State of the Knowledge and Practice: Assessing the Adequacy of Urban Nutrient Load Measurements

Supporting Document 2: Pre-workshop Questionnaire Results Summary

March 2018

Contents

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Preface

Designing policies and establishing best management practices for controlling nutrient inputs to water bodies from municipal point and nonpoint sources is an important component of watershed management. Estimates of nutrient loadings from runoff contributing areas as well as tributary nutrient loadings to downstream receiving water bodies are typically derived from point measurements of nutrient concentrations combined with measured or modeled discharge rates to calculate loadings. These kinds of measurements are also frequently used to derive export coefficients for different types of land use to yield loading estimates over larger scales.

However, the validity and effectiveness of this approach depends largely on whether the point measurements of nutrient concentrations and flows are sufficiently representative of conditions at the desired spatial and temporal scales to meet study objectives. Evaluating how well nutrient loading estimates meet management decision needs requires clear objectives that will depend on how the results are to be used (e.g. model calibration, computation of annual, seasonal or event loads, etc.). A better understanding is required of how well typical loading calculations reflect actual loadings, and the degree to which variability in factors such as land use, flow, and nutrient water quality compromise decision making based on current practices.

With financial support from Environment and Climate Change Canada (ECCC), Canadian Water Network (CWN) undertook a project to assess how well existing tributary nutrient loading measurements and statistical approaches in urban areas meet the requirements of urban wet weather water management and of watershed managers. The objectives of this work were to help improve the alignment between nutrient loading study objectives and methods, and to clarify under what circumstances current practices may be inadequate to support management decisions.

CWN convened an advisory group of eight leading experts with diverse expertise in municipal wastewater and stormwater management, nutrient transport and loading, water quality and tributary monitoring, environmental impacts and landscape modelling. Led by advisory group Chair Mr. Duncan Boyd, and supported by input from advisory group members, a whitepaper was developed to provide an assessment of the state of the knowledge and practice on measuring urban nutrient loads, including the state of the knowledge on the utility achieved through various nutrient monitoring methods typically used in Canada.

In February 2018, CWN hosted a 1.5-day experts' workshop in Toronto, Ontario with advisory group members and an expanded group of experts from across southwestern Ontario. This expanded group included leading decision makers, researchers and practitioners with strong combined knowledge and credibility in areas of urban water management, nutrient transport and loading, water quality and tributary monitoring, environmental impacts and landscape modelling. The workshop discussions, together with the experts' responses to a pre-workshop questionnaire, were designed to help validate, augment and update the whitepaper knowledge and assess gaps in existing knowledge and inform decisions.

A culminating framework document has been developed based on insights from the draft whitepaper together with workshop discussions. The framework document will help guide future actions and decisions by water managers, including the future development of a decision support system that guides the progression from preliminary to more detailed assessments across multiple scales.

As a supporting document to the framework, the current document provides a summary of workshop participants' responses to the pre-workshop questionnaire.

Introduction

Led by the advisory group chair and supported by the CWN project team, a questionnaire was developed on the usage of urban nutrient loading measurements to inform decisions. The objective of the questionnaire was to inform discussions at the February 2018 experts' workshop in Toronto, and in particular to assist the advisory group in understanding urban planning and watershed management information requirements regarding water quality and loading estimates, as well as establishing gaps in available knowledge that decision makers need and want. Specifically, the questionnaire focused on understanding:

- What types of water quality/quantity information are used to inform watershed management decision-making or assessment
- What geographical and time scale is information collected
- How information about watershed nutrient loads, critical source areas, land use effects, best management practices, low impact development and infrastructure improvements is used to inform watershed management decision-making and assessment

Methodology

An invitation and link to an online questionnaire was sent via email from CWN in January and February 2018 to 28 confirmed workshop attendees, including all advisory group members as well as the expanded group of experts. The questionnaire was completed by a total of 18 respondents, representing an overall response rate of 64%.

Questionnaire respondents were required to complete all demographic questions, however, for the remaining questions, respondents were offered the opportunity to skip questions that were outside their area of expertise or that they preferred not to answer. A copy of the questions is provided in Appendix A.

Some questions were accompanied by response options that prompted respondents to "select all that apply." For these questions, the number of responses exceeds the total number of respondents due to some respondents selecting multiple responses. It should also be noted that not all respondents chose to answer each question. For increased clarity, the total number of respondents for each question is indicated in the detailed results section.

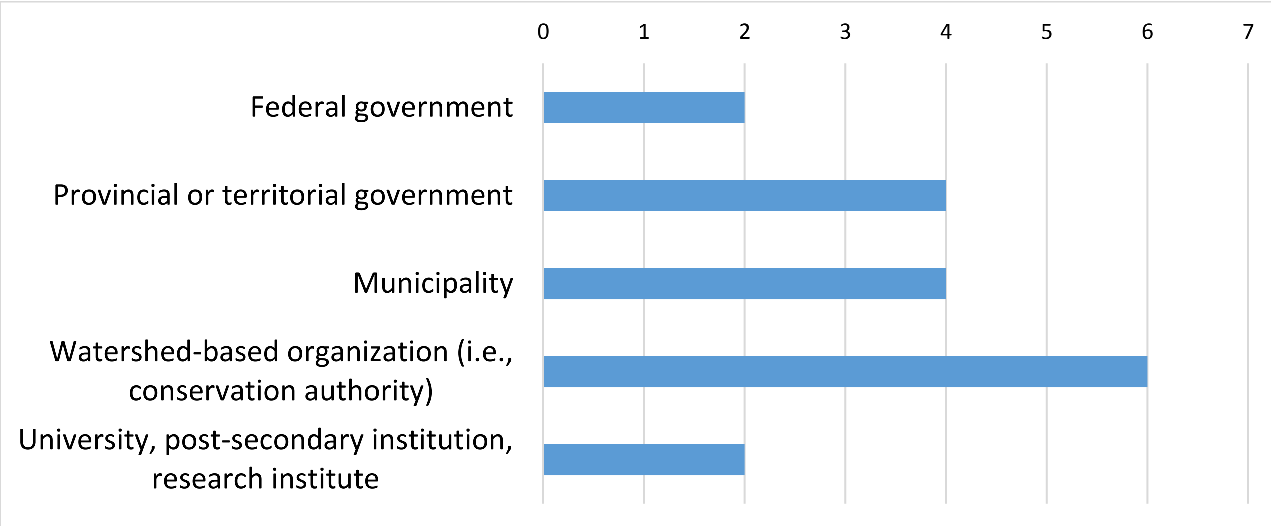
Detailed Results

Demographic questions

As shown in Figures 1-3, responses to the demographic questions revealed a range of perspectives represented among questionnaire respondents. Given the Great Lakes focus of the workshop discussions, all workshop invitees and all questionnaire respondents were located in Ontario.

Q: What is the nature of your organization? Select one.

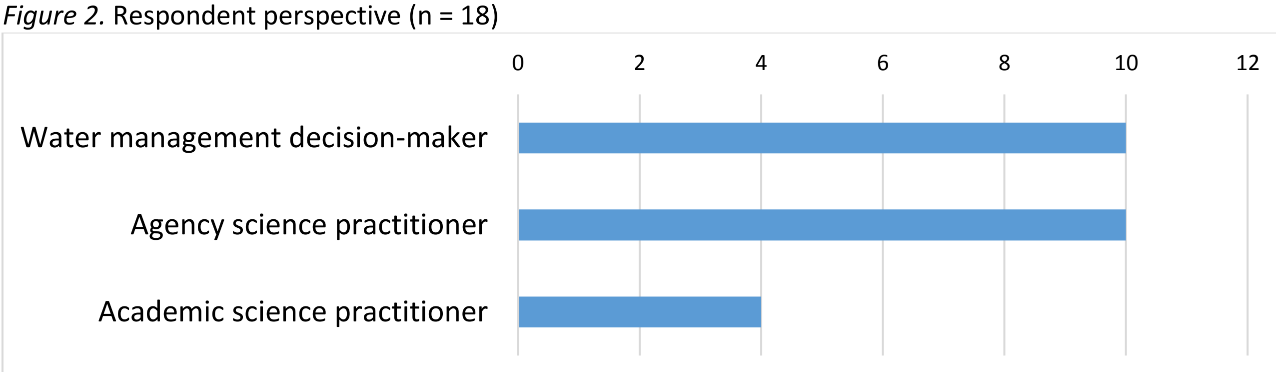
Figure 1. Nature of organization (n = 18)



CWN reached out to a range of organizations with invitations to participate in the workshop and complete the pre-workshop questionnaire. Watershed-based organizations and governments as a whole were well represented. Given the small sample size limited to the number of workshop participants, the mix of organizations noted above it is also a matter of which attendees had an opportunity to complete the questionnaire ahead of the workshop.

Q: What is your perspective within the context of this questionnaire? Select all that apply.

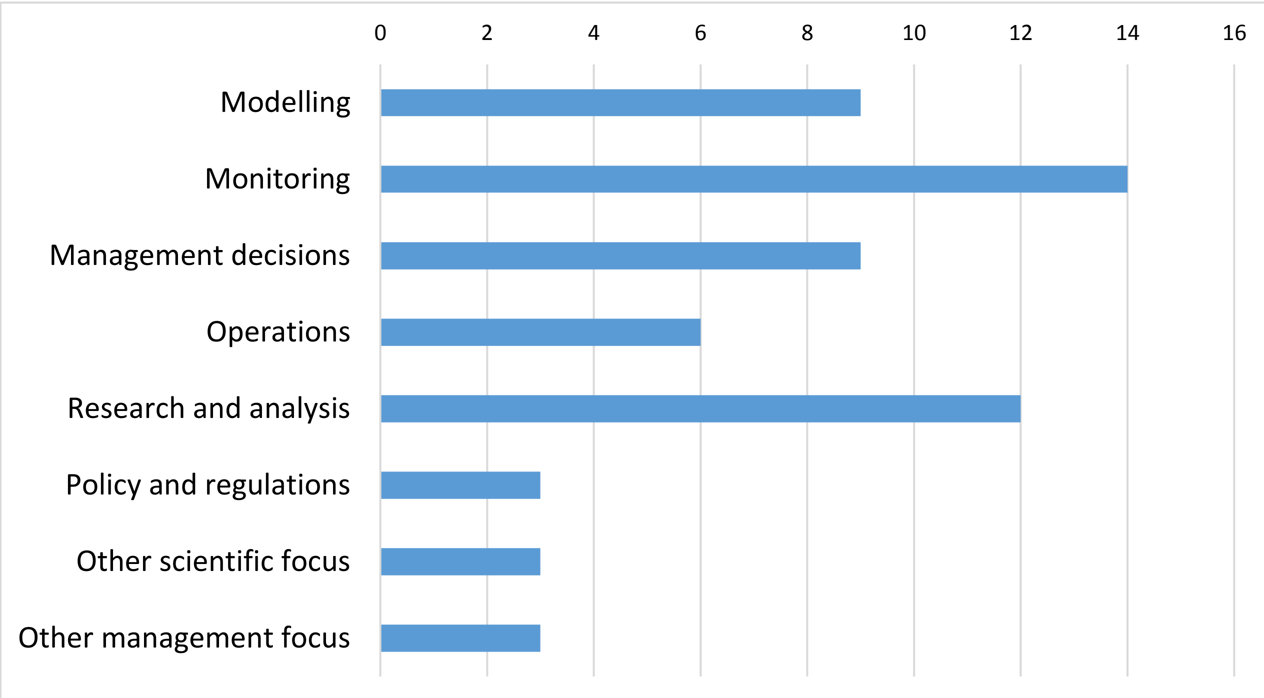
Figure 2. Respondent perspective (n = 18)



One of the goals of the workshop together with the pre-workshop questionnaire was to engage and gather insights from decision-making perspectives. As anticipated, these results suggest that the line between the two perspectives is not clear cut. This was also discussed at the workshop, noting important overlap between decision-making and scientific roles.

Q: What is the focus of your current work? Select all that apply.

Figure 3. Focus of current work (n = 18)



'Other scientific focus' included:

- GIS spatial analysis
- Land/lake interactions
- Working with science to inform policy

'Other management focus' included:

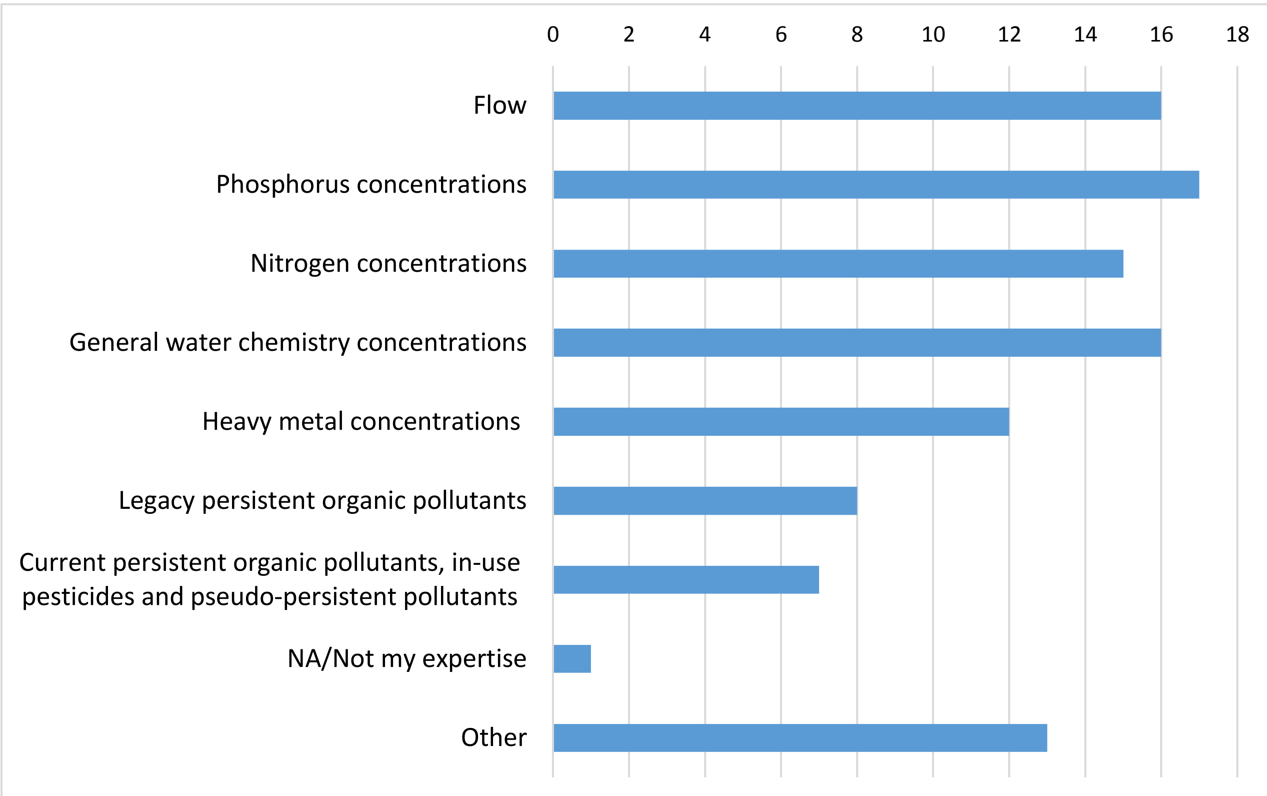
- Total phosphorus loadings
- Watershed planning
- Integrated water management

Consistent with above question on perspectives, some respondents reported a mix of decision-making and scientific roles, with the focus of their work touching on various aspects of water and nutrient management. Several respondents differentiated their roles in watershed planning and integrated water management from the broader category of management decisions.

Section 1: Water quality and loading information

Q: Which of the following types of urban water quality/quantity information does your organization use to inform watershed management decision-making or assessment? Select all that apply.

Figure 4. Types of urban water quality/quantity information used to inform decision-making or assessment (n = 18)



'Other' information included:

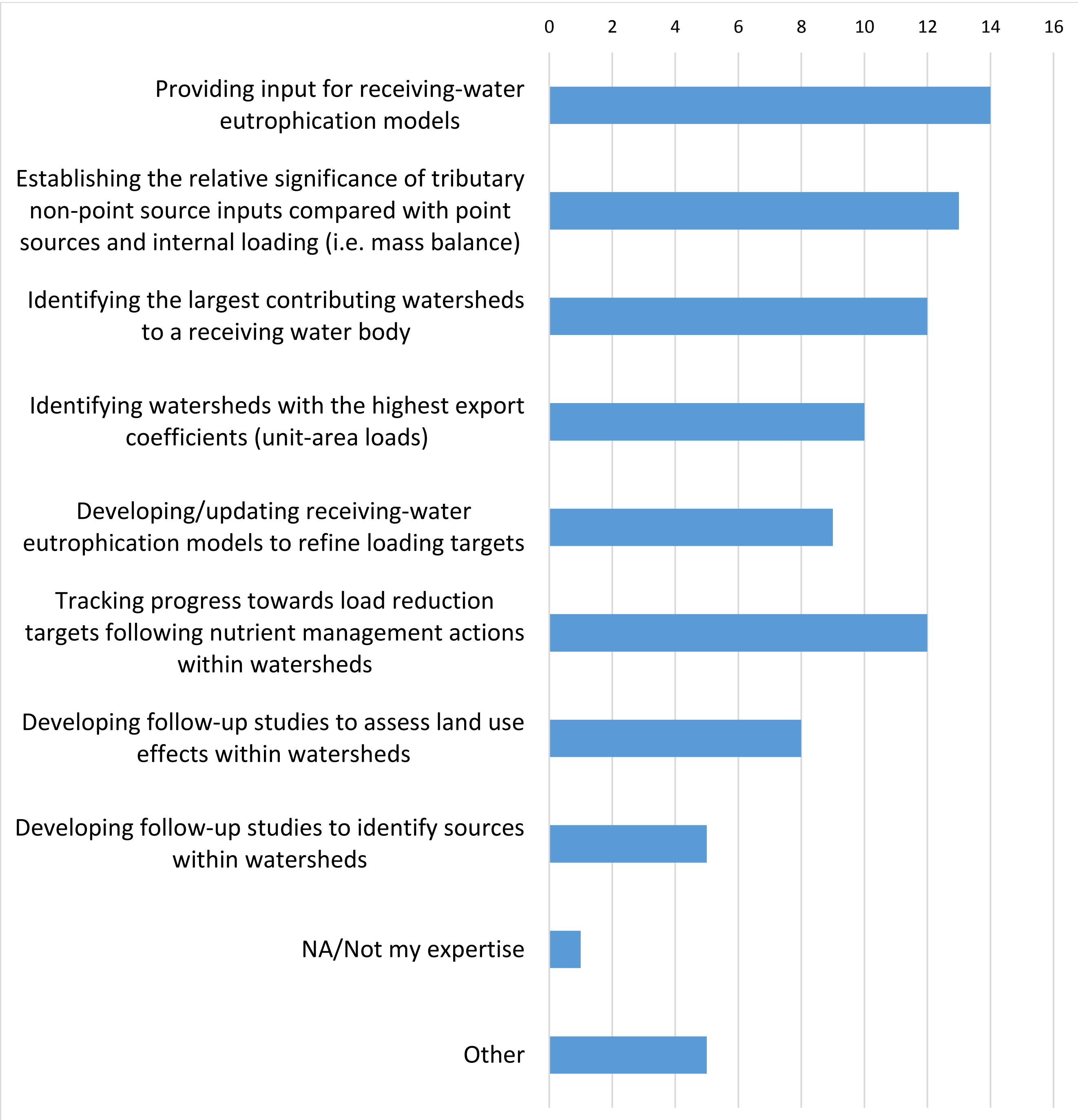
- Benthic macroinvertebrate communities
- Stable isotopes of O and H
- Microplastics
- GIS spatial information
- Snowpack (snow water equivalent, depth)

Results suggest standard chemical water quality and quantity parameters are currently being monitored by most respondents. Responses also point to the importance of biological data, mapping/spatial information and emerging pollutants such as microplastics.

Section 2: Nutrient mass loadings from watersheds

Q: In what ways does your organization use watershed nutrient load information to inform watershed management decision-making and assessment? Select all that apply.

Figure 5. Ways watershed nutrient load information is used to inform decision-making and assessment (n = 18)



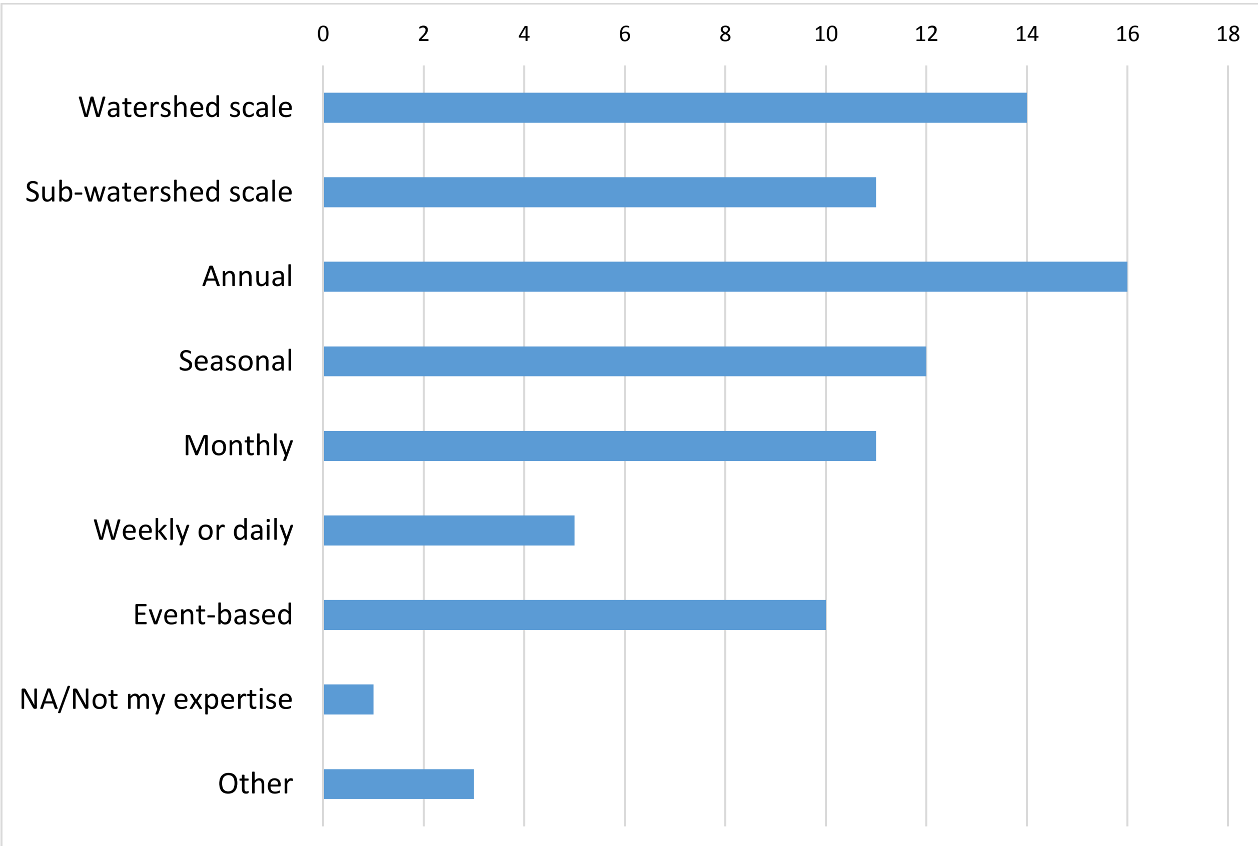
‘Other’ uses included:

- Determining impacts of sewage treatment plants
- Linking with other agencies to develop studies within watersheds
- Use of real-time water quality monitoring technologies
- Developing restoration strategies for load reduction

Watershed managers and practitioners responding to this questionnaire are using nutrient loading data in expected ways to identify the largest contributing watersheds and/or the most significant tributary source inputs, to measure progress on load reductions and to feed information back into models.

Q: At what geographical and time scales does your organization apply nutrient load information to inform watershed management decision-making and assessment? Select all that apply.

Figure 6. Geographical and time scales applied to nutrient load information to inform decision-making and assessment (n = 18)



'Other' scales included:

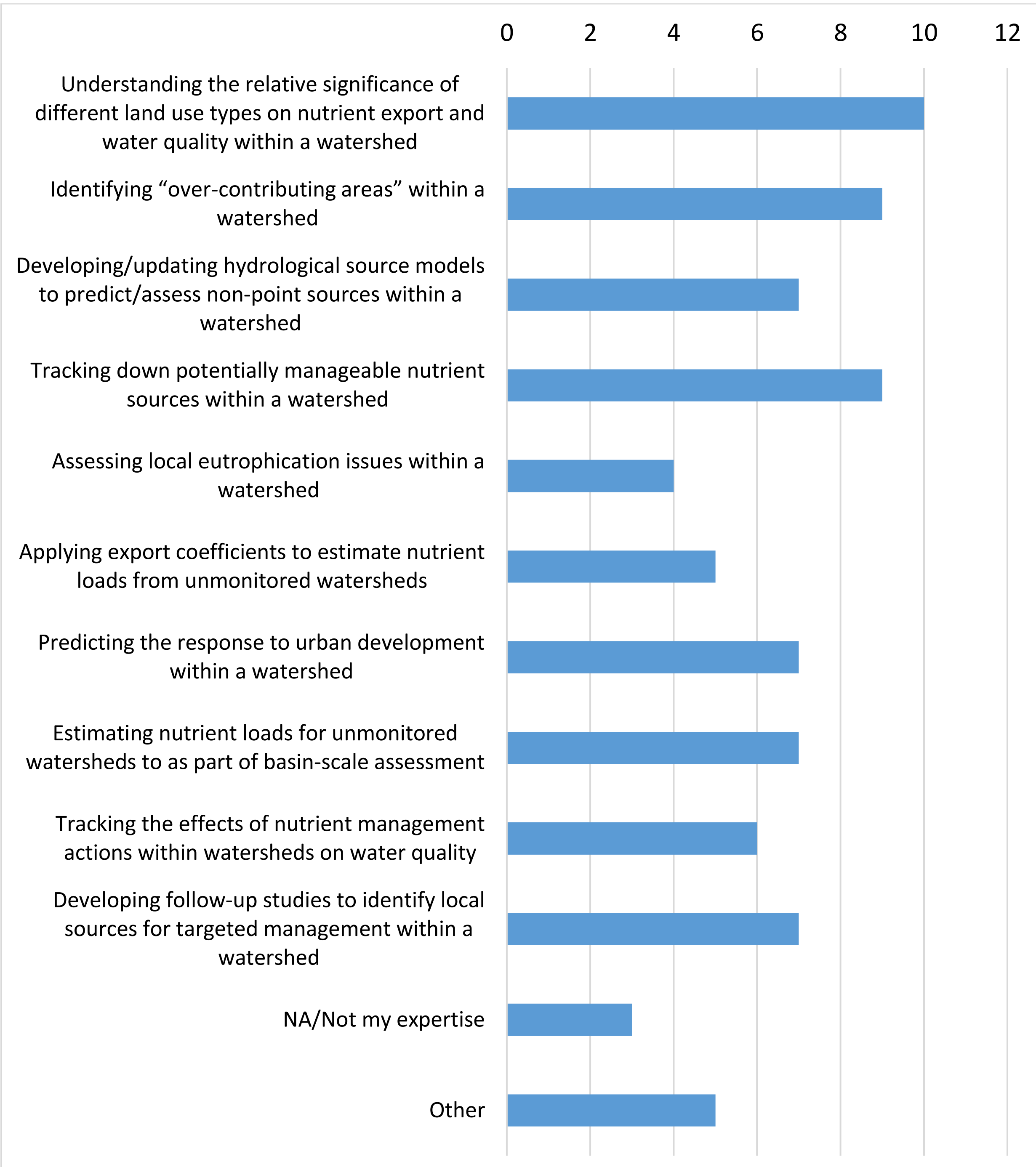
- Lake-wide and basin wide scales
- Annual analysis using combination of mid-point method (bi-weekly) and event-based sampling
- Links with models and modellers working at sub-watershed scales

Despite the small sample size, the results suggest a trend toward applying nutrient load information at larger geographic and time scales to inform decision making and assessment.

Section 3: Critical source areas and land use effects

Q: In what ways does your organization use critical source area (CSA) and/or land use effect information to inform watershed management decision-making and assessment? Select all that apply.

Figure 7. Uses of CSA and/or land use effect information to inform decision-making and assessment (n = 17)



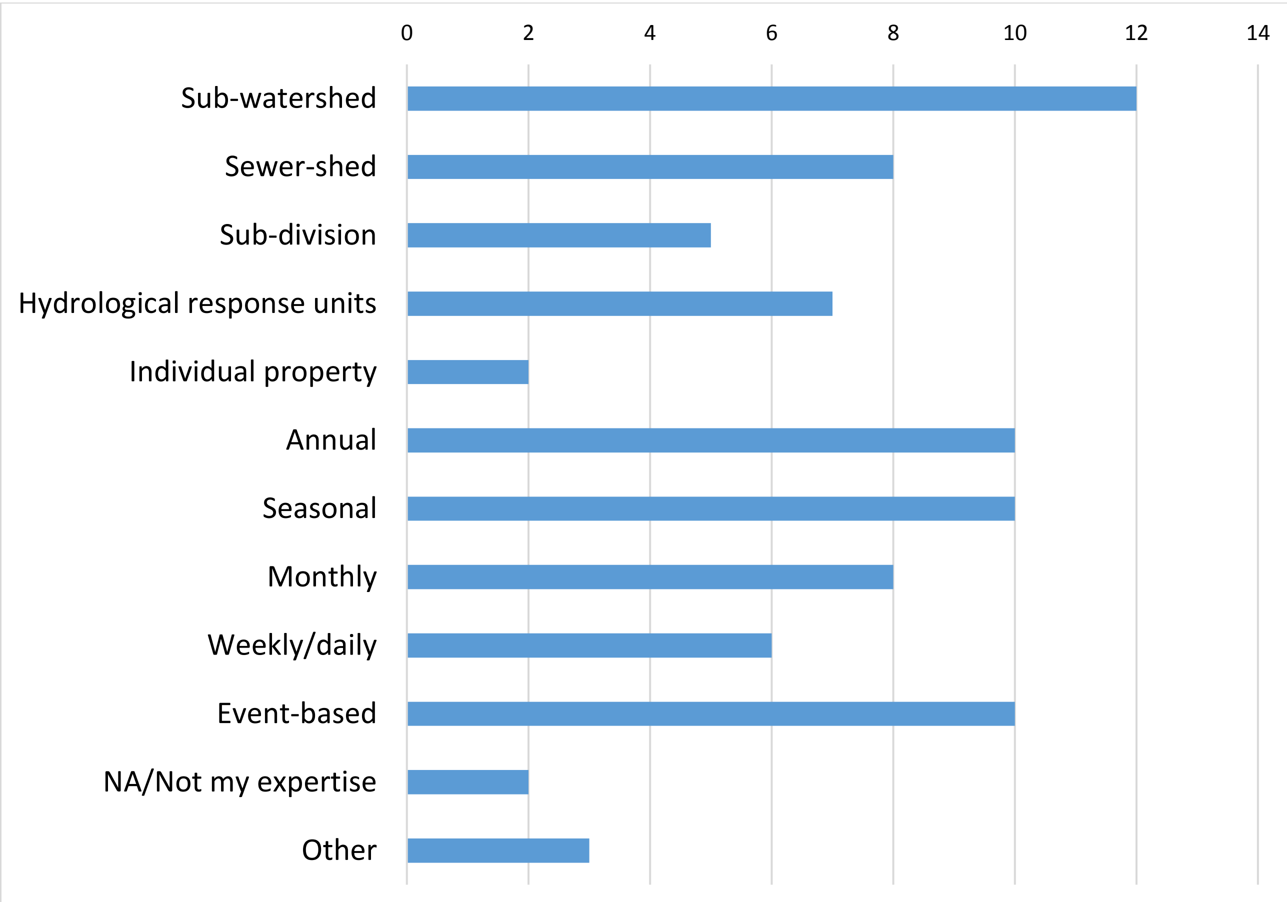
‘Other’ uses included:

- Understanding relative contribution of urban and rural runoff of total phosphorus (TP) compared to wastewater treatment plant discharges
- Estimating nutrient load from unmonitored watersheds using nutrient load from monitored watersheds with similar land use and prorating the result based on area, essentially export coefficient approach using calculated nutrient load
- Assigning hot zones focused on compounds like PCBs and cross-connection sanitary wastes *(E. coli*) rather than total phosphorus
- Linking with other agencies/studies to understand nutrient dynamics throughout watershed

The results suggest that CSA and land use data are used in a number of different ways by different organizations. Although the mix of perspectives as well as the overall small sample size may be factors, workshop discussions focused on this scale pointed out the need to further define how and why critical source (priority) areas are identified, with more attention paid to the benefits of monitoring land use impacts in particular.

Q: Which of the following geographical and time scales related to CSA and land use effects does your organization apply to watershed management decision-making and assessment? Select all that apply.

Figure 8. Geographical and time scales related to CSA and land use effects applied to decision-making and assessment (n = 17)



'Other' scales included:

- Sewershed related to specific compounds
- Annual loading and by export per unit area from each sub-watershed
- Combination of scales informing assessments (projects informed by hydrological response units, seasonal, monthly and event-based info (assessment only, not for decision-making)

Q: If applicable, please provide examples of management and/or planning decisions taken by your organization based on predicted outcomes of CSAs and/or land use effects (e.g. development policies, stormwater management initiatives, etc.).

Given the open-ended nature of the question, examples (n = 8) were shared at varied levels and varied degrees of detail.

Province-wide examples

- Ontario objectives set for urban runoff on watershed basis, rather than technology basis.
- Ontario's Phosphorus Reduction Strategy recommended no-net phosphorus increase from new development. Tool developed to predict pre- and post-development phosphorus load using export coefficient approach.

Specific watershed examples

- Grand River watershed: Nitrate management plants, salt shifting/reduction programs, wastewater monitoring program.
- Toronto and Region watershed: Used in environmental assessments, infrastructure planning, urban development reviews, LID design and implementation, source water protection, etc.
- Hamilton watershed: Water quality data collected biweekly, year-round for main tributaries. Estimate annual loadings based on available Water Survey of Canada flow data. Identify relative contributions of main watercourses; and support watercourse nutrient concentration targets for delisting.

General examples

- Priority sub-watersheds identified help focus BMP implementation and extension.
- From urban perspective, implementation and performance monitoring of LID features (lot, subdivision, and/or sub-watershed level).
- From rural perspective, identifying and prioritizing nutrient source hot spots, proposing site specific restoration/retrofit measures, assessing changes through monitoring and/or modeling.
- Developing/piloting sub-watershed-based environmental compliance approval (ECA) for municipal stormwater. Stormwater infrastructure for the sub-watershed is treated as a system to be managed in relation to achieving specified receiver targets (e.g. quality, quantity, etc.). Receiver monitoring helps inform ECA owner (municipality) where hotspot areas are for further investigation and possible management action (e.g. retrofits, new works).

Section 4: Best management practices, low impact development, infrastructure improvements

Q: What kind of evaluation of best management practices (BMPs), low impact development (LID), and/or infrastructure improvements does your organization undertake?

The following is a brief summary of the open-ended responses (n = 12) regarding how BMPs, LID and/or infrastructure improvements are currently being evaluated and assessed.

Studies

- Literature-based assessments of techniques.
- Case-by-case studies of the efficacy of projects and project designs, site specific from erosion control to nutrient management.
- Partnerships with academia to undertake research-oriented projects aimed at understanding specific BMPs (limited capacity to undertake event-based sampling).
- Mass balance studies of specific municipal water/energy optimization plans (EOPs).

Guidelines, bylaws and planning

- Design and engineering review guidelines for water, wastewater, and stormwater (part of regulation permitting or commenting agency review for local developments).
- MOECC is updating stormwater design manual; also released draft LID manual. Watershed planning guidance under development by MOECC in conjunction with MNRF.
- Municipal sewer-use bylaws.
- Improvements in source protection and planning.

Monitoring

- Review of monitoring programs of installed water quality features, typically stormwater management ponds.
- Trend analysis of environmental monitoring data over multiple years to determine improvements/deficiencies in stormwater systems.
- Require ECA holder to undertake monitoring of certain works to demonstrate compliance.
- Monitoring of specific space confined adaptations of LIDs incorporated into innovative settings.
- All water quality monitoring related to Provincial (Stream) Water Quality Monitoring Network (PWQMN), lack of funds to do more.

Modelling

- Scenario analysis – evaluating effectiveness of various alternative measures/combinations.

Implementation

- BMP pilot projects and infrastructure retrofits.

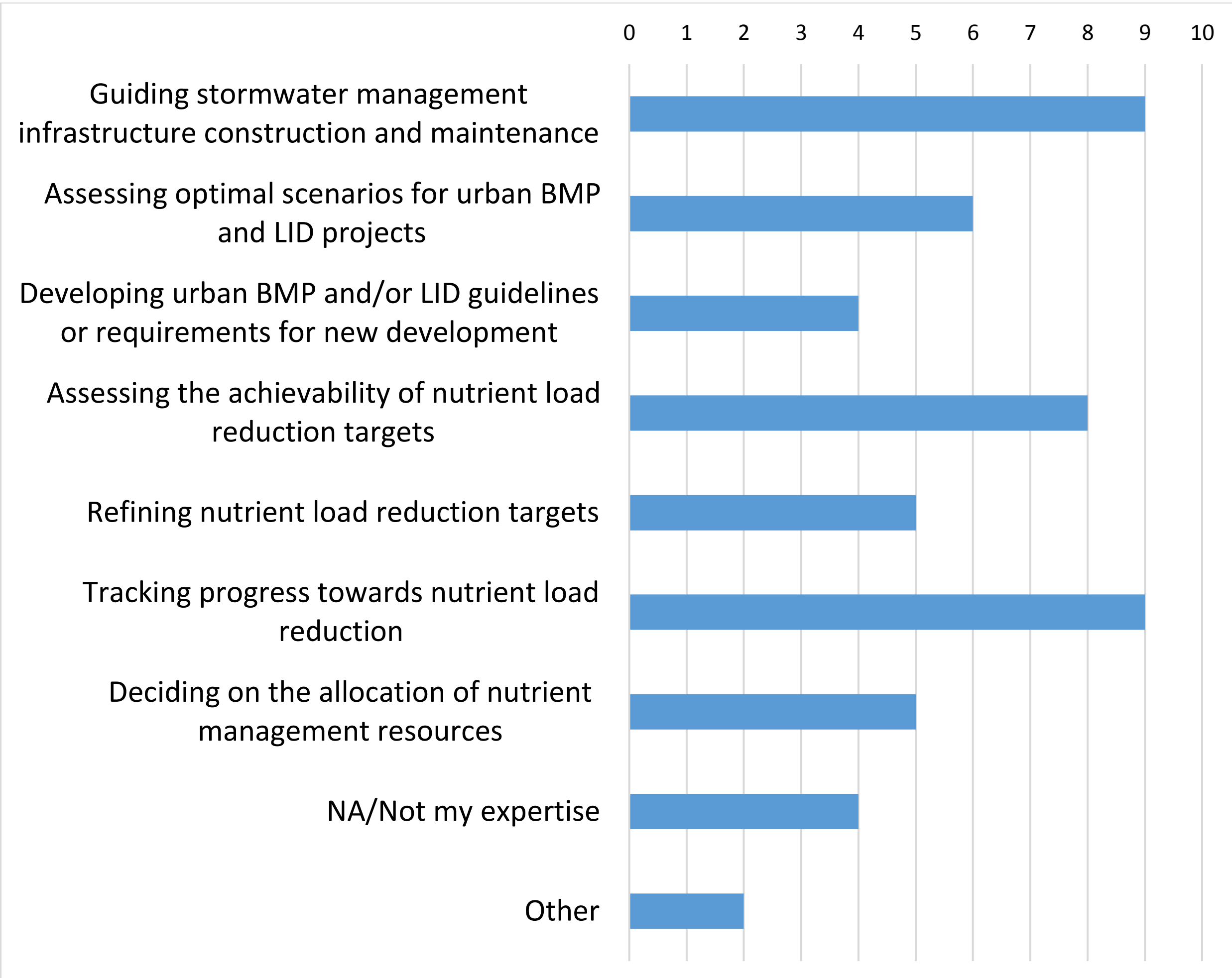
- New pilot projects approaches developed to incorporate combination of receiver targets coupled with receiver monitoring to assist decisions about where/when infrastructure improvements are needed for the most impact.
    - Parameters deviate from TSS % removal efficiencies to include total phosphorus, temperature, benthic macroinvertebrates, stream erosion and flow (specific to sub-watershed of interest).
- Specific evaluation of effectiveness of stormwater ponds, results showed how ponds fill up and become less and less effective without proper maintenance.

Offsetting

- Water quality trading or phosphorus offsetting. Approach uses BMPs to offset phosphorus loads from new development, and identification of stormwater works that need improvement.

Q: *In what ways does your organization use BMP, LID and/or infrastructure improvement information to inform watershed management decision-making and assessment? Select all that apply.*

Figure 9. Uses of BMP, LID and/or infrastructure improvement information to inform decision-making and assessment (n = 16)



'Other' uses included:

- Determining how to retrofit a mature urban city with LID.
- Conducting a technical review of BMPs/LID based on research and case studies.

Q: If applicable, please provide examples of management and/or planning decisions taken by your organization based on predicted outcomes of BMPs, LID and/or infrastructure improvements (e.g. bylaws, development requirements, etc.)

The following is a brief summary of the open-ended responses (n = 7) with respect to the implementation of BMPs, LID and infrastructure improvements in local urban areas.

Province-wide

- Treatment: Requirements determined for sewage treatment plants are based on permissible loadings which are in turn based on existing watershed or local stream loadings.

Specific watershed examples

- Halton watershed: Supporting integrated watershed management. In the future, this information will help make better decisions at watershed level.
- Toronto and Region, Credit Valley, and Lake Simcoe Region: Sustainable Technology Evaluation Program (STEP).
- Credit Valley: Watershed/sub-watershed/site level modelling of LID performance. Developed guidance documents on LID design, construction, maintenance and performance monitoring.

General examples

- Planning and source protection: Official plans have policy to protect water, source protection policies on salt use for parking.
- Wet Weather Flow Guidelines (used for lot development applications from private sector. Being applied to redevelopment of specific streets (green streets and complete streets.

Additional comments

Finally, respondents were given an opportunity to provide any further comments (n = 6), which are summarized below.

- Interested in shared methodologies including field, lab and computational methods, especially tailoring methodologies for urban environments.
- Suggest monitoring needs to be more robust to inform watershed management decisions, promoting collaborative integrated watershed management.
- Critical to understand direct urban contributions to nearshore from sewershed outlets.
- Need to focus on whether further reductions of total phosphorous will cause too much oligotrophication of offshore waters
- Curious at what temporal and spatial scales are we most interested in predicting or assessing the effectiveness of BMPs and infrastructure improvements in improving water quality and eutrophication levels?

Appendix A: Questionnaire

Using urban nutrient load measurements to inform decision-making

Canadian Water Network (CWN) is leading a project to help determine how well existing urban nutrient load measurements and statistical approaches meet the requirements of urban planning and watershed managers. In other words, how well do current methods: a) fit the reality of urban nutrient load management decisions, and b) reflect actual loadings? The project will facilitate conversations between decision makers and science practitioners to evaluate the effectiveness of measurements and improve the application of science to management decisions.

An advisory group has been established to assess the current state of knowledge and practice of measuring water quality and nonpoint source nutrient loads. The advisory group's work will be augmented by other experts' with knowledge and experience in water monitoring and modelling, urban planning, and watershed management.

Questionnaire objectives

You have been invited to complete this questionnaire based on your perspective, knowledge and expertise as a water management decision maker, agency or academic science practitioner, or another relevant perspective.

- *Water management decision makers* are those tasked with making decisions regarding the development and implementation of policies and/or regulatory instruments, as well as those responsible for determining the allocation of resources for flow management and pollution abatement infrastructure.

- *Agency science practitioners* are those with the responsibility and authority to undertake applied research and/or design monitoring programs and the technical capacity to undertake sample collection, as well as those who use the resulting data for source modelling and/or calculation of nutrient loads.

- *Academic science practitioner* in this context are a subset of *science practitioners* who undertake investigative research that may involve the development and testing of innovative sampling or data interpretation methodologies in such areas as hydrological modeling, eutrophication modeling, or data mining. This research will frequently be undertaken in partnership with, or on behalf of, government agencies.

Your responses to this questionnaire will assist the project advisory group in understanding urban planning and watershed management information requirements regarding water quality and loading estimates, as well as establishing gaps in available knowledge that decision makers need and want.

Instructions

- Questionnaire participants who self-identify as *water management decision makers* are asked to consider the questions within the context of their organization's decision-making context.
- Questionnaire participants who self-identify as *agency* or *academic science practitioners* are asked to consider the questions within the context of their own research program(s) and/or partnerships.
- The survey is expected to take approximately 10-15 minutes to complete.
- Please ensure you have enough time to complete the survey before you begin. You will not be able to save your responses and come back later. We ask that you do not complete the survey more than once.
- All responses will be confidential. You will not be identified, and the responses will be aggregated.

This project was undertaken with the financial support of the Government of Canada through the federal Department of Environment and Climate Change.

Demographic questions

What is the nature of your organization? Please select one.

- Watershed-based organization (i.e. conservation authority)
- Municipality
- Provincial or territorial government
- Federal government
- University, other post-secondary institution, or research institute
- Consultancy
- Water utility
- Other (please specify): *[open ended]*

What is your perspective within the context of this questionnaire? Select all that apply.

- Water management decision-maker
- Agency science practitioner
- Academic science practitioner
- Other (please specify): *[open ended]*

What is the focus of your current work? Select all that apply.

- Modelling
- Monitoring
- Management decisions
- Operations
- Research and analysis
- Policy and regulations
- Other scientific focus (please specify): *[open ended]*
- Other management focus (please specify): *[open ended]*

In what province or territory are you physically located? Please select one.

- British Columbia
- Alberta
- Saskatchewan
- Manitoba
- Ontario
- Québec
- New Brunswick
- Nova Scotia
- Prince Edward Island
- Newfoundland and Labrador
- Yukon
- Northwest Territories
- Nunavut
- Other (please specify): *[open ended]*

If you wish, please specify your watershed, community or geographic perspective in the context of this survey (e.g., name of community, region, watershed). This will allow us to interpret your responses within a more specific context. *[open-ended response]*

Section 1: Water quality and loading information

Which of the following types of urban water quality/quantity information does your organization use to inform watershed management decision-making or assessment? Select all that apply.

- Flow
- Phosphorus concentrations
- Nitrogen concentrations
- General water chemistry concentrations (e.g. suspended solids, turbidity, pH, chloride and major ions, dissolved oxygen, temperature)
- Heavy metal concentrations (e.g. copper, cadmium, chromium, iron, mercury, nickel, lead, zinc)
- Legacy persistent organic pollutants (e.g. PCB, organochlorine pesticides)
- Current persistent organic pollutants, in-use pesticides and pseudo-persistent pollutants (e.g. PAHs, organophosphate/triazine herbicides, neonicotinoids, pharmaceuticals and personal care products)
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

Section 2: Nutrient mass loadings from watersheds

In what ways does your organization use watershed nutrient load information to inform watershed management decision-making and assessment? Select all that apply.

- Providing input for receiving-water eutrophication models
- Establishing the relative significance of tributary non-point source inputs compared with point sources and internal loading (i.e. mass balance)
- Identifying the largest contributing watersheds to a receiving water body
- Identifying watersheds with the highest export coefficients (unit-area loads)
- Developing/updating receiving-water eutrophication models to refine loading targets
- Tracking progress towards load reduction targets following nutrient management actions within watersheds
- Developing follow-up studies to assess land use effects within watersheds
- Developing follow-up studies to identify sources within watersheds
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

At what geographical and time scales does your organization apply nutrient load information to inform watershed management decision-making and assessment? Select all that apply.

- Watershed scale
- Sub-watershed scale
- Annual
- Seasonal
- Monthly
- Weekly or daily
- Event-based
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

Section 3: Critical source areas and land use effects

In what ways does your organization use critical source area (CSA) and/or land use effect information to inform watershed management decision-making and assessment? Select all that apply.

- Understanding the relative significance of different land use types on nutrient export and water quality within a watershed
- Identifying "over-contributing areas" within a watershed
- Developing/updating hydrological source models to predict/assess non-point sources within a watershed
- Tracking down potentially manageable nutrient sources within a watershed

- Assessing local eutrophication issues within a watershed
- Applying export coefficients to estimate nutrient loads from unmonitored watersheds
- Predicting the response to urban development within a watershed
- Estimating nutrient loads for unmonitored watersheds to as part of basin-scale assessment
- Tracking the effects of nutrient management actions within watersheds on water quality
- Developing follow-up studies to identify local sources for targeted management within a watershed
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

Which of the following geographical and time scales related to CSA and land use effects does your organization apply to watershed management decision-making and assessment? Select all that apply:

- Sub-watershed
- Sewer-shed
- Sub-division
- Hydrological response units
- Individual property
- Annual
- Seasonal
- Monthly
- Weekly/daily
- Event-based
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

If applicable, please provide examples of management and/or planning decisions taken by your organization based on predicted outcomes of CSAs and/or land use effects (e.g. development policies, stormwater management initiatives, etc.). *[open-ended response]*

Section 4: Best management practices, low impact development and/or infrastructure improvements

What kind of evaluation of best management practices (BMPs), low impact development (LID), and/or infrastructure improvements does your organization undertake? *[open-ended response]*

In what ways does your organization use BMP, LID and/or infrastructure improvement information to inform watershed management decision-making and assessment? Select all that apply.

- Guiding stormwater management infrastructure construction and maintenance
- Assessing optimal scenarios for urban BMP and LID projects
- Developing urban BMP and/or LID guidelines or requirements for new development

- Assessing the achievability of nutrient load reduction targets
- Refining nutrient load reduction targets
- Tracking progress towards nutrient load reduction
- Deciding on the allocation of nutrient management resources (e.g. between NPS management projects and wastewater treatment plant upgrades)
- Not applicable/not my area of expertise
- Other (please specify): *[space to insert]*
- Other (please specify): *[space to insert]*

If applicable, please provide examples of management and/or planning decisions taken by your organization based on predicted outcomes of BMPs, LID and/or infrastructure improvements (e.g. bylaws, development requirements, etc.) *[open-ended response]*

Additional comments

Are there any additional comments you would like to add? *[open-ended response]*

Thank you for completing this questionnaire. Learn more about Canadian Water Network.