

# NATIONAL RESEARCH AGENDA FOR MUNICIPAL WASTEWATER AND BIOSOLIDS

## OUTCOME REPORT

Prepared by the Canadian Water Network  
Canadian Municipal Water Consortium

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## EXECUTIVE SUMMARY

This report documents the evolution to date of the “*National Research Agenda for Municipal Wastewater and Biosolids (the Agenda)*”, which was developed jointly by the Canadian Water Network (CWN), Environment Canada, and the Canadian Water and Wastewater Association in 2012. The desired outcome of the Agenda was to:

**generate and prioritize, through research and consultation, a large and comprehensive list of research topics that addressed the needs of Canadian communities in the relevant areas of wastewater and biosolids.**

As part of the ongoing consultation process, an advisory workshop was convened on March 29<sup>th</sup>, 2012 to determine scientific research priorities for CWN’s Canadian Municipal Water Consortium (CMWC), a national research consortium addressing municipal water management needs. The aim of the workshop was to generate, using the Agenda as background, a more refined and targeted list of potential research project areas that could be initiated over the next year by the CMWC which would generate significant partner interest, value and co-investment, and launch key activities within the larger end-user community on a national basis. The workshop generated six important research project areas that participants felt had strong potential to both address clear needs and garner interest from prospective partners who could help collectively to ensure strong design and support for meaningful research and application of results.

The purpose of this report is to provide an overview of the research and development activities that have been undertaken by CWN since the March 29<sup>th</sup>, 2012 Workshop. Research activities were prioritized that would both advance the objectives set out in the Agenda, as well as accelerate the accomplishment of CWN’s CMWC goal of developing research programs that identify the shared water-related research needs of Canadian municipalities for application of best science, technology and management options to address their complicated challenges and prioritize investment. The culmination of this work has resulted in the development of two Calls for Research Proposals and two Calls for Expressions of Interest (EOIs) by the CMWC related to the management of municipal biosolids and nutrients in wastewater.

In developing the Calls, special attention was placed on determining the state of the knowledge with respect to current research related to biosolids and wastewater management in Canada, as well as assessing how well the proposed research project areas correlated to existing programs and focus areas of CWN. Assessment efforts during the call development period focused on:

- (1) conducting a literature review of the research project areas generated at the March 29<sup>th</sup> workshop with the objectives of identifying areas with a high level of interest and assessing the current capacity for research in each area;

- (2) conducting a scientific research gap analysis with respect to wastewater and biosolids management in Canada;
- (3) consulting with Canadian experts in the field of biosolids and wastewater management to gain insight into the challenges and needs of water managers and operators in Canada from individuals with practical experience and 'first-hand knowledge' of the wastewater sector.

As a result of the analysis, an initial program phase is being launched through the CMWC that includes 2 Research and Knowledge Integration studies and two Research Projects that address key issues and research needs related to biosolids and wastewater management in Canada. The scope and objectives of these research Calls complement the existing CMWC program and the original goals set out by the Agenda by developing research with the capacity for addressing the priority water-related research needs of the collective public- and private-sector community in Canada identified through research and user consultation. The key outcome from the research will be knowledge important to decision makers and practitioners involved in the management of biosolids and wastewater in Canada. Figure 1 provides a summary of the relationship of the resultant Calls within the initial CWMC project phase to the March 29<sup>th</sup> Workshop outputs for reference. A detailed overview of the Calls for Research Proposals and Calls for EOIs is provided below.

Figure 1: Outcome of the Six Research Project Areas generated at the March 29<sup>th</sup> Workshop

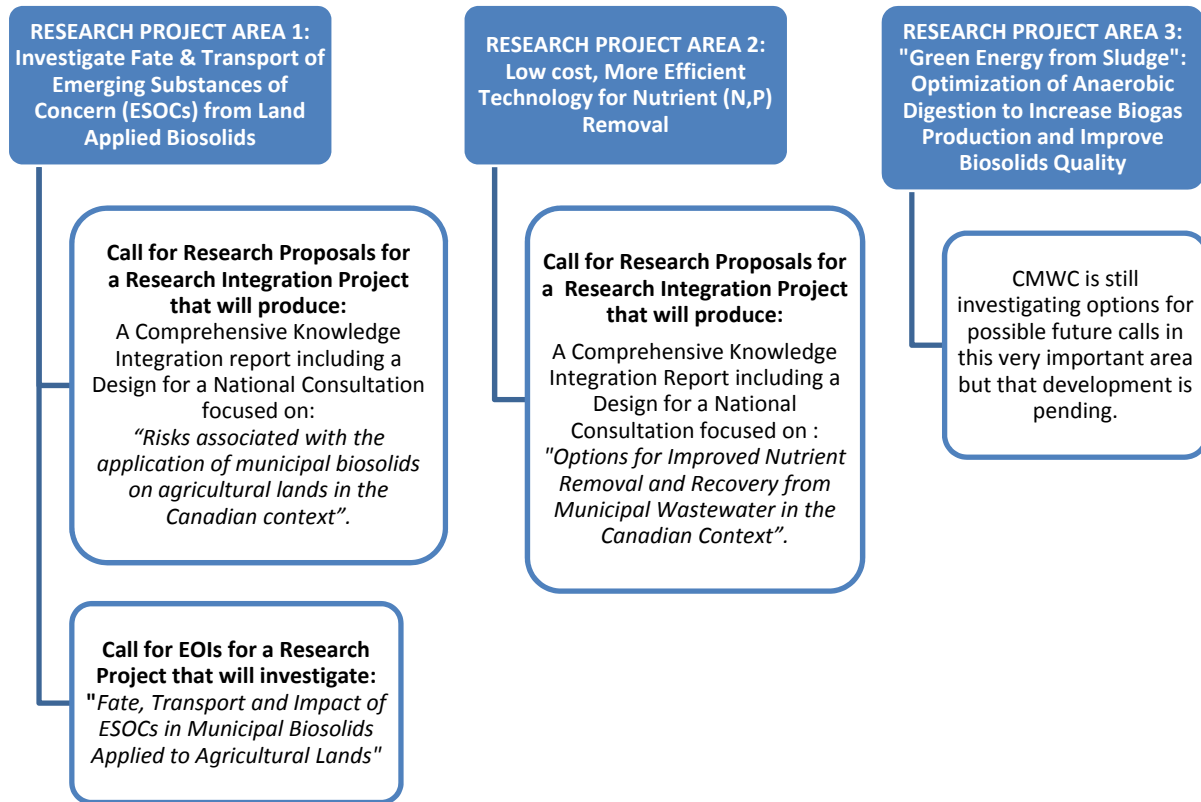
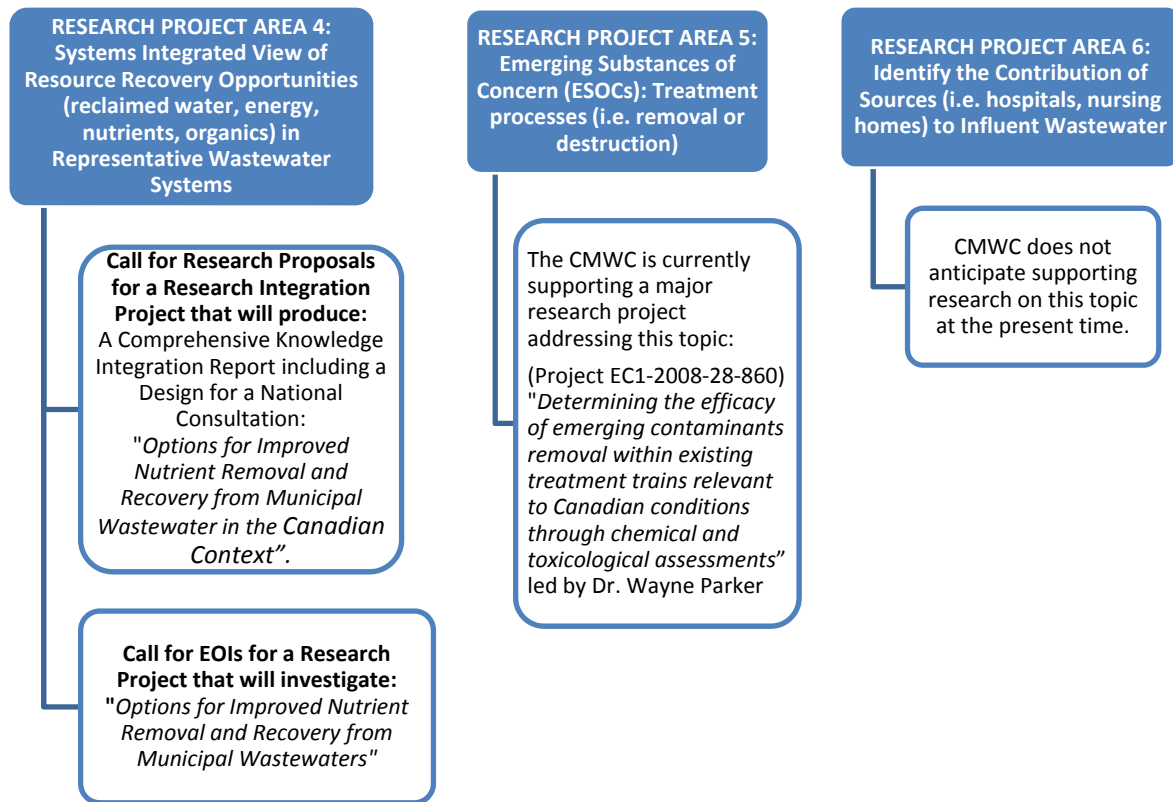


Figure 1: continued



The expected outputs of the Calls for Proposals will be a report and a recommendation of key components for a design for a national consultation workshop that will address current knowledge on the respective topics and will interpret and communicate information about these topics in the context of Canadian conditions and decision needs. The key output for the EOs will be knowledge important to decision makers and practitioners involved in the one of the two focus areas. The EOs that will arise from these Calls are expected to demonstrate an end user-recognized relevance either nationally or within significant regions in Canada, as well as exhibit a strong potential for advancing Canada's capacity to develop better and more efficient policy and/or practice in managing municipal wastewater and biosolids.

Detailed descriptions of these proposed projects, as well as context and background for the CMWC's selection of the focus areas and associated key research topics for both the Calls for Proposals and EOs are discussed in this report.

## 1.0 INTRODUCTION

In Canada, over 150 billion litres of untreated and undertreated wastewater effluent are discharged into our waterways every year from wastewater treatment systems. This effluent represents one of the largest sources of pollution in Canadian waters. These wastewater treatment systems also serve a significant proportion of the Canadian population, with levels of treatment ranging from no treatment to very sophisticated and thorough treatments (Environment Canada, 2011). Insufficient wastewater treatment in Canada has proven to have deleterious impacts on human health and the country's ecosystems, compromising not only the health of fish and wildlife populations but also the quality of our drinking water.

Canadian wastewater treatment plants also produce more than 660,000 dry tonnes of biosolids per year (Dinwoodie, et al., 2011). Although the merits of applying municipal biosolids to agricultural land are well established (i.e. composting, natural fertilizer for agriculture, forestry, and mines reclamation), for many countries and provinces in Canada disposal options still include incineration and burial in landfills. Much of this is due to the fact that biosolids also contain some chemical and biological substances of concern presenting a formidable challenge to those individuals who manage municipal biosolids. The growing concern over the quality of water for consumption, the quality of receiving waters, and the risks posed by biosolids to the environment and human health has prompted the Canadian Government to focus its efforts on developing an effective and harmonized approach for managing the wastewater sector in Canada.

In keeping with this objective, the Canadian Council of Ministers of the Environment (CCME) endorsed the development of the "Canada-wide Strategy for the Management of Municipal Wastewater Effluent" in 2009. As part of its development, the CCME identified the need for better coordination of priority settings, execution and dissemination of scientific research on biosolids and wastewater management in Canada. As a result, the National Research Agenda for Municipal Wastewater and Biosolids (the Agenda) was developed jointly by the Canadian Water Network (CWN), Environment Canada, and the Canadian Water and Wastewater Association (<http://www.cwn-rce.ca/assets/resources/pdf/national-research-agenda-municipal-ww-biosolids-final-report.pdf>). The desired outcome of the Agenda was to generate, through research and consultation, a large and comprehensive list of priority ranked research topics that addressed the needs of Canadian communities in the relevant areas of wastewater and biosolids.

Through further research, workshops and consultation with experts in the field of wastewater and biosolids management in Canada, CWN's Canadian Municipal Water Consortium (CMWC) identified key focus areas with a strong potential for addressing both the current and future needs of the scientific research and end user communities with respect to the management of wastewater and biosolids. These focus areas have been developed into potential topics for research that will be supported by CWN through the CMWC. Context and rationale for the CMWC's selection of the focus areas and possible topics for research are presented in this report, as well as specific details and background information on the focus areas.

## 2.0 ESTABLISHING CALLS FOR RESEARCH PROPOSALS AND EXPRESSIONS OF INTEREST

An advisory workshop sponsored by CWN and CCME entitled, “Identifying and Prioritizing Municipal Wastewater and Biosolids Research Needs” was held on March 29<sup>th</sup>, 2012. The focus of the workshop was to generate a short list of compelling wastewater- and biosolids-related research project areas to be initiated over the next year by CMWC that would generate significant partner interest, value and co-investment and launch key activities within the larger end-user community on a national basis. Workshop participants included mainly representatives from various end-user communities (i.e., municipalities, consultants, private sector users, government departments and the public) some of whom are members of the CMWC Management Committee.

The workshop generated six important research project areas (shown in the Table 1) that participants felt had strong potential to both address the needs of municipal water managers and operators and garner interest from prospective partners who could help collectively to ensure strong design and support for meaningful research and application of results.

**Table 1: Research Themes, Sub-Themes and Topics of the Agenda and Research Project Areas Generated at March 29<sup>th</sup> 2012 Workshop**

Title #	Theme	Sub-Theme	Topic	Research Project Area
1	Biosolids	Biosolids Application	Effects & Mitigation Strategies (incl. social issues)	Investigate Fate & Transport of Emerging Substances of Concern (ESOCs) from Land Applied Biosolids
2	Municipal Wastewater Treatment	Nutrients	Process Research	Low cost, More Efficient Technology for Nutrient (N,P) Removal
3	Biosolids	Biosolids & Sludge Treatment & Management	Process Research & Optimization	"Green Energy from Sludge": Optimization of Anaerobic Digestion to Increase Biogas Production and Improve Biosolids Quality
4	Climate Change & Sustainability	Sustainable Wastewater/Biosolids Management	Energy Reduction/Resource Recovery Processes	Systems Integrated View of Resource Recovery Opportunities (reclaimed water, energy, nutrients, organics) in Representative WW Systems

**Table 1: Continued**

Title #	Theme	Sub-Theme	Topic	Research Project Area
5	Municipal Wastewater Treatment	WWTP Processes & Optimization (incl. nutrients)	Receiving Water Effects & Mitigation Strategies	Emerging Substances of Concern (ESOCs): Treatment processes (i.e. removal or destruction)
6	Municipal Wastewater Treatment	Emerging Substances of Concern (ESOCs)	Source Control (for both wastewater and biosolids)	Identify the Contribution of Sources (i.e. hospitals, nursing homes) to Influent Wastewater

CWN through its CMWC agreed to develop, where feasible and consistent with its mandate and resources, research projects arising from the workshop. As such, the next phases of work were devoted to exploring the research activities and projects that could potentially arise from the suggested Research Project Areas and possible project titles resulting from the workshop. Efforts focused on: (1) conducting a literature review of the Research Project Areas generated at the workshop with the objectives of identifying areas with a high level of interest and assessing the current capacity for research in each area; (2) conducting a scientific research gap analysis with respect to wastewater and biosolids management in Canada; (3) consulting with Canadian experts in the field of biosolids and wastewater management to gain insight into the challenges and needs of water managers and operators in Canada from individuals with practical experience and ‘first-hand knowledge’ of the wastewater sector.

### **3.0 SELECTION OF TOPICS FOR RESEARCH CALLS**

The primary goal of the CMWC is to address the water research-related needs of the collective public- and private-sector community in Canada by identifying and addressing both current and future challenges in the area of municipal water systems. To this end, the CMWC assessed how well each of the six Research Project Areas corresponded to existing programs and interests of the CMWC. A special focus was placed on assessing the potential of each Research Project Area for addressing priority needs of municipal water managers and improving decision-making frameworks for policy development for elected officials in Canada.

The outcome of this work has resulted in the development of a Calls for Research Proposals and Calls for Expressions of Interest (EOIs) by the CMWC in each of the two focus areas: biosolids and nutrients in wastewater. The section below provides a detailed description of the focus areas and research topics selected by the CMWC to be developed into Calls for Research Proposals and EOIs, as well as the rationale applied in making the selections.



### 3.1 Establishing Focus areas and Topics for Biosolids Research Calls

Among the six Research Project Areas identified by workshop participants, two addressed issues concerning municipal biosolids: Workshop Research Project Areas 1 and 3 listed in Table 1. The outcome and decisions of the CMWC regarding these two Topics are listed and discussed below.

i) **Workshop Research Project Area 1: “Investigate Fate & Transport of Emerging Substances of Concern (ESOCs) from Land Applied Biosolids”**

**Outcome 1: Call for Research Proposals for a Comprehensive Knowledge Integration Project Including a Design for a National Consultation focused on:**

***“Risks associated with the application of municipal biosolids on agricultural lands in the Canadian context”***

**Outcome 2: Call for Expressions of Interest (EOI) to investigate:**

***“Fate, Transport and Impact of ESOCs in Municipal Biosolids Applied to Agricultural Lands”***

ii) **Workshop Research Project Area 3: “Green energy from sludge: Optimization of anaerobic digestion to increase biogas production and improve biosolids quality”**

**Outcome: CMWC is still investigating options for possible future calls in this very important area but that development is pending.**

#### 3.1.1 Overview of Outcomes: Biosolids-related Research Project Areas

i) **Workshop Research Project Area 1: Investigate the fate & transport of emerging substances of concern (ESOCs) from land-applied biosolids.**

Over the last decade there has been a sustained interest and extensive research conducted on this topic by many international and national groups and agencies. These studies have helped to improve our understanding of the fate and transport of ESOCs in both water and soil. These studies have also resulted in the development of increasingly sensitive analytical techniques which permit the widespread identification and detection of several ‘emerging substance of concern’ at the ng/L or ng/g TS (dry weight). These advancements have, in turn, challenged the understanding of the scientific and public communities of any potential risk associated with their detected presence. Since the release of the 2010 Hydromantis report prepared for the

CCME and the 2010 report prepared by Water Environment Association of Ontario (WEAO), there has been no study produced which provides an updated overview, assessment and interpretation of the current knowledge on ESOCs in biosolids or an evaluation of the risks associated with the application of municipal biosolids on agricultural land in Canada. Moreover, in spite of a significant body of published reports which conclude that if applied according to recommended procedures and conditions, the practice improves soil fertility and imposes minimal risks to humans and the ecosystem (Nutrient Management Act, 2002), some end-user groups (i.e., municipalities, consultants, private sector users, government departments and the public) continue to express their concern and uncertainty about the practice. These concerns relate to ESOCs, the potential for pathogen release and odours. The situation is in part due to the lack of a national, consensus-based, and scientifically sound message about the risks associated with the agronomic application of biosolids, as well as the difficulty on the part of end users to acquire, review and formulate concrete conclusions from the plethora of emerging literature on ESOCs.

Indeed, the ability of the Canadian government and other end-user groups to effectively assess and manage the risks associated with biosolids necessitates that current information on the occurrence, fate, exposure, effects of ESOCs be obtained and effectively communicated to these groups. This is especially important since many end-users particularly those with municipal connections, are often called upon to address public concerns in this regard.

As such, it is the conclusion of the CMWC that there is a demonstrable need for a “National Dialogue” to address perceptions and processes for assessment of risks associated with the agronomic application of biosolids in order to promote a common understanding and agreement among key end-user groups on ESOC issues and solutions with regard to biosolids. This is an essential and necessary step that must be taken to improve public acceptance and promote the adoption of this practice since the benefits to crop growth are well established and many within the end-user community want the practice to continue.

### **Outcome 1: Call for Research Proposals**

In response to the information and data needs identified above, the CMWC has developed a Call for Research Proposals for a **Comprehensive Knowledge Integration Project including a Design for a National Consultation** focused on:

***“Risks associated with the application of municipal biosolids on agricultural lands in the Canadian context”.***

The multi-institutional, multi-disciplinary research team chosen to undertake this project will produce:

- a) A detailed report which evaluates and interprets leading research and integrates it with best current knowledge and practice, and identifies and evaluates relevant risks

associated with and that impact the practicability of the application of municipal biosolids on agricultural lands over the range of conditions and practices in place in Canada. Risks to be evaluated could include, but are not limited to, regulatory, socioeconomic, human health, and environmental risks.

- b) Key elements of a design for a national consultation workshop and on-line dialogue forum to be conducted by CMWC. The purpose of the workshop and dialogue will be to better disseminate nationally the issues and elevate the discussion on practice and policy options, risks, and opportunities for the application of municipal biosolids on agricultural lands in Canada.

The current call seeks to support the development of one project by an academically-based research team that will directly undertake the two project components outlined above. Both of these project components will address current knowledge on the seven key topics listed below and will interpret and communicate information about these topics related to risks in the context of Canadian conditions and decision needs. These seven topics emerged as research priorities as a result of research and consultations undertaken by CWN.

- ESOCs and pathogens: evaluate risks to humans, animals, and soil and aquatic fauna.
- Fate and transport of ESOCs: investigate the movement of ESOCs through a range of soils and the impact of drainage systems on transport.
- Impact of variations in application practices and biosolids characteristics: the impact of the range of regulations governing biosolids application practices.
- Effects of variations in processes used to produce and condition biosolids: impact of various processes (i.e., pretreatment for enhanced anaerobic digestion, alkaline treatment, filter bags and dewatering methods, etc.) on the presence of ESOCs and pathogens in biosolids.
- Testing for toxicity and biological end points: evaluate methods suitable for testing toxicity of biosolids using biological end points; distinguish toxicity due to ESOCs from that due from other possible causative compounds such as ammonia and metals.
- Antimicrobial resistance: evaluate current knowledge on antimicrobial resistance in biosolids and soil in response to pharmaceuticals and other possible causative substances.
- Public acceptance: assess the factors which affect public acceptance of agronomic application of biosolids and methods used to improve acceptance.

## **Outcome 2: Call for Expressions of Interest (EOI)**

As previously stated, some end-user groups (i.e., municipalities, consultants, private sector users, government departments and the public) continue to express their concern about the practice of applying biosolids to land due to the uncertainty surrounding the fate and transport of ESOCs and pathogens in biosolids, and the potential risks they pose to both humans and the

environment. To advance the understanding of the risks and promote the development of innovative technologies and strategies for managing the risks, the CMWC has decided to solicit Calls for EOIs in establishing multi-institutional, multidisciplinary research to support projects in the following area:

***“Fate, Transport and Impact of ESOCs in Municipal Biosolids Applied to Agricultural Lands”***

Through this EOI process, CWN will select a short-list of research teams demonstrating a strong potential to address needs within the four research sub-topic areas listed below:

***I. Ecological Response End Points***

Recent research on the fate, transport and ecological impacts of ESOCs in biosolids applied to agricultural lands has focused on specific compounds for the purpose of developing compound-specific recommendations for source control. This has provided valuable information but the list of ESOCs in biosolids with potentially adverse effects is extensive, the resources required to complete such work are substantial and the time lines are long. Moreover, these types of studies are also limited in that they are unable to characterize and measure the aggregate toxicity of an effluent or ambient waters on a particular test species. The development and use of an analogue to “whole effluent toxicity” testing being used effectively for municipal wastewater effluent evaluation would produce an important tool for assessing the impact of biosolids and their contents applied to land. CMWC is currently funding a research project with a similar objective. The project is entitled “*Practical monitoring and assessment strategies to discern ecosystem health impacts of wastewater discharges of emerging contaminants*” led by Professor Chris Metcalfe at Trent University. Emphasis is on developing simplified procedures using biological end points available in receiving waters.

Similar to the above-mentioned study, the CMWC is soliciting a Call for EOIs for a project that will support, together with partners, research that will identify and evaluate biological end points that can be used to evaluate the risks associated with the agronomic application of biosolids with emphasis on the presence of ESOCs in the biosolids. In particular, the proposed research will investigate variations in biological end point responses to represent expected ranges of soil types, biosolids properties, application practices and climatic conditions which can be found across Canada.

***II. Effects of Alkaline Stabilization Processes on the Properties and Concentrations of ESOCs in Biosolids and their Impact upon Application to Agricultural Soils***

A report issued by the CCME in 2010 entitled “Emerging Substances of Concern in Biosolids: Concentrations and Effects of Treatment Processes” recommended that further study be conducted on the efficacy of alkaline stabilization processes for inactivating pathogens in

biosolids with emphasis on the use of biosolids from different sources, with different prior processes treated in various alkaline environments. It also recommended that variations in application rates and methods, soil characteristics and the timing of application be considered as important factors that could affect ESOC properties and responses induced in the soil. The practice of subjecting biosolids to alkaline stabilization prior to land application to inactivate pathogens in biosolids is currently being practiced in North America. A Canadian corporation currently provides such service to a small number of municipalities across Canada. The effectiveness of pathogen inactivation appears to be substantial but the impact of alkaline treatment on ESOCs and their subsequent behavior after land application is not well understood. Also, ESOCs can potentially be present in amendments used for alkaline stabilization. CMWC is therefore soliciting EOIs for a project that will support, together with partners, research that will identify modifications if any to ESOCs in biosolids exposed to alkaline treatment and to investigate what changes in their availability and possible impact in soil would occur as a result of this treatment.

### **III. Impacts on Risks Associated with ESOCs in Biosolids as a Result of Implementing Processes to Improve Energy and Nutrients Recovery from Municipal Wastewater Treatment Systems**

Much attention is currently being directed at efforts to improve and increase the recovery of energy and nutrients from municipal wastewater treatment systems, particularly from waste sludge streams produced from conventional and other secondary treatment systems. These processes such as enhanced biogas production and struvite recovery focus on anaerobic digestion processes and the liquid residual produced during biosolids dewatering. The processes involve changes to more traditional treatment configurations and as such have the potential to change the properties, composition and/or concentrations of ESOCs in biosolids eventually sent to agricultural lands for disposal.

CMWC is soliciting a Call for EOIs for a project that will support, together with partners, research that will (a) evaluate current knowledge on the possibility of such transformations taking place and how these might affect risks associated with land disposal of biosolids and (b) engage in innovative research that will explore the nature and extent of changes to ESOCs and their possible ecological impacts.

### **IV. Other Innovative Research Initiatives**

While the topics listed above represent important issues for innovative research on the fate, transport and impact of ESOCs in municipal biosolids applied to agricultural lands, respondents to this Call are able to submit EOIs addressing other important topics within the focus area provided that sufficient descriptions and rationale for the proposed research are provided to allow reviewers of the EOIs to judge its merits and that value for the end-user community is clearly demonstrated.

ii) **Workshop Research Project Area 3: "Green energy from sludge": Optimization of anaerobic digestion to increase biogas production and improve biosolids quality"**

Much attention is currently being directed towards the future management and sustainability of Canada's energy and water resources, as well as the potential impacts of climate change on these resources. As such, there is a demonstrable need to develop new technologies and improve practices for the production and use of energy, and the treatment of waste and wastewater. The development of technologies that can recover 'value-added products' (i.e. nutrients, energy, water, biosolids) from waste and wastewater and effectively treat wastewater has emerged as the most effective and sustainable option for solving our energy, water and climate change challenges.

**Outcome:** Options for research in this area are currently under consideration.

In recognition of the potential benefits of such research related to this topic, the CMWC is still investigating options for possible future calls in this research project area but that development is pending.

### **3.2 Establishing Focus areas and Topics for Wastewater Research Calls**

Among the six Research Project Areas identified by workshop participants, four addressed issues concerning the management of municipal wastewater, Research Project Areas 2, 4, 5 and 6 listed in Table 1. The outcome and decisions of the CMWC regarding these four Workshop Research project Areas are listed and discussed below. Note: Research Project Areas 2 and 4 have been addressed together (see below).

i) **Workshop Research Project Area 2: "Low cost, More Efficient Technology for Nutrient (Nitrogen, Phosphorus) Removal"**

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ii) **Workshop Research Project Area 4: "Systems Integrated View of Resource Recovery Opportunities (reclaimed water, energy, nutrients, organics) in Representative Wastewater Systems (Collection and Treatment)"**

**Outcome 1: Call for Research Proposals for a Comprehensive Knowledge Interpretation Project Including a Design for a National Consultation focused on:**

***"Options for Improved Nutrient Removal and Recovery from Municipal Wastewater in the Canadian Context".***

Outcome 2: Call for Expressions of Interest (EOI) to investigate:

***“Options for Improved Nutrient Removal and Recovery from Municipal Wastewaters”***

- iii) **Workshop Research Project Area 5: “Emerging Substances of Concern (ESOCs): Treatment processes (i.e. removal or destruction)”**

Outcome: **The CMWC is currently supporting a major research project addressing this topic**

Project EC1-2008-28-860: *“Determining the efficacy of emerging contaminants removal within existing treatment trains relevant to Canadian conditions through chemical and toxicological assessments” led by Dr. Wayne Parker.*

- iv) **Workshop Research Project Area 6: “Identify the Contribution of Sources (i.e. hospitals, nursing homes, etc.) to Influent Wastewater”**

Outcome: **CMWC does not anticipate support for work on this topic at the present time.**

### **3.2.1 Overview of Outcomes: Wastewater-related Research Project Areas**

- i. **Workshop Research Project Area 2: Low cost, More Efficient Technology for Nutrient (Nitrogen, Phosphorus) Removal”**

&

- ii. **Workshop Research Project Area 4: “Systems Integrated View of Resource Recovery Opportunities (reclaimed water, energy, nutrients, organics) in Representative Wastewater Systems (Collection and Treatment)”**

Traditionally, the main driver for research and practice related to nutrient removal has been the need to improve effluent quality, to reduce the effects of eutrophication with the focus on phosphorus removal, to reduce effluent toxicity through the control of ammonia nitrogen, or to do both. Research and planning for future advancements in nutrient recovery and reuse are driven mainly by the desire to recover and reuse nutrients with emphasis mainly on phosphorus. Regulatory drivers for nutrient removal are varied among the Provinces and Territories of Canada, and as a result, municipal wastewater facilities are inconsistently

managed across Canada. The new Environment Canada Municipal Wastewater Effluent (MWWWE) Regulations do not regulate phosphorus discharges and limit nitrogen as ammonia-nitrogen regulation on a toxicity basis as opposed to a recovery or reuse basis. There is no regulation driven by phosphorus recovery and reuse.

Interest in phosphorus recovery has grown over the years due in large part to the growing awareness that it is a finite, non-renewable resource and that global reserves are nearing their peak (Ulrich et al., , 2009; Soil Association, 2012). As a result, many international groups and agencies are presently engaged in research and planning for future research related to both topics; but seldom are these two topics examined in combination with the other. Although it has been acknowledged that the objectives and conditions for undertaking nutrient removal and nutrient recovery are incongruent and that there is a lack of coordination and uniformity in our national regulatory and economic systems, CMWC has chosen to design projects that will pursue both topic areas.

### **Outcome 1: Call for Research Proposals**

The CMWC intends to solicit a Call for Proposals for a **Comprehensive Knowledge Integration Project Including a Design for a National Consultation** focused on:

***“Options for Improved Nutrient Removal and Recovery from Municipal Wastewater in the Canadian Context”.***

The research team conducting this project will produce:

- a) A detailed report which evaluates and interprets leading research and integrates it with best current knowledge and practice, and identifies feasible options for both nutrient removal and nutrient recovery from wastewater treatment systems effluents and process streams;
- b) Key components to be incorporated into a national consultation workshop and on-line dialogue forum on nutrient removal, recovery and reuse from WWTS and process to be conducted by CMWC. The purpose of the workshop and dialogue will be to better disseminate nationally the issues and elevate the discussion on practice and policy options, risks, and opportunities for improved nutrient removal and recovery.

The current call seeks to support the development of one project by an academically-based research team that will directly undertake the two project items outlined above. Both of these project components will address current knowledge on the seven key topics listed below and will review and analyze current information available on processes and conditions required for effective nutrient removal and nutrient recovery from municipal wastewater treatment effluents and process streams and will interpret the findings in terms of technical, economic



and social feasibility for application in the Canadian context. This will be accomplished in three focus areas:

I. *Concurrent Nutrient Removal and Recovery In Canadian Municipal Wastewater Treatment Systems;*

- Identify and analyze the range of Canadian regulatory conditions, existing treatment process configurations and efficiencies, and the potential for and economics of process up-upgrades to achieve effective removal and recovery.
- Interpret and analyze possible future changes to regulatory conditions and economic drivers and develop scenarios to accommodate effective removal and recovery in this changing environment.
- Identify research needs and make recommendations for optimal process configurations

II. *Improved Performance and Cost Efficiency for Nutrient Removal in Canadian Municipal Wastewater Treatment Systems;*

- Document the range of treatment configurations currently in existence in Canada and limits to removal.
- Identify feasible up-upgrades for both primary and secondary treatment configurations should improved nutrient removal beyond current levels be required.

III. *Feasibility and Cost Effectiveness of Phosphorus Recovery in Canadian Municipal Wastewater Treatment Systems*

- Evaluate existing and emerging technologies for phosphorus recovery and reuse with respect to feasibility, optimal operating conditions and economics for implementation in Canadian municipalities.

## **Outcome 2: Call for Expressions of Interest**

Developing new and innovative technologies for nutrient removal and/or recovery from municipal wastewaters is an area of active research in many countries around the world including Canada. Stages of development range from laboratory bench scale experiments through pilot scale to implementation at full scale. Although much has been accomplished, much remains to be done on many emerging technologies depending on the processes involved. For example, although the Ostara process developed at the University of British Columbia is being used successfully at full scale for phosphorus recovery, research is still being conducted on reaction kinetics, reactor hydrodynamic properties, optimizing operating conditions and managing economic conditions. Technical research needs for less well-developed processes are significant and will involve substantial innovative research efforts. In

To address these research needs, the CMWC has decided to solicit Calls for EOIs in establishing multi-institutional, multidisciplinary research to support projects in the following area:

***“Options for Improved Nutrient Removal and Recovery from Municipal Wastewaters”***

The information provided below sets out important topics for investigation within this focus area.

**I. Evaluation and Optimization of Emerging Processes for Phosphorus Recovery Under Canadian Conditions**

Phosphorus recovery using innovative precipitants, algae based systems, iron reducing bacteria and filamentous microorganisms, membranes in various forms and configurations, and urine as a source material among others are processes for which additional investigation is needed before wide spread application in Canada will be feasible. In some cases, these processes and procedures have been successfully implemented at full scale in other countries and regions; but applications in Canadian settings have been slow to appear.

CMWC is soliciting a Call for EOIs for a project that will support, together with partners, research that will undertake innovative experimental research on these processes and procedures to explore the extent to which they might find beneficial application under Canadian conditions. CMWC will consider EOIs submitted in response to this topic for research over a range of possible processes to achieve nutrient primarily phosphorus recovery.

**II. Improved Efficiency and Cost Reductions for Nitrogen Removal in Canadian Municipal Wastewaters**

Nitrogen removal from municipal wastewaters is frequently accomplished through the use of biological nutrient removal (BNR) for the purpose of reducing treated effluent toxicity due to free ammonia (NH<sub>3</sub>-N). While BNR has been successfully implemented in many North American municipalities, costs associated with BNR can be high due to energy required for aeration and due also to carbon source supplementation when needed. NH<sub>3</sub>-N removal in the Anammox process involves deamination in dewatered anaerobically digested sludge supernate through nitritation and subsequent oxidation to nitrogen gas. The process has been reported to require significantly less oxygen and thus energy inputs than BNR without the need for carbon source supplementation; as such, the process appears to offer the opportunity for significant cost savings for municipalities. Four full-scale applications exist in Europe but uptake in North America has been slow.

CMWC is soliciting a Call for EOIs for a project that will support, together with partners, research that will investigate: (a) if the implementation of the Anammox process is feasible

under Canadian conditions and if so, what the necessary conditions would be (b) whether or not the process can be operated in conjunction with phosphorus recovery through struvite formation which requires  $\text{NH}_3\text{-N}$  for formation and (c) whether or not cost savings compared to BNR can be realized. Respondents to this topic of the Call will be required to identify innovative experimentation to be undertaken to address these questions.

### **III. Nutrient Removal from Anaerobic Membrane Bioreactor Treatment of Municipal Wastewaters Treatment Systems**

There has been much recent research interest in the use of membrane bioreactors (MBR) under anaerobic conditions (AnMBR) to treat municipal wastewaters to capture energy benefits from increased biogas production while reducing energy inputs otherwise required for traditional aerobic municipal treatment processes. CMWC currently supports related research, a project entitled *“Recovering the Energy in Municipal Wastewater with Membrane Centered Processes”* with Professor Hongde Zhou, University of Guelph as principal investigator.

While the objectives of increased energy production and reduced energy input appear to be attainable, research on the extent to which concurrent nutrient removal and nutrient recovery can be achieved is very limited. Since contact times under aerobic conditions are very short in MBR wastewater treatment and since conditions under AnMBR treatment are anaerobic, removal and/or conversion of ammonia-nitrogen ( $\text{NH}_3\text{-N}$ ) under very low oxygen tension will be a significant challenge. There is therefore a need to investigate the types and extent of additional treatment that would be needed to reduce effluent toxicity due to free ammonia. At the same time, much of the influent wastewater phosphorus, unless previously precipitated with metallic salts, will be present in the effluents from MBR/AnMBR processes. If so, phosphorus removal will be required for control of eutrophication but phosphorus rich effluent streams can provide opportunities for phosphorus recovery and reuse.

CMWC is soliciting a Call for EOIs for a project that will support, together with partners, research that will investigate the types and extent of additional treatment that would be needed to reduce effluent toxicity due to  $\text{NH}_3\text{-N}$ . EOIs for innovative experimental research to address the various aspects of this topic are invited.

### **IV. Nitrogen Recovery from Wastewater**

While the case for phosphorus recovery and reuse from municipal wastewater treatment systems is being well made, much less attention has been paid to nitrogen recovery and reuse. This is notwithstanding the considerable reductions in greenhouse gas that might be possible when compared to emissions released from the manufacture of commercial fertilizers containing nitrogen.

CMWC is soliciting a Call for EOIs for a project that will support, together with partners,

research that will interpret current knowledge and undertake innovative experimentation to investigate the feasibility of nitrogen recovery and reuse from municipal wastewaters in a Canadian context.

## **V. Other Innovative Research Initiatives**

While the topics listed above represent important areas of need for innovative research to investigate “Options for Improved Nutrient Removal and Recovery from Municipal Wastewaters”, respondents to this Call are able to submit EOIs addressing other important topics related to this focus area provided that sufficient description and rationale for the proposed research are provided to allow reviewers of the EOIs to judge its merits and that value for the end-user community is clearly demonstrated.

### **iii. Workshop Research Project Area 5: Emerging substances of concern (ESOCs): Treatment processes (i.e., removal or destruction)**

The CMWC is currently supporting a major research project addressing this topic:

Project EC1-2008-28-860: *Determining the efficacy of emerging contaminants removal within existing treatment trains relevant to Canadian conditions through chemical and toxicological assessments”.*

The multi-institutional team conducting this research is led by Professor Wayne Parker, Department of Civil and Environmental Engineering, University of Waterloo and is expected to be completed by April 30, 2013; information about the 3-year project is available at:

<http://www.cwn-rce.ca/initiatives/municipal-consortium/municipal-projects/dr.-wayne-parker/>

### **Outcome: No Project Development**

Since the scope of the project is extensive and closely aligned with issues associated with this Topic, the CMWC has decided not to support any new projects related to this topic until the project, led by Dr. Wayne Parker is complete and the CMWC has had an opportunity to review the results.

### **v) Workshop Research Project Area 6: Identify the contribution of sources (i.e., hospitals, nursing homes, etc.) to influent wastewater**

Understanding how contaminants reach our waterways and municipal wastewater treatment systems and where they come from is necessary for improving our ability to predict future impacts and formulate source control strategies. However, it has been determined by the CMWC that the development of a research project on this topic will be difficult to achieve

notwithstanding the benefits of such work. A key finding of the CCME 2010 Report “Emerging substances of concern in biosolids: concentrations and effects of treatment processes” was that it is unlikely that source control can restrict inputs of pharmaceuticals to wastewater treatment plants. This was reflected in the dearth of publications found in the literature review, both on a national and international scale.

#### **Outcome: No Project Development at this time**

CMWC has concluded that the scope of such an undertaking is inordinately large and not completely consistent with its research mandate. It was also determined that the CMWC does not currently have sufficient resources and possible partners to undertake investigations that might support source control. As a consequence, CMWC does not anticipate support for work on this topic at the present time.

## **4.0 SUMMARY AND NEXT STEPS**

The outcome of the research activities and consultations undertaken by CWN’s CMWC to advance the objectives of the Agenda, as well as the goals of the CMWC has been the development of potential research projects for which CWN will solicit Calls for Research Proposals and EOIs in the fall of 2012.

The current Calls for Proposals are for Comprehensive Knowledge Integration Projects including the Design of a National Consultation in topic areas related to biosolids and wastewater management. The CMWC seeks to support the development of one project in each topic area. The maximum funding that CWN will provide for a successful project is \$100,000. The project duration shall be between 12 to 18 months, with an anticipated project start date of February 1, 2013 and a latest project end date of August 29, 2014.

#### **Call for Research Proposals for a Comprehensive Knowledge Integration Project Including a Design for a National Consultation:**

- a) **“Risks associated with the application of municipal biosolids on agricultural lands in the Canadian context”.**

*Key topics for investigation within this focus area are:*

- i. ESOCs and pathogens
- ii. Fate and transport of ESOCs
- iii. Impact of variations in application practices and biosolids characteristics
- iv. Effects of variations in processes used to produce and condition biosolids
- v. Testing for toxicity and biological end points

- vi. Antimicrobial resistance
- vii. Public acceptance

**b) “Options for Improved Nutrient Removal and Recovery from Municipal Wastewater in the Canadian Context”.**

*Key topics for investigation within this focus area are:*

- i. Evaluation and Optimization of Emerging Processes for Phosphorus Recovery Under Canadian Conditions
- ii. Improved Efficiency and Cost Reductions for Nitrogen Removal in Canadian Municipal Wastewaters
- iii. Nutrient Removal from Anaerobic Membrane Bioreactor Treatment of Municipal Wastewaters Treatment Systems
- iv. Nitrogen Recovery from Wastewater
- v. Other Innovative Research Initiatives

The current Calls for EOIs in the Research Focus Areas listed below seeks to support projects across the two focus areas related to biosolids and wastewater management, with a maximum per-project contribution from CWN of \$300,000 over two years (April 1, 2012 – March 31, 2015).

**Calls for EOIs that will investigate:**

**a) “Fate, Transport and Impact of ESOCs in Municipal Biosolids Applied to Agricultural Lands”**

*Key research topics for investigation within this focus area are:*

- i. Ecological Response End Points
- ii. Effects of Alkaline Stabilization Processes on the Properties and Concentrations of ESOCs in Biosolids and their Impact upon Application to Agricultural Soils
- iii. Impacts on Risks Associated with ESOCs in Biosolids as a Result of Implementing Processes to Improve Energy and Nutrients Recovery from Municipal Wastewater Treatment Systems
- iv. Other Innovative Research Initiatives

**b) Options for Improved Nutrient Removal and Recovery from Municipal Wastewaters**

*Key research topics for investigation within this focus area are:*

- i. Evaluation and Optimization of Emerging Processes for Phosphorus Recovery under Canadian Conditions
- ii. Improved Efficiency and Cost Reductions for Nitrogen Removal in Canadian

### Municipal Wastewaters

- iii. Nutrient Removal from Anaerobic Membrane Bioreactor Treatment of Municipal Wastewaters Treatment Systems
- iv. Nitrogen Recovery from Wastewater
- v. Other Innovative Research Initiatives

CMWC will use an external, expert panel to view and make recommendations on the merits of the Proposals and EOIs received in response to this Call. Through this review process, CWN will select a short-list of research teams demonstrating a strong potential to address needs within the described project areas.

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