic Abatement Technologies	X		
Full Servicing	X		
Site Specific Soils Investigation	X		
Enhanced Lot Sizes	X		
Limit Lot Creation	X		
Compliance Monitoring/Securities	X		
Monitoring Intensity	X		

HESL 34

Management Triggers for Planning Policies

"Triggers" address uncertainty in the model-based classification system by adding additional information from the monitoring program.

Trigger 1. Are epilimnetic or spring overturn phosphorus concentrations >20 µg/L?

Trigger 2. Is there a statistically significant increasing trend in phosphorus concentrations (or decreasing transparency or decreasing hypolimnetic oxygen) in a lake?

Trigger 3. Have cyanobacterial blooms been observed?

HESL 35

Summary – Classifications and Triggers for Planning Policies

	Management Response	
Classification	No Triggers	Triggers
Enhanced	Enhanced	The lake is at risk of blooms now and additional phosphorus loading should be avoided. Planning policy should be focussed on preventing additional loading by implementing Best Management Practices or limiting the creation of new un-serviced shoreline lots.
Moderate	Moderate	Causation Study Lake is not sensitive and not overloaded and so other factors may be triggering changes
Standard	Standard	Causation Study Lake is not sensitive and not overloaded and so other factors may be triggering changes

HESL 36

BUT !

- Why scale level of protection to lake classification ?
- Why not recognize that all lakes should be protected from development?
  - Implement BMPs and minimum development standards for all lakes
    - Lot sizes, frontages, naturalization, buffers, enhanced septic setback, SW management for all lakes
  - Enforce these !
- Why not base lake management on facts instead of assumptions and models?
  - We are monitoring the lakes – use the data to assess lake health and not to validate model accuracy
- Why not base enhanced management activities on observed threats or changes ?
  - Threshold water quality
  - Trends in water quality
  - Observed problems such as cyanobacterial blooms

HESL

Conclusions
Recommended Approach – 2015 (DMM)

All lakes be afforded a high degree of protection by a requirement for a minimum set of BMPs for new development or redevelopment.

Minimum Lot sizes, frontages, naturalization, buffers, enhanced septic setback, SW management for all lakes
Addresses water quality, social crowding, habitat protection …

HESL

Conclusions
Revised Approach – 2015

Monitoring records for all lakes be reviewed annually and results compared against the three "triggers" of: Total Phosphorus > 20 µg/L, an increasing trend in total phosphorus and documented presence of a blue green algal bloom.

That triggered lakes be subject to:

Enhanced BMPs for new development or redevelopment as a precaution against phosphorus loading,

A detailed "causation study" to determine any role of shoreline development in water quality.

This would include use of advanced and lake specific water quality models but with detailed review of input data, review of land use patterns in the immediate watershed, review of settlement history, paleolimnology, a "Limits to Growth" assessment and remedial actions if warranted

A "freeze" on new development if the trigger is long lasting (>1year) and the causation study determines that human phosphorus loading is the cause.

HESL

Thank You

HESL 40

Appendix C. Presentation - Jurisdictional Review

Hutchinson Environmental Sciences Ltd.

Managing Shoreline Development on Inland Lakes

REVIEW AND ANALYSIS OF EXISTING APPROACHES

NORTH SASKATCHEWAN WATERSHED ALLIANCE LAKE PLANNING AND MANAGEMENT PROFESSIONAL DEVELOPMENT DAY

JUNE 3, 2015

TAMMY KARST-RIDDOCH, PH.D.

Outline

Introduction

Purpose of Study & Approach

Findings of the Review
- Goals, Targets, Rationale
- Technical Approaches
  - Capacity
  - Mitigation
  - Classification & Screening (more this afternoon)
- Planning, Regulatory & Implementation Tools

Introduction

Ontario recognizes the need to advance the practice for managing shoreline development to consider a more comprehensive approach.

Existing Approach: Lakeshore Capacity Assessment, Lake Trout Policy

Limitations:

- Other shoreline development concerns are not addressed:
  - Social crowding, boating, aesthetics, noise levels, light pollution, safe drinking water, pathogens, fish and wildlife, protection of shorelines
- Model not applicable province-wide, issues with accuracy
- Requires detailed lake and watershed data and technical expertise
- Does not explicitly consider Best Management Practices
- Challenges to the approach
  - based on only one factor (phosphorus) that can be mitigated with BMPs (e.g., septic system phosphorus abatement)

Purpose of Study

- Analyze and evaluate existing approaches for managing development on inland lakes, and
- Recommend options for use in Ontario that consider:
  - various levels of planning organization (i.e., unorganized areas vs. organized municipalities),
  - diversity of geographic conditions and lake characteristics,
  - implementation tools (i.e., policy, enforcement)
  - Ontario's Provincial Policy Statement
  - resource requirements for implementation and follow up monitoring, and
  - performance measures

Review Jurisdictions

- 14 jurisdictions in Canada and the US
- Developed a series of questions
  - program framework
  - implementation tools
  - Best Management Practices
- Information sources:
  - direct communication
  - documented information

"Stated Goals"

- Protection of a combination of social, environmental and economic attributes:
  - Social Density (Crowding)
  - Access
  - Aesthetics (viewscapes, scenic vistas, 'character', building density and form)
  - Fish and Wildlife Habitat
  - Drinking Water Resources
  - Water Quality (total suspended solids and total phosphorus concentration)
  - Economic Resources
- Many jurisdictions noted a need to balance social and environmental protection with economic concerns
- Stated goals were mostly general without specific management targets, or rationale for using selected management tools
  - Hampers ability to assess 'success'
  - Does not promote 'buy-in' by local governments, residents and developers

Goals, Targets, Rationale
Recommendations

1. Define desired **attributes for protection** that:
   - consider provincial interests, and
   - recognize local concerns (i.e., economic and social factors),
2. Define specific **management goals or targets** for each attribute to:
   - select appropriate management tools, and
   - evaluate success
3. Provide a clear **rationale for the selection of management tools** to meet the intended goals for the desired attributes
   - promotes uptake of the approach and reduce challenges

7

Technical Approaches
Overview

Approaches generally used a combination of:

1. **Capacity tools** set limits to the amount of shoreline development allowed on a lake based on one or more factors, and
2. **Mitigation tools** including development standards and Best Management Practices are used to reduce the impacts of development.

- Selection of management tools was guided in nearly all instances by a **screening approach** or **lake classification method**
  - to identify lakes or shoreline areas that are most susceptible to impacts from shoreline development
- In many situations, **lake-specific management** was used or was recognized by the jurisdiction as an approach that could be used to address locally-specific or lake-specific issues

8

Capacity Tools
Lakeshore Capacity Assessment (Lakecap)

District of Muskoka

Elliot Lake

City of Kenora

Seguin Township

- Sets limits to shoreline development on recreational lakes on the Precambrian Shield based on phosphorus concentration
  - To meet revised Provincial Water Quality Objective (PWQO) modeled background total phosphorus concentration plus 50% to a maximum cap of 20 µg/L

Advantages:

- Developed using a well-studied scientific approach and long term records of phosphorus
- Watershed-based approach
- Provides clear and quantitative capacities that are easily expressed (i.e., specific development counts)
- Based on a measurable threshold that can be monitored to assess success
- Presented as stable requirements that are unlikely to change providing stability in planning
- Well-established history of implementation

Disadvantages: …

9

Capacity Tools
Lake Trout Policy

Elliot Lake

Seguin Township

Photo credit: Paul Vesk, 2012

- Sets limits to shoreline development on designated Lake Trout Lakes
  - Requires oxygen concentration (as Mean Volume Weighted Hypolimnetic Dissolved Oxygen, MVWHDO) ≥ 7 mg/L

Advantages:

- Based on strong physiological evidence of responses of lake trout to oxygen
- Provides clear and quantitative capacities that are easily expressed (i.e., specific development counts)
- Based on a measurable threshold that can be monitored to assess success
- Stable requirement that is unlikely to change providing stability in planning
- Well-established history of implementation

Disadvantages:

- Requires long-term data (3-5 years) measured within a discrete timeframe (within 2 weeks of September 1st)
- Oxygen data can be highly variable between years
  - Driven by weather patterns
  - Capacity can change depending on years of data (e.g., Elliot Lake)
- Requires detailed lake bathymetry, which is often not available
- Based on premise that shoreline development increases phosphorus concentration and therefore decreases oxygen
- If phosphorus can be mitigated, then the policy can, and has been, challenged

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Capacity Tools
Recreational Carrying Capacity

Seguin Township

- Sets limits to shoreline development to 1 lot/1.62 ha of lake surface area to limit social crowding, and indirectly limit boat traffic

Advantages:

- Easily computed for a large number of lakes with little information needs
- Provides clear and quantitative capacities that are easily expressed (i.e., specific development counts)
- Presented as stable requirements that are unlikely to change providing stability in planning

Disadvantages:

- May not be widely applicable
  - Differences in social values (urban lakes vs recreational lakes)
  - Social filter determined in the 1970s (unpublished) based on recreational patterns in central Ontario
- Difficult to defend because it is based on a threshold that is not science-based and could be considered as 'arbitrary'
  - Seguin Township defends its use on the same planning principal as that used for public park spaces

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Capacity Tools
Recommendations

1. Alternative approaches should be considered where **technical and funding resources** are lacking (e.g., unorganized territories)
2. Consider **mitigation** approaches and new technologies
   - to reduce phosphorus loads
   - to minimize impacts of crowding
3. Consider **lake sensitivity or other screening techniques** recognizing uncertainties with models and availability of mitigation techniques
4. Allow **flexibility in the modelling approach** to accommodate lake characteristics
5. Implement **long-term monitoring**

12

Mitigation Tools Overview

Used by all jurisdictions reviewed in the study (except the City of Elliot Lake Cottage Lot Program)

- Included a variety of Best Management Practices (BMPs) to protect a wide range of attributes:
  - Minimum development standards (e.g., lot sizes, setbacks, frontage)
  - Shoreline buffers
  - Erosion and Sediment Control plans
  - Limits to impervious surfaces
  - Septic system design and sighting
- In US, states mandate BMPs and require LGUs to implement them through ordinances
- Not mandated at the Provincial level in Ontario, but addressed in Official Plan policies and zoning bylaws

13

Mitigation Tools Overview

Used by all jurisdictions reviewed in the study (except the City of Elliot Lake Cottage Lot Program)

Advantages:

- Can address a wide range of management goals
- Several BMPs available to control for the same attribute
- A 'toolbox' of options whereby different BMPs and different scaling of BMPs can be used
  - Resource availability
  - Site-specific conditions

Disadvantages:

- Can be difficult to enforce
- Success may be dependent on enforcement
- Effectiveness not always documented quantitatively
- Often requires maintenance to ensure effectiveness

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Mitigation Tools Vegetative Buffers

Photo credit: Extreme Exteriors

- Maintenance of a naturally vegetated or re-vegetated area along the shoreline
- Dimensions of buffers varied, but most commonly required 30 m for stream environments (Natural Herige Reference Manual (MNR, 2010), Environment Canada, 2013)

Advantages:

- Well-established method with documented effectiveness for infiltration and attenuation of stormwater
- Mitigates social impacts by screening view of development from the lake, reducing noise
- Provides protection and habitat for wildlife
- Protects shorelines from erosion
- Low cost

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Mitigation Tools Vegetative Buffers

Photo credit: Jim Bruek, 2014, Michigan State University

Disadvantages:

- Less documented effectiveness for mitigating phosphorus from septic systems
- Definitions of 'Natural' vegetation vary
- Often a preference for a 'manicured' aesthetic and relative effectiveness of garden type buffer vegetation is not well-documented
- Difficult to enforce

Recommendations:

1. Additional study may be required to determine whether the buffer requirements are equally suited to lakes
   - Buffer size, type of vegetation
2. Need for enforcement or education/outreach

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Mitigation Tools Stormwater Management

- Methods to control stormwater runoff to lakes
- Usually included in a Management Plan or Erosion and Sediment Control Plan – to demonstrate effective infiltration, capture and treatment
- Low Impact Development techniques and BMPs
  - District of Muskoka SWMPs – proper recontouring, discharging of roof leaders, use of soakaway pits
  - Grassed and vegetated swales, French drains
- Often focused on Construction Phase of development
- Can include complex modeling (e.g., Halifax)
- Simplest approach used limits on impervious surfaces (e.g., NH, MN, MI, WI)
  - Ranged from 15% to 30% maximum imperviousness
- Site characteristics and nature of proposed development dictate the appropriateness of various stormwater management tools

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Mitigation Tools Septic System Design and Maintenance

Methods to mitigate phosphorus from septic systems:

- Use of mineral rich and non-calcareous soils
- Increased setbacks, minimum vertical saturation distances based on local soil conditions
- New technologies not promoted by any jurisdiction
- Septic re-inspection programs

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Mitigation Tools
Septic System Design and Maintenance

Recommendations:

1. Support a septic system inspection program to identify malfunctioning units
2. Consider design options (e.g., setbacks, depth of the unsaturated zone, soil conditions that promote attenuation of phosphorus) to mitigate phosphorus
3. Base design requirements on the sensitivity of a lake to phosphorus loading
4. Support new technologies on a case-by-case basis
   - would foster continued research and development of these technologies that in time, may become more readily available at reasonable costs and with greater assurance of effectiveness

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Jurisdiction	Building Setback (m)	Septic Setback (m)	Lot Size (ha)	Lot Frontage (m)
Elliot Lake	20	-	0.4	45
Kenora - Black Sturgeon Lake	20	-	0.8	61 (122 for restricted development area)
Muskoka (& Muskoka Lakes	20	30	-	60
Seguin	20[1]	-	1 (1.2 for island lots)	90 (120 for island lots)
Lake Simcoe Protection Plan	15 (Town of Innisfil)	-	-	-
Rideau Valley CA	30 – 90	-	-	60 (Rideau Lakes)
Cariboo	7.6	35	-	46
Maine	23 – 76	30	0.19	61
New Hampshire	-	23 – 38	-	46
Minnesota	23 – 46	-	0.19 – 0.74	30 – 61
Wisconsin	23	-	0.19	30

Mitigation Tools
Minimum Development Standards

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Mitigation Tools
Minimum Development Standards

Recommendations:

1. Consider a set of minimum development standards scaled to lake and watershed characteristics for implementation Province-wide (e.g., Minnesota's approach)

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Screening and Classification Tools

- To group lakes with similar characteristics or management needs so that appropriate management tools can be applied to protect desired attributes from the impacts of shoreline development
- Widespread use across jurisdictions
  - Watershed level and lake level
- Accommodate varying lake and watershed characteristics
- Tailored by using criteria to best address issues at hand and the availability of data and resources

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Planning, Regulatory and Implementation Tools

Tool	Advantages	Disadvantages
Ontario Legislation	Enabling type legislation	Even a minimum standard may not be achieved
	Provincial priorities set through policy statement	Differing standards throughout Province
	Flexibility for municipalities	Differing enforcement throughout Province
Official Plans	Can be tailored to municipal needs and interests	Policies not enforceable
	Provides vision for municipality	Differing policies depending on municipality
	Regional Plans can provide consistency over a region	Expensive for small municipalities to keep up to date
	Requires update every 5 years	

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Planning, Regulatory and Implementation Tools

Tool	Advantages	Disadvantages
Zoning Bylaws	Tailored to Official Plan	Court system is challenging
	Flexible through amendment processes	Amendment process can be abused and not uphold the intent of the Official Plan (minor variances)
	Enforceable	Enforcement can be expensive
Site Plans	Excellent implementation of best management practices	Refers only to the site in question and not the broader surrounding area (watershed, lakewide shoreline)
	Can be very specific to site	Should have qualified staff to administer
	Can require securities to ensure BMPs carried out	A challenge to enforce without securities
	Can bind future owners through registration on title	No long term site monitoring

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Enforcement

- Commonly cited as an issue – requires significant expenditures, staff resources
- Typically achieved through bylaws and ordinances (US)
- Township of Seguin and the Township of Muskoka Lakes each enforce approximately 20 - 25 infractions every year
  - Focus on enforcement through the OMB, Provincial Offenses Act and Shoreline Protection Bylaws
  - Also uses Restrictive Covenant Agreements on purchase of Shore Road Allowances – addresses existing development
  - Annual budget of $75 – 100K

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Conclusions

- Jurisdictions employ a wide variety of approaches for managing shoreline development
- Ontario is the only approach that sets capacity limits
- Evaluation of the approaches is difficult (lack of information)
- A lake classification system, with minimum development standards and Best Management Practices is the most common approach
- Capacity tools can be effective, but are likely best suited where:
  - financial and technical resources permit
  - more stringent control is required due to specific lake or watershed conditions (e.g., where development pressures are great and lake characteristics are particularly vulnerable to nutrient enrichment)

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Appendix D. Presentation - Lake Classification

Screening & Classification Tools


Photo Credit: Chloe Green, InformationAge

TO IDENTIFY LAKE TYPES, DETERMINE MANAGEMENT NEEDS & MANAGE COMPETING INTERESTS

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Cariboo Region

Classification:
Water Quality Sensitivity
Septic System Design

Lake and Watershed Characteristics

- Shallow, unstratified to deep stratified lakes
- Mesotrophic to eutrophic, alkaline
- Variable lake surface and watershed areas
- Off the Precambrian Shield
- Primarily forested (coniferous) with pockets of agriculture, ranching, logging and minor rural development
- Unserviced

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Cariboo Region – 6 Objectives

- Preserve water quality of lakes and watercourses
- Manage shoreland development to preserve the integrity and capability of existing aquatic and shoreland environmental resources for wildlife habitat,
- Preserve the aesthetic quality of the natural setting by integrating shoreland developments with the natural surroundings,
- Protect shorelands from erosion and degradation,
- Provide shoreland access to the general public where appropriate and to reduce conflict with adjacent landowners
- Determine suitable areas for shoreland development

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Purpose of Classification	Criteria for Classification
To define the extent to which septic system and buffer guidelines will apply: **Sensitivity** / **Applies to lots within:** High: 250 m of the shore, 100 m of a tributary Moderate: 200 m of the shore Low: 150 m of the shore	Water Quality Sensitivity - Lake Trophic State - Lake Flushing Period - Mean Lake Depth - Watershed Characteristics
Sighting septic systems (vertical saturated depth) to mitigate phosphorus loads	Minimum Vertical Unsaturated Distance (septic system design) - Water Quality Sensitivity - Soil Characteristics - Lot area

Classification and Screening Tools – Cariboo Region 34

Criteria	Low Water Quality Sensitivity	Moderate Water Quality Sensitivity	High Water Quality Sensitivity
Trophic State	Highly oligotrophic and highly eutrophic (lakes which are sufficiently advanced into a eutrophic state such that only large amounts of additional nutrients will result in noticeable further deterioration in water quality)	Oligotrophic to eutrophic	Oligotrophic to slightly eutrophic
Flushing Period	Short (generally 0-2 years)	Average (generally 2-8 years)	Long (typically greater than 8 years)
Mean Depth	Deep (generally >15 m)	Average (5-15 m)	Relatively shallow (generally <5 m)
Watershed Characteristics	Watershed in natural state or large watershed for highly oligotrophic lakes	Larger watersheds than those under the "high" sensitivity with less activity	Small or with a significant degree of activity (agriculture, logging or other development)

Cariboo Region – WATER QUALITY SENSITIVITY 35

Development Density	Low WQ Sensitivity	Moderate WQ Sensitivity	High WQ Sensitivity
Very low (2 ha lots)	Level 1	Level 1	Level 2
Low (0.4 ha)	Level 1	Level 1	Level 3
Medium (0.2 ha)	Level 1	Level 2	Level 4
High (0.07 ha)	Level 2	Level 3	Level 4

Level of Phosphorus to be Removed	Minimum Vertical Unsaturated Distance		
	Soil A	Soil B	Soil C
Level 1	1.2 m	1.2 m	1.2 m
Level 2	9 m	3 m	1.6 m
Level 3	15 m	5 m	2 m
Level 4	Septic disposal not recommended	8 m	3.5 m

Cariboo Region – SEPTIC SYSTEM DESIGN 36

Minnesota

- Based on a classification system of the shoreland
  - all land within 1,000 feet (305 m) of a lake and 300 feet (91 m) of a river and its designated floodplain
  - applies to all lakes greater than 25 acres (or >10 acres within municipalities)
- Development restrictions, standards and BMPs are tailored to the different lake classes
- Local governmental units are required by State Law to adopt the minimum state standards into their zoning ordinances

Purpose of Classification	Criteria for Classification	Lake and Watershed Characteristics
To scale BMPs and minimum development standards to protect water quality and natural resources based on lake characteristics and existing development patterns	Lake surface area Shoreline to lake area Amount and Type of Existing Development Water Depth	Shallow, unstratified to deep stratified lakes Oligotrophic to eutrophic Variable lake surface and watershed areas On and off the Precambrian Shield Mixed land use Unserviced, recreational development of shoreline areas Increasing population density and shoreline development pressure, in general

Classification	Description
Natural Environment Lakes (shallow, low development pressure)	<150 acres (<61 ha) of lake surface area <60 acres of lake surface per mile (<15 ha/km) of shoreline <3 dwellings per mile (<1.9 dwellings per km) of shoreline May be some winterkill of fish, may have shallow, swampy shoreline <15 ft (<4.6 m) deep
Recreational Development Lakes (deep, moderate development pressure)	60 - 225 acres of lake surface area per mile (15 – 140 ha/km) of shoreline 3 - 25 dwellings per mile (1.9 - 16 dwellings per km) of shoreline >15 feet (>4.6 m) deep
General Development Lakes (large, deep, high development pressure)	>225 acres of lake surface area per mile (>140 ha/km) of shoreline >25 dwellings per mile (>16 dwellings per km) of shoreline >15 feet (>4.6 m) deep

Minnesota Minimum Development Standards for Unsewered Lakes

Lake Class	Lakeshore				Non-Lakeshore	
	Lot Width ft. (m)	Lot Area sq. ft. (ha)	Structure Setback ft. (m)	Shore Impact Zone sq. ft. (ha)	Lot Width ft. (m)	Lot Area sq. ft. (ha)
Natural Environment	200 (60)	80,000 (0.74)	150 (46)	75 (23)	200 (60)	80,000 (0.74)
Recreational Development	150 (46)	40,000 (0.37)	100 (30)	50 (15)	150 (46)	40,000 (0.37)
General Development	100 (30)	20,000 (0.19)	75 (23)	37.5 (11)	150 (46)	40,000 (0.37)

Best Management Practices

- building elevations a minimum 0.9 m above the high water elevation
- sewage system elevation 0.9 m above the highest groundwater level or bedrock
- <25% impervious surfaces
- additional BMPs 'encouraged' (for sewage treatment, erosion and sediment, lawns and gardens, toxic chemicals, stormwater runoff, species habitat and eutrophication

Kenora

- Lake specific management plan
- 'in-lake' classification of the shorelands
- Large lake (1,600 ha) and watershed (731 km^2)
- Mesotrophic (TP = 15.6 mg/L)
- Dystrophic (DOC = 8 mg/L)
- Primarily warm water fishery
- Primarily forested with pockets of rural residential and minor tourist commercial land use
- Unserviced
- Concern related to rapid pace of development, impacts of development on water quality and scenic amenity

Purpose of Classification	Criteria for Classification
To establish 'restricted development areas' of the lake shoreline where larger frontages are required to: o Limit crowding o Protect scenic amenity o Protect Natural Heritage features	Narrow channels Islands Embayments Natural Heritage features including wetlands

Screening and Classification Tools

Recommendations:

1. Can be an effective method to appropriately scale mitigation measures for a wide range of lake and watersheds characteristics, resource availability and planning environments that exist in large jurisdictions
2. Selection of classification/screening criteria should be developed based on the attributes that are required to be protected

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Appendix E. Presentation - Case Studies in Lake Classification

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Case Studies in Classification

Ontario Lake Management Classifications

1. PreCambrian Shield – Off Shield – Large Lakes – Great Lakes

Reflected in PWQO for TP : <10 µg/L, 20 µg/L

2. PreCambrian Shield
   Lake Trout – Recreational – Warm Water

3. Preventive (Regional and Planning Based)–LakeCap
   vs
   Remedial (Causation and Lake specific)
   (Lake of the Woods / Lake Simcoe / Lake Wilcox / Sturgeon Bay)

HESL

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Case Studies in Lake Classifictaions

Phospho-centric by Necessity

Hutchinson Environmental Sciences Ltd.

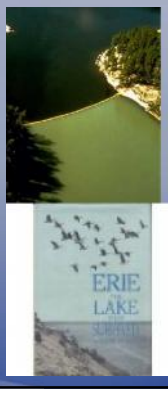
Case Studies in Lake Classifictaion

Phospho-centric by Necessity

Because that is what we have managed for 40 years

The Phosphorus Story

- Algal Blooms. Cladophora and anoxia in Lake Erie
- Macleans Magazine Pronounces Lake Erie dead
- Scientific Investigation Identifies Phosphorus as Limiting Nutrient
- Industry spokespeople say it is carbon and nitrogen
- Scientific Persistence – The Definitive Experiment by David Schindler
- Public Pressure
- Political Will
- Great Lakes Water Quality Agreement
  Phosphorus Limits in Detergent
  Phosphorus Removal at WWTPs



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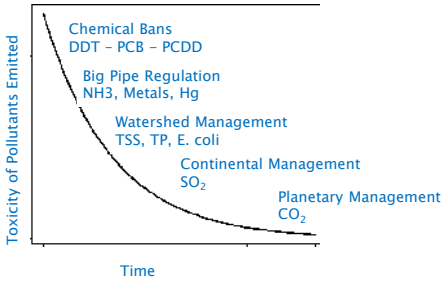
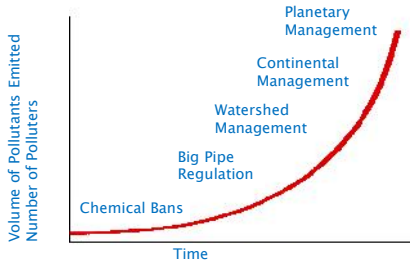
Good News - Trends in Pollutant Management



Modern Day Pollutants Less Toxic than Before

egetg 6

Bad News - Trends in Pollutant Management



Modern Day Pollutants Come From Many Sources

egetg 7

Evolution of Responsibility

Ban the Worst DDT. ~ 1964 , 1980s	Corporations
Control "Big Pipe" Pollution ~1970s-1980s	Businesses
Manage the Watershed 1980s - present	Municipalities
Manage the Airshed ~1990s	Land Owners
Manage the Planet	Individuals

HESL 8

Evolution of Responsibility

Ban the Worst – DDT. ~ 1964 , 1980s	Polluter Pays (Profits)	Corporations
Control "Big Pipe" Pollution ~1970s-1980s		Businesses
Manage the Watershed 1980s - present	Polluter Pays (Taxes)	Municipalities
Manage the Airshed ~1990s		Land Owners
Manage the Planet	Polluter Pays (Changed Behaviour)	Individuals

HESL 9

Classification of TP by Ecoregion

HESL 10

Phosphorus by Ecoregion – USEPA Approach

The process uses the ecoregion as a classification to help develop nutrient criteria based on designated water uses for different States as follows:

a) historic data are reviewed for quality and utility and then classified within each ecoregion;
b) reference sites within each ecoregion are compared and smaller classifications developed, if appropriate, to reduce variance within an ecoregion;
c) technical working groups at the EPA and within each region ensure consistency in classification and approach; and
d) reference conditions are combined with modelling, downstream considerations and other elements of criteria development to set regional water quality standards, either by States or Tribes, or by the EPA itself.

HESL 11

Phosphorus by Ecoregion – USA Examples

- Minnesota
- Classify by ecoregion (north, north-central, western), land cover (plains vs forested), soils, lake morphometry (stratification and depth)
  - lakes in forested regions deeper, smaller with lower chl "a"
- Choose reference lakes (unimpacted) within each classification
- Compare candidate lakes to reference lakes

HESL 12

Phosphorus by Ecoregion – USA Examples

- Wisconsin
  - Seepage vs surface water, stratified vs non-stratified, impoundments vs natural
  - started with 21 ecoregions – reduced to north, central and south Wisconsin
  - Identified need for good data
  - concluded that lake specific standards were preferred

Draft lake and impoundment criteria were developed based on the above analysis. A review of scientific information on phosphorus and phosphorus related impacts, however, led to conclusions that:

a) meaningful stand alone statewide phosphorus standards could not be developed on a state or regional-wide basis and,

b) the determination of whether lakes and impoundments have undesirable phosphorus related impacts should be made on a site-specific basis, utilizing technical information and partner input.

Phosphorus by Ecoregion – USA Examples

- Georgia
  - classify trophic status and set standards by geographic location within state, location within watershed and hydrology
  - Develop lake specific guidelines and trigger values for management based on ecoregion and lake use

This approach incorporates the ecoregion concept through direct measurements of lake trophic status, which will reflect the influences of the local ecosystem on trophic status. Lake specific guidelines reflect lake use and can incorporate the reference condition and trigger values. It is cost intensive, however, as it requires a dedicated monitoring, assessment and management program for each lake. It does not consider the ecoregion as an "a-priori" determinant of trophic status.

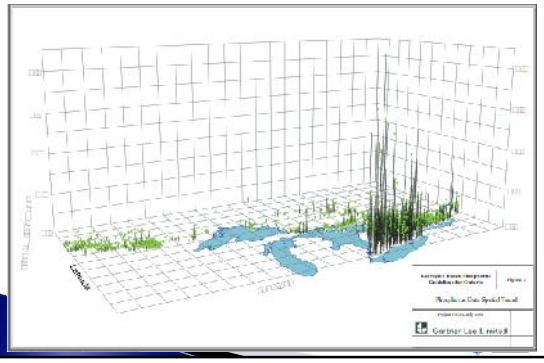
HESL 14

Phosphorus by Ecoregion – Ontario Case Study

Gartner Lee

HESL 15

Classifying a range in TP over large and diverse geographic area



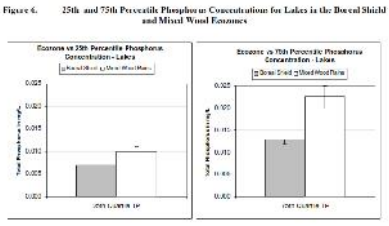
Gartner Lee Limited

HESL 16

3 Ecozones and 18 Ecoregions

HESL 17

3 Ecozones



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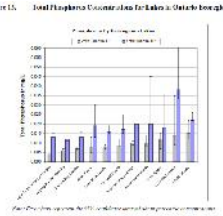
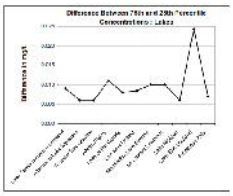
18 Ecoregions





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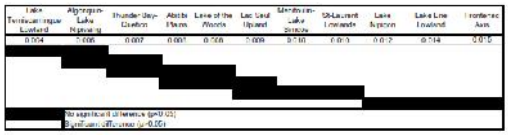
18 Ecoregions and 3 Statistically Distinct Classifications

0.004 mg/L – 0.006 mg/L – "Ultra-Oligotrophic" - Lake Temiscamingue and Algonquin-Lake Nipissing Ecoregions.

0.007 – 0.010 mg/L – "Oligotrophic" Thunder Bay-Quetico, Abitibi Plains, Lake of the Woods, Lac Seul Upland, Manitoulin – Lake Simcoe, and St. Laurent Lowlands Ecoregions;

0.011 – 0.015 mg/L - "Mesotrophic" – Lake Nipigon, Frontenac Axis and Lake Erie Lowland Ecoregions.



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Conclusions

Table 5. Revised Trigger Ranges for Ontario based on Ecoregion Analysis

	Revised Trigger Ranges Total Phosphorus in mg/L			
	Lakes		Rivers and Streams	
Trophic Level	Original (Table 1)	25th Percentile	Original (Table 1)	25th Percentile
Ultra-oligotrophic	< 0.004	< 0.004 - 0.006 [a]	-	< 0.011[a]
Oligotrophic	0.004 - 0.010	0.007 - 0.010[a]	< 0.025	0.012 - 0.020[a]
Mesotrophic	0.010 - 0.020	0.011 - 0.020[a]	0.025 - 0.075	0.021 - 0.035[a]
Meso-eutrophic	0.020 - 0.035	0.020 - 0.035[a]	-	0.035 - 0.075[b]
Eutrophic	0.035 - 0.100	0.035 -0.100[b]	0.075	> 0.075b
Hypereutrophic	> 0.100	> 0.100[b]	-	-

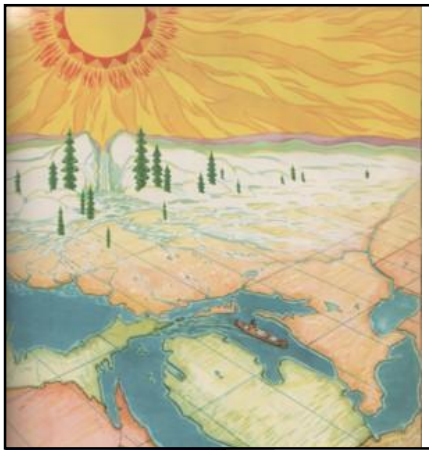
[a] Supported by statistically significant differences in concentration between ecoregions
[b] - Suggested by authors to match Environment Canada ranges - beyond range examined

HESL

Conclusions

-Classification requires good data – quality and quantity
dedicated sampling program with classification as the intent
– Case studies are for ecoregion approaches
– Best examples find statistically significant differences
– Classification seen as one step in the lake management process
– Classification sets a "reference" condition and triggers for comparison to specific lakes
– Management reverts to lake specific in the end

HESL



Thank You

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Appendix F. Presentation - A Risk-Based Classification Proposal

PROTOTYPE LAKE CLASSIFICATION TOOL

This classification tool is proposed in order to establish protection, management and restoration priorities in Alberta lakes.

"Risk" in this classification is defined as vulnerability to human encroachment with a potential to exhibit changes in water quality and ecosystem health. Characteristics are assigned a score of 1 (low), 2 (moderate) or 3 (high).

- **High** total scores denote lakes and watersheds with "questionable" capacity for further development or requiring restoration
- **Moderate** total scores denote lakes and watersheds requiring careful management to prevent further degradation
- **Low** total scores denote lakes and watersheds with high conservation value

BASIC ASSESSMENT

(***ENHANCED ASSESSMENT –** add to Basic assessment if information is available)

CHARACTERISTIC	LOW RISK (1)	MODERATE RISK (2)	HIGH RISK (3)	
Watershed Factors				
Watershed Land Cover	Natural state	Agriculture/Forestry/O+G (0-25% disturbance)	Agriculture/Forestry/O+G (25% - 75% disturbance)	
Watershed Area: Lake Surface Area Ratio	<5	5- 10	>10	
*Tributary Water Quality	Good [TP] <100 ug/L	Fair [TP] 100-250 ug/L	Poor [TP] >250 ug/L	
Shoreline Factors				
Proportion of Shoreline Developed	Natural State	0% - 25%	25% - 75%	
Shoreline Development Factor – Shape of Lake (WQ vs Fish habitat)	SDF 1-2	SDF 2-3	SDF >3	
*Riparian Zone Health	Healthy	Moderately Impaired	Highly Impaired	

*Soil suitability for septic	Depth to water table >3.0 m	Depth to water table 1.0 -3.0 m	Depth to water table <1.0m	
Water Quality Conditions				
Trophic Status	Highly Oligotrophic	Oligotrophic to Mesotrophic	Mesotrophic to slightly eutrophic	
Summerkill Risk	Well mixed – high [DO] Holomictic	Moderate rate of hypolimnetic [DO] depletion Dimictic	Extended hypolimnetic [DO] depletion Meromictic	
Winterkill Risk	Mean depth >5.0 m	Mean depth 3.0 - 5.0 m	Mean depth < 3.0 m	
*Internal Loading	< 1 mg/m2/day	1 – 5 mg/m2/day	>5 mg/m2/day	
Hydrologic and Morphometric Factors				
Flushing Rate (% of Lake Volume/yr)	>10%/yr	3% - 10%yr	<3%/yr	
Water Allocation Volume % of Inflow (or outflow or flushing capacity)	< 10%	10% -20 %	>20%	
Littoral Zone (< 4m) as % of Lake Area	< 25%	25% - 50%	> 50%	

*Groundwater Inflow Volume to Lake	High Inflow	Medium Inflow	Low Inflow	
*Groundwater Recharge	Discharge	Transitional	Recharge	
Biodiversity Factors				
Threatened or Endangered Species (plants or animals)	Designated species not present	Designated Species may be present or historically present	Designated species are present	
*Capability to support a sport fishery	High Capability	Moderate Capability	Low Capability	
Economic Considerations				
*Value of lake-based recreational opportunities	Minimal public use	Moderate public use	High public use	
*Value of ecological goods and services	Ecosystem value > Economic Value	Ecosystem value = Economic Value	Ecosystem value < Economic Value	
Social Considerations				
Recreational footprint	Low impact, non-mechanized recreation	Mixed usage, low to moderate mechanized recreation	High impact, mechanized recreation	

Distance from major urban centers	>2 hours	1-2 hours	<1 hour	
Boating footprint	Low impact, non-mechanized boating	Limited powerboat usage with no-wake zones and speed limits	High impact, mechanized boating	
			TOTAL POINTS	