Sharing Loading Estimation Experiences Workshop

Tuesday, January 20, 2015
9:00 a.m. to 4:00 p.m.

One Stone Road West, Guelph, Ontario
Conference Rooms 2 and 3


Workshop Proceedings

AUSABLE BAYFIELD CONSERVATION
CREATING AWARENESS | TAKING ACTION

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TABLE OF CONTENTS

Executive Summary 1

Introduction 2

Workshop Agenda 3

Workshop Proceedings 4

1. Introduction to the Multi-watershed Nutrient Study *Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change* 4
2. Lessons from loads *Trevor Dickinson, Professor Emeritus, University of Guelph* 6
3. An empirically-based regression method for estimating total phosphorus loads to Hamilton Harbour from the four tributary inputs *Tanya Long, Environmental Scientist, Ministry of the Environment and Climate Change* 8
4. Regression-based loading estimates applied in small, agricultural watersheds *Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change* ... 10
5. City of Toronto Wet Weather Flow Monitoring Network: Baseline conditions 2008 to 2011 *Derek Smith, Surface Water Field Coordinator, Ministry of the Environment and Climate Change* 12
6. Lake Erie loadings estimations in support of the Great Lakes Nutrient Initiative *Alice Dove, Environmental Scientist, Environment Canada* 14
7. Optimization of water quality sampling and load estimation modeling in the Lake Simcoe watershed: Evaluations using a continuous phosphorus dataset *Eavan O'Connor, Water Quality Specialist, Lake Simcoe Region Conservation Authority* 16
8. Case study #1: Predicting blue-green algae blooms at a Wheatley drinking water intake in western Lake Erie *Chitra Gowda, Source Water Protection Lead, Conservation Ontario; and Katie Stammler, Water Quality Scientist and Source Water Protection Project Manager, Essex Region CA* 18
9. Case study #2: Evaluating stewardship actions for Healthy Lake Huron *Mari Veliz, Healthy Watersheds Supervisor, Ausable Bayfield Conservation Authority* 19
10. Closing remarks and discussion *Isobel Heathcote, President, Wyndham Research Inc.* 21

Appendix: Workshop Participants 22

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EXECUTIVE SUMMARY

On January 20, 2015, the Ausable Bayfield Conservation Authority hosted a Sharing Loading Estimation Experiences Workshop in Guelph, Ontario. The event brought together 46 participants from 17 organizations to share experience with sediment and nutrient loading estimation methods. Mohamed Mohamed of the Ministry of the Environment and Climate Change began the session with an overview of the new Multi-Watershed Nutrient Study (MWNS), which will revisit some of the goals of the Pollution from Land Use Activities Reference Group (PLUARG, 1972-1979) in a then-versus-now analysis. Trevor Dickinson of the University of Guelph provided historical context for the day with a review of "Lessons from Loads," including findings from the PLUARG studies. Five presentations then described the application of regression-based, Beale ratio, and midpoint methods for loading estimation in a variety of recent studies. Two case studies presented information about projects currently underway, and invited suggestions and comments from speakers and participants on those cases.

The workshop format encouraged people with varying levels of experience in loading estimation to share their questions and ideas in an open forum. The discussion revealed a broad spectrum of challenges, both in the physical characteristics of the systems under study, and in the quality and quantity of data available to characterize those systems. Core messages from the presentations included:

- There is no single "best" method for estimating loads. If the system is well characterized, a variety of methods may each produce accurate results. Patterns in the data (*e.g.*, seasonal patterns) may provide clues as to how to stratify data to support more accurate load estimates.
- Characterizing a system well entails collecting long-term, continuous discharge data as a foundation for any load estimation initiative. Concentration data collection should aim to characterize system response to as wide a range of storms as possible. It is important to update both discharge and concentration information as climate and watershed conditions change.
- When ideal sampling technology is not available, even low-tech methods can be helpful in filling data gaps and building an understanding of system behaviour.

A final theme in this workshop was the importance of sharing data and interpretation with landowners and decision makers, to encourage positive change in the watershed.

Introduction

Organizations in Ontario and Canada are working towards updated and improved sediment and nutrient loading estimates for tributaries of the Great Lakes. One example of this is the Multi-Watershed Nutrient Study, which is being led by the Ontario Ministry of the Environment and Climate Change (MOECC) and involves partnerships with various conservation authorities.

In 2014, the Ausable Bayfield Conservation Authority (ABCA) was tasked by the MOECC with assessing monitoring methods for estimating nutrient and sediment loading in small streams, with agricultural watersheds, that drain into Lake Huron. One of the objectives of this project was to bring people with varying levels of loading estimation experience together to share relevant knowledge.

The ABCA received input on the format, presenters, and participants for a loading estimation workshop from representatives of several organizations:

- Conservation Ontario;
- Grand River Conservation Authority;
- Ontario Ministry of Agriculture, Food and Rural Affairs;
- Ontario Ministry of the Environment and Climate Change;
- Upper Thames River Conservation Authority; and
- Wyndham Research Inc.

The **Sharing Loading Estimation Experiences Workshop** took place on January 20, 2015, in Guelph, Ontario. It was attended by 46 people, representing 17 organizations. (A list of attendees can be found in the Appendix). The workshop agenda included presentations on the Multi-Watershed Nutrient Study, lessons from historical loading estimations in Ontario, and methods that have been used more recently for estimating loads in Ontario, as well as a discussion about how to approach loading estimations for two case studies.

WORKSHOP AGENDA

Time	Agenda Item
09:00 – 09:15	Registration
09:15 – 09:30	Introduction to the Multi-watershed Nutrient Study Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change
09:30 – 10:10	Lessons from loads Trevor Dickinson, Professor Emeritus, University of Guelph
10:10 – 10:30	Break
10:30 – 11:00	An empirically-based regression method for estimating total phosphorus loads to Hamilton Harbour from the four tributary inputs *(Method: Regression with level-weighted composite sample concentrations)* Tanya Long, Environmental Scientist, Ministry of the Environment and Climate Change
11:00 – 11:30	Regression-based loading estimates applied in small, agricultural watersheds *(Method: Regression using LOADEST with discrete concentrations)* Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change
11:30 – 11:50	City of Toronto Wet Weather Flow Monitoring Network: Baseline conditions 2008 to 2011 *(Method: Beale ratio with event mean concentrations)* Derek Smith, Surface Water Field Coordinator, Ministry of the Environment and Climate Change
11:50 – 12:10	Lake Erie loadings estimations in support of the Great Lakes Nutrient Initiative *(Method: Beale ratio with data stratified by flow)* Alice Dove, Environmental Scientist, Environment Canada
12:10 – 12:20	Question and Answer Period for the two Beale ratio presentations
12:20 – 13:00	Lunch
13:00 – 13:30	Optimization of water quality sampling and load estimation modeling in the Lake Simcoe watershed: Evaluations using a continuous phosphorus dataset *(Method: Comparison of Midpoint, Beale ratio, and regression methods with stratification of data)* Eavan O'Connor, Water Quality Specialist, Lake Simcoe Region Conservation Authority
13:30 – 13:40	Case Study #1: Predicting blue-green algae blooms at a Wheatley drinking water intake in western Lake Erie Chitra Gowda, Source Water Protection Lead, Conservation Ontario Katie Stammler, Water Quality Scientist and Source Water Protection Project Manager, Essex Region CA
13:40 – 14:30	Panel Discussion of Case Study #1 Facilitator: Isobel Heathcote, President, Wyndham Research Inc.
14:30 – 14:40	Short Break
14:40 – 14:50	Case Study #2: Evaluating stewardship actions for Healthy Lake Huron Mari Veliz, Healthy Watersheds Supervisor, Ausable Bayfield Conservation Authority
14:50 – 15:40	Panel Discussion of Case Study #2 Facilitator: Isobel Heathcote, President, Wyndham Research Inc.
15:40 – 16:00	Closing Remarks Isobel Heathcote, President, Wyndham Research Inc.

WORKSHOP PROCEEDINGS

1. Introduction to the Multi-watershed Nutrient Study

Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change

- **Current concerns** with agricultural non-point source (NPS) pollution include:
    - Are agricultural NPS loadings increasing?
    - What is the scope for loading reductions?
- The **Pollution from Land Use Activities Reference Group (PLUARG)** looked at loading issues between 1972 and 1979.
- **PLUARG objectives** were to:
    - examine the magnitude of NPS loading in agricultural, urban, and forested watersheds
    - develop relationships between land use, features of the landscape, and nutrient loading
    - develop recommendations to reduce these loads, if significant
- **PLUARG methods:**
    - for agricultural loadings, generated zones based on three characteristics that influence nutrient loss – climate, potential for runoff (soils, slope), and agricultural intensity
    - selected 11 small agricultural watersheds (about 20-70 km^2) in different zones
    - monitored near-continuous discharge and nutrient concentrations on an event basis to estimate nutrient loadings
    - collected information about land features (soils/geology, slope) and field-by-field land use and land management practices
- **PLUARG results:**
    - land features and land use could be used to predict nutrient loadings (*e.g.*, about 80 per cent of the variation in nitrogen and phosphorus loadings could be explained by the percentage of the watershed with clay soil and row crops)
    - these relationships were extrapolated to estimate total agricultural loadings to the Great Lakes
- The **Multi-Watershed Nutrient Study (MWNS)** will revisit some of the PLUARG goals in a then-versus-now analysis.

- **MWNS research questions and objectives:**
    - Have agricultural NPS nutrient loadings changed since the PLUARG work?
    - Has the relationship between agricultural land use/management and nutrient loadings changed?
    - Has the seasonal pattern of stream nutrient loadings changed between now and those found in past studies?
    - What are the relevant fractions of phosphorus delivered by agricultural watersheds? Has this changed over time?
    - assess the scope for change in agricultural NPS loadings
    - make new recommendations on mitigation strategies
- **MWNS methods:**
    - selecting 10 small agricultural watersheds (including several of the original PLUARG watersheds) based on a gradient of agricultural input (*e.g.*, total nutrient application) and landscape potential (*e.g.*, slope, soils)
    - will monitor continuous discharge and nutrient concentrations (automated samplers) to estimate nutrient loadings
    - will also collect information about land use and land management (roadside/aerial surveys, farmer interviews), soil characteristics, and slope (high-resolution Digital Elevation Model surveys)
- **Questions for the workshop:**
    - How do we measure loading?
    - What type of loads do we want to evaluate…annual, seasonal, or event?

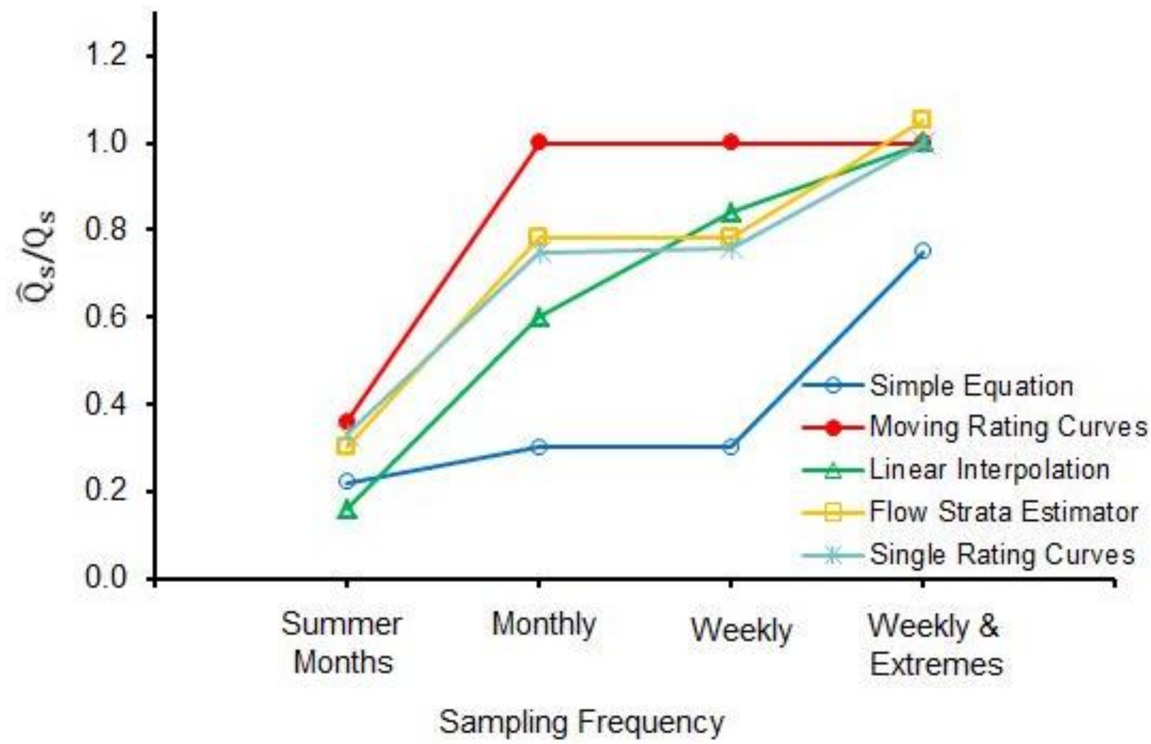
2. Lessons from loads

Trevor Dickinson, Professor Emeritus, University of Guelph

- When starting a study, **decide up front whether the focus will be on concentrations or loads, or both**. If the focus is on concentration targets or standards, or limiting ecological conditions, then concentration values are needed. If the focus is on land use management or downstream issues (*e.g.*, Great Lakes), then loads are needed.
- **Imperatives for loads:**
    1) **Excellent flow data** – Continue to check and update rating curves for stage and flow data.
    2) An understanding of the **relationship between concentration and flow** – Sample concentrations strategically, throughout the year and including events.
    3) Accurate load estimations – **Evaluate different estimation methods**.
- When there is a linear relationship between concentration and flow (*e.g.*, suspended sediment, particulate phosphorus), there may be a single, constant relationship or the relationship may change seasonally and/or between the rising and falling limb of an event (hysteresis).
- **Continually check the relationship between concentration and flow**, as it may change over time.
- **Obtain some depth-integrated concentration samples** (not necessarily everywhere) so that you can know your bias. (The concentration of a sample from a single depth will likely be low compared with a depth-integrated sample.)
- To **accurately estimate loads**:
    1) **At first, sample concentration frequently**, over a wide range of flow and using depth-integrated samples.
    2) With an understanding of the relationship between concentration and flow, **modify sampling frequency and sample more strategically**.
    3) **Evaluate a few loading estimation methods using the data**. If the sampling frequency is sufficiently high and strategic, several methods may produce accurate load estimates.

Accuracy of Load Estimates

Trevor presented data from Big Creek in the 1970s, where the site had a good record of flow and suspended solids data collected during events. The dataset was mined to evaluate different sampling frequencies and load estimation methods. The graph on the next page shows that, if sufficient samples are collected (year-round and including events), several load estimation methods may each provide accurate results.



Comparison of load estimation methods – Big Otter Creek: *if sufficient data are available, several load estimation methods may each provide accurate results.*

3. An empirically-based regression method for estimating total phosphorus loads to Hamilton Harbour from the four tributary inputs

Tanya Long, Environmental Scientist, Ministry of the Environment and Climate Change

- **Objective:** reduce uncertainty in total phosphorus (TP) loading estimates for the four tributaries to Hamilton Harbour
- **Data collection approach:**
  - discharge data for two stations came from co-located Water Survey of Canada (WSC) Hydat flow stations and for the other two stations were based on regressions with WSC Hydat stations
  - ISCO automated samplers collected hourly water samples over 24 hours for each rain and snowmelt event, plus baseflow samples
  - 87 events were sampled between July 2010 and May 2012
  - for each event, a level-weighted composite sample was created from the 24 hourly samples and was analyzed for total suspended solids (TSS), nutrients (phosphorus and nitrogen species), heavy metals, dissolved organic carbon, dissolved inorganic carbon, silicates, and chloride
  - **rationale for sample collection approach**:
    - level-weighted samples were ideal for loading estimation
    - 24 hours was (usually) enough to capture a full event hydrograph
    - autosamplers were needed for capturing samples during off-hours
- **Loading estimation approach:**
  - a **regression-based approach**, which is suitable if the r^2 of a log(concentration) versus log(discharge) regression is greater than 0.5
  - addressed re-transformation bias by applying a correction to all log-log regressions
  - alternative approaches considered: stratified Beale ratio, LOADEST, and LoadRunner
  - **rationale for regression-based approach:**
    - needed a simple loading method for future use by the Hamilton Harbour Remedial Action Plan
    - only Excel, WSC flow data, and precipitation data were needed for this approach
    - strong regressions were formed by the data
- **Results:**
  - TP concentrations during high flow events did not vary spatially or seasonally
  - nutrient concentrations generally increased with flow except nitrate at two stations

- the relationship between TP concentration and flow differed between summer/fall and winter/spring in the agricultural watershed
- TP loads were driven by large storm events in the urban watersheds and by the spring freshet in the agricultural/rural watersheds

- **Challenges and limitations:**
  - cell phone reception can be an issue, even in urban areas
  - power sources for stations – partnering to use existing WSC stations versus meter installations
  - predicting ISCO trigger times without a remote connection to a station
  - landowner permissions
  - washout of equipment during large storms
  - 24 litres of water are heavy!
  - very different winter conditions in 2011 versus 2012 (but this could be an opportunity too)
- **Recommendations based on experience:**
  - winter season cannot be ignored
  - flow-weighted composite samples may be an improvement over level-weighted composite samples
  - doing QA/QC as you go may be less of a headache than doing it all at the end of data collection

4. Regression-based loading estimates applied in small, agricultural watersheds

Mohamed Mohamed, Surface Water Scientist, Ministry of the Environment and Climate Change

- **Objectives:**
  - observe seasonal trends in loads and concentrations of nutrients (nitrogen and phosphorus), suspended solids, and *Escherichia coli* (*E. coli*) in 15 small streams draining agricultural lands
  - consider potential in-stream consequences (through concentrations) and potential impacts on receiving waters (through loadings)
  - compare concentration and load estimates to previous studies
  - examine relationships between land use (Nutrient Management Act) and water quality
- **Data collection approach:**
  - wading discharge was measured during sample collection, and was combined with WSC downstream data
  - approximately 12 to 14 discrete water samples were collected per year between 2004 and 2009, throughout all seasons and during some events
  - samples were analyzed for total phosphorus (TP), nitrite, nitrate, suspended solids, and *E. coli*
  - Nissouri Creek was sampled more frequently with an ISCO automated sampler
  - **rationale for sample collection approach**: several years of samples already collected
- **Loading estimation approach:**
  - a **regression-based approach with LOADEST** (a FORTRAN program) and LoadRunner (a graphical user interface for LOADEST) – LOADEST is finicky in terms of input data format, but LoadRunner helps to put data into the correct format
  - LOADEST requires mean daily discharge data (but you can trick it to use data on other time scales) and less frequent concentration data that matches up with discharge data points
  - it fits regressions of varying complexity and provides summary statistics to assess model fit
  - alternative approaches considered: Beale ratio
  - **rationale for regression-based approach:**
    - data availability

    - many events missed, but wanted to estimate seasonal and annual loads
    - wanted to estimate concentrations at baseflow
    - Beale ratio assumes a linear relationship between concentration and flow, and works best with random sampling

- **Results:**
    - nitrate loading was highest during the winter months
    - TP concentrations could be high in the summer (with in-stream effects), but loadings tended to be higher at other times of the year (with implications for receiving waterbodies)
- **Challenges and limitations:**
    - wading discharge measurements and 12 to 14 water samples per year were insufficient to develop an annual loading model for each stream and understanding seasonal variability for individual streams
    - method did not account for hysteresis
    - even with better monitoring data and a good loading model, large land use changes may be difficult to detect by monitoring over only a five-year period
- **Recommendations based on experience**:
    - ensure robust discharge data, which are critical to loadings
    - use automated samplers to collect water samples throughout event hydrographs
    - conduct preliminary work to assess required sampling frequency
    - explore other proxies (*e.g.*, turbidity) to improve load estimates
    - use a program that accepts frequent (*e.g.*, hourly) data or develop a strategy to more easily input frequent data into LOADEST

5. City of Toronto Wet Weather Flow Monitoring Network: Baseline conditions 2008 to 2011

Derek Smith, Surface Water Field Coordinator, Ministry of the Environment and Climate Change

- **Objective:** establish baseline information at 14 stations to assess the effects or benefits of implementing the City of Toronto Wet Weather Flow Master Plan over the next 25 to 50 years
- **Data collection approach:**
  - discharge and solid and liquid precipitation data were obtained from gauges operated by Toronto and Region Conservation Authority, Environment Canada, and Water Survey of Canada (WSC)
  - water quality was monitored during dry weather (once per season), wet weather (typically, rainfall events ≥ 10 mm; as many events as conditions and resources would allow), and snowmelt (minimum one event per season)
  - water samples were collected hourly with an ISCO automated sampler (triggered by water level) over a 42-hour period for each event
  - for dry weather, a composite sample was created with equal volumes from the 42 samples
  - for wet weather and snowmelt, a composite sample was created with flow-weighted volumes from the 42 samples
  - the composite sample provided Event Mean Concentrations
- **Loading estimation approach:** a **Beale Ratio estimator** was used to produce area-weighted loads
- **Results:**
  - concentrations of total suspended solids and total phosphorus were similar between wet weather and snowmelt events
  - chloride concentrations were higher during snowmelt and dry weather, and lower during wet weather
  - two smaller streams contributed some of the largest contaminant loads
- **Recommendations based on experience:**
  - Treat snowmelt as wet weather and do not ignore snowmelt events.
  - Water quantity monitoring is critical. Keep an eye on the rating curve to make sure that it is not shifting, which can happen if there are changes in the channel.

- Trigger autosamplers based on water level instead of rainfall. It could be raining in another part of the watershed, creating an event, but the event may not be detected by a rainfall gauge at the monitoring location if it is not raining there.
- Keep the sampling approach consistent between equal-weighted or flow-weighted composite samples. Flow-weighted samples are better than equal-weighted.
- Do not use a weir for discharge measurements or a stilling well for sample collection.

6. Lake Erie loadings estimations in support of the Great Lakes Nutrient Initiative

Alice Dove, Environmental Scientist, Environment Canada

- **Objective:** measure total and bioavailable phosphorus loadings from tributaries discharging to Lake Erie
- **Data collection approach:**
  - obtained discharge data by co-locating stations with Water Survey of Canada (WSC) flow gauging stations
  - collected water samples year-round, with an emphasis on rain and snowmelt events, but also under low-flow conditions
  - samples were collected every eight hours continuously with an ISCO automated sampler and were picked up from each site once a week
  - samples for analysis were selected based on an investigation of the hydrograph
  - samples were analyzed for unfiltered total phosphorus (TP), filtered TP, soluble reactive phosphorus (SRP), total suspended solids (TSS), total Kjeldahl nitrogen (TKN), ammonia, nitrate + nitrite, and major ions
  - **rationale for sample collection approach:**
    - consistent with the approach used on Lake Erie tributaries in the United States
    - because the rivers are large, it takes a long time for event hydrographs to rise and fall
- **Loading estimation approach:**
  - a **stratified Beale ratio estimator** was used to calculate annual loadings for the water year
  - a discharge threshold of 80 per cent of the values from a recent three-year time period was chosen to stratify data between baseflow and runoff
  - **rationale for Beale ratio approach:**
    - consistent with the approach used on Lake Erie tributaries in the United States
    - appropriate for large rivers
    - Environment Canada has developed and implemented a Loading Estimate Decision Support System that uses this method
- **Results:**
  - have draft loading estimates for nine Lake Erie tributaries in 2012 and 2013
  - loading estimates from 2014 are in progress and monitoring will continue until the end of the 2015 water year

- **Challenges and limitations:**
    - hut installation:
        - obtaining permits
        - running hydro to them
    - sampling equipment:
        - finding equipment that will withstand high flows
        - requiring divers and winches for installation and maintenance
        - troubleshooting problems (*e.g.*, water intake lines freezing, pumps clogging, and power failing)
    - sample processing:
        - filtering
        - sample holding times for SRP, ammonia, and nitrate + nitrite
    - tracking data:
        - complicated by a database transformation that was concurrent with data collection
        - keeping track of sample dates and times for multiple automated samplers
    - calculating loads: water year versus calendar year

7. Optimization of water quality sampling and load estimation modeling in the Lake Simcoe watershed: Evaluations using a continuous phosphorus dataset

Eavan O'Connor, Water Quality Specialist, Lake Simcoe Region Conservation Authority

- **Objective:** compare and evaluate a range of sampling scenarios and load estimation models against a measured annual tributary load to optimize load assessments for the East Holland and Beaver rivers
- **Data collection approach:**
  - discharge was monitored continuously
  - collected daily and event water samples with an ISCO automated sampler for a full year
  - event samples were time-weighted composite samples (two samples per bottle every two or four hours)
  - total phosphorus (TP) dataset was then artificially reduced to represent a range of sampling scenarios:
    - routine sampling – bi-weekly in ice-free seasons, tri-weekly in winter, plus events
    - weekly (same day every week) on either Mondays or Wednesdays
    - bi-weekly on Wednesdays with intense event sampling
    - bi-weekly on Wednesdays with partial event sampling (peak only)
    - monthly with intense event sampling
    - bi-weekly (same day every two weeks) on either Mondays or Wednesdays
- **Loading estimation approach:**
  - FLUX software was used to run different load estimation models (FLUX is friendlier than LOADEST, but still very tedious to use)
  - **Midpoint method** was the best approach for this dataset
  - alternative approaches considered: Beale Ratio and regression
  - **rationale for Midpoint method:**
    - data violated two assumptions for Beale Ratio and regression methods: 1) a significant slope and good r^2 of concentration versus flow; and 2) sampling across a range of flows and conditions
    - *e.g.*, Beale Ratio approach often overestimated loads because sampling was biased towards high flows in almost all of the sampling scenarios
    - Beale Ratio and regression methods may be suitable for longer term data

    - stratifying the data by season or the hydrograph may help in meeting the assumptions for these methods

- **Results:**
  - the two rivers differed in terms of land use, flow regime, and water quality:
    - Beaver River – agricultural (63% of watershed area); long periods of elevated flow; TP concentration peaked at the beginning of an event and then quickly dropped off
    - East Holland River – urbanized (22% of watershed area); short, intense peaks in flow; TP concentrations rose and fell with flow
  - despite these differences, the optimal sampling scenario and load estimation method were consistent between the two systems: bi-weekly plus intense event sampling paired with the Midpoint method
- **Challenges and limitations:**
  - installation:
    - setting up housing and power for autosampler
    - keeping intake free of biofouling (amphipods) and ice
  - seasons: maintaining correct sample temperature throughout year
  - timing:
    - estimating when an event would hit
    - capturing entire events (rise, peak, and fall)
    - events occurring on weekends
  - sampling equipment failures leading to data gaps
  - data: organization and quality control were time consuming
  - data analysis: three iterations were required
- **Recommendations based on experience:**
  - place a strainer on intake to reduce biofouling and heat intake line
  - use a refrigerated autosampler and heat station housing during cold months
  - documentation is important
  - ensure the time zone is consistent for all discharge and concentration data (*e.g.*, maintain Eastern Standard Time throughout the year)

8. Case study #1: Predicting blue-green algae blooms at a Wheatley drinking water intake in western Lake Erie

Chitra Gowda, Source Water Protection Lead, Conservation Ontario
Katie Stammler, Water Quality Scientist and Source Water Protection Project Manager, Essex Region CA

Please review the presentation slides for an introduction to this case study. The discussion period following the presentation is highlighted below.

- Derek Smith indicated that sampling a variety of storms is important. He classified storms based on rainfall amount (*e.g.*, 0-10 mm, 10-20 mm, 20-30 mm, 30-40 mm, >40 mm).
- Trevor Dickinson wondered if anything could be done with these data without a continuous stream flow record. A simple start would be to look at which size of rainfall events are generating runoff at different times of the year. When it rains, drive around the watershed looking at stream crossings and recording whether or not there is flow in each location from that rain event.
- Eavan O'Connor suggested using flow data from a nearby Water Survey of Canada (WSC) station, and correcting them for the stream monitoring location. Katie Stammler responded that, because the systems for this study were so small, there were no WSC flow monitoring locations that could have been used.
- Alice Dove wondered if the blue-green algae blooms that occur at the Wheatley drinking water intake may be related to things happening in other areas of the western basin of Lake Erie, rather than specifically to loadings from nearby Muddy Creek. There was some discussion about how a better understanding is needed regarding the many sources and the processes that result in nearshore algal blooms in the lake. Environment Canada is considering doing some regular sampling in the nearshore (perhaps installing a probe in the nearshore and visiting the site once a month to collect data and samples).
- Derek Smith indicated that flow information could be obtained relatively inexpensively. A non-vented level logger could be set up in a false well. Or, for almost no money, a staff gauge could be mounted somewhere where it will not move (not a T-bar in the creek). During an event, someone could record stage periodically as the water level moves up and down. Also, flow could be measured up to the water depth that is wadeable and then the rating curve could be predicted up to the top of the bank. If WSC were befriended, WSC might be willing to run the rating curve using a program called Aquarius.
- Lance Aspden suggested that a hunting/wildlife camera could be installed to take photos of a staff gauge at regular intervals.
- Pradeep Goel indicated that, if an objective is to identify the sources of loadings, a study needs to be run for at least 8 to 10 years.

9. Case study #2: Evaluating stewardship actions for Healthy Lake Huron

Mari Veliz, Healthy Watersheds Supervisor, Ausable Bayfield Conservation Authority

Please review the presentation slides for an introduction to this case study. The discussion period following the presentation is highlighted below.

- Tanya Long cautioned that calculating annual loads reflects precipitation and other climate conditions rather than land management practices. One could look at the slope in the relationship between concentration and flow. Is it changing over time?
- Mohamed Mohamed agreed that, from year to year, annual loads will be driven by precipitation. He guessed that, even if loads could be measured accurately, it could take longer than ten years to detect a connection between a change in land management and a change in loads because there is so much annual variation in climate factors.
- Pradeep Goel indicated that the monitoring program may need to be tweaked if the location in the watershed where land management practices are changing is known. Monitoring only at the watershed outlet is unlikely to detect any changes related to the land management practices. It would be better to add a site upstream, closer to the location of the land management practices.
- Derek Smith noted that it is important to keep data collection methods consistent. Otherwise, data collected before and after a change in land management practices will not be comparable.
- Mari Veliz indicated that it may be difficult to continue to justify the expense of continuing these monitoring programs over the long term when they do not seem to be yielding the desired results (detecting changes from increased uptake of Best Management Practices) in the short term.
- Derek Smith suggested that monitoring resources could be optimized by determining which size of an event is important to capture and which ones do not need to be sampled.
- Trevor Dickinson would look at the hydrographs because land management changes can cause shifts in the flow as well as concentrations and loads. When looking at the flow record, is the flow changing during a particular season? If a concentration versus flow relationship can be developed, it is not necessary to sample every event. Instead, events can be sampled periodically to confirm that the relationship has not changed.
- Alice Dove suggested that a Standard Operating Procedure could be written for how to develop and maintain a concentration versus flow relationship. She is hesitant to recommend composite samples because the valuable information of concentration versus flow would be lost. Her group struggled with determining when their ISCOs had triggered and when they had not, so they went to setting their ISCOs to run on a fixed interval (eight hours). Targets will probably be based on percentage cuts in loads, so it is important to continue to monitor in a way that produces loading estimates.

- Mari Veliz asked if this discussion was pointing towards a regression-based method for estimating loads for her dataset.
- Trevor Dickinson indicated that a regression method could be used and the data could be stratified as needed (*e.g.*, by flow and/or by season).
- Mohamed Mohamed suggested that, if low flows have been oversampled (Gully Creek seems to have a lot of low-flow data), sampling could be reduced for lower flows and targeted more towards higher flows.
- Derek Smith indicated that the relationship between concentration and level could also be examined and decisions about which events or samples need to be collected could be based on level instead of flow.
- Craig Merkley asked how to avoid capturing bedload with an ISCO intake line.
- Derek Smith responded that the intake line is ideally positioned at approximately 60 per cent of the water depth. He usually makes his installations moveable, so they can be adjusted in dry versus wet weather conditions. The intake needs to be at least a foot off of the bottom.
- Jacqui Empson Laporte noted that agriculture is not a blanket land use category. There is a lot of variation in agricultural land cover (*e.g.*, pasture vs. crop, corn vs. wheat) and in agricultural practices. It may be difficult to see changes in water quality when land management in some of these watersheds is not changing. Over the longer term, it will be informative to evaluate changes in land use and water quality in the different watersheds.

10. Closing remarks and discussion

Isobel Heathcote, President, Wyndham Research Inc.

The variety of case studies and the lively discussion associated with them demonstrates that there is no “silver bullet” method for calculating loads. Rather, the choice of method may depend on the particular case, the data available, and the goals of the study. In some cases, it may be important to use a particular method simply because it has been used in the past, and will allow you to compare current results to historical ones.

Many of these presentations did, however, emphasize the critical importance of reliable, long-term discharge data as a foundation for any load estimation initiative. It is important to characterize a system’s response to as wide a range of storm events as possible, and to update those results over time, as climate and watershed conditions change. Several speakers reminded the group of the need to look critically at data before making decisions. Are there gaps? (For example, do you have adequate concentration data for the full range of discharge at your site?) Are there seasonal patterns or other clues in the relationship between flow and concentration that could help you stratify your data set to support more accurate loading estimates?

Assembling strong long-term flow and water quality datasets is important, even if it is not always possible to sample with high frequency. Automated equipment can help with water sampling throughout storm events, but it can be challenging to trigger sample collection at the appropriate time and to determine the appropriate sampling interval (for instance, in the case of extended, multi-day storm events). Several speakers noted that it is not always necessary to have the best sampling technology available. In some cases, low-tech approaches or visual estimation can help to fill data gaps; try to work with what you have.

A final theme in this workshop was the need to share data with the public, other stakeholders, and other agencies. Ensuring that metadata are associated with the data helps to improve the utility of data sets for a variety of users. Participants also spoke about the need to get the information from our work into the hands of those who make decisions about land management. An example of this could be contributing articles to the Ontario Farmer about the importance of winter runoff and what we can do to prevent it. It is not enough to collect and analyze the data. Communicating our findings effectively helps to make them relevant to landowners and decision makers, and increases the potential for positive change in the watershed.

This workshop provided an unusual and important opportunity to share a wide range of approaches and experiences for data collection and load estimation. It was a particularly useful forum for participants from a variety of backgrounds to network and gain advice on specific technical challenges. Many expressed their thanks to the Ausable Bayfield Conservation Authority for organizing the workshop and to the speakers for sharing their experiences with the group.

APPENDIX: WORKSHOP PARTICIPANTS

Name	Affiliation
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Sean Backus	Environment Canada
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