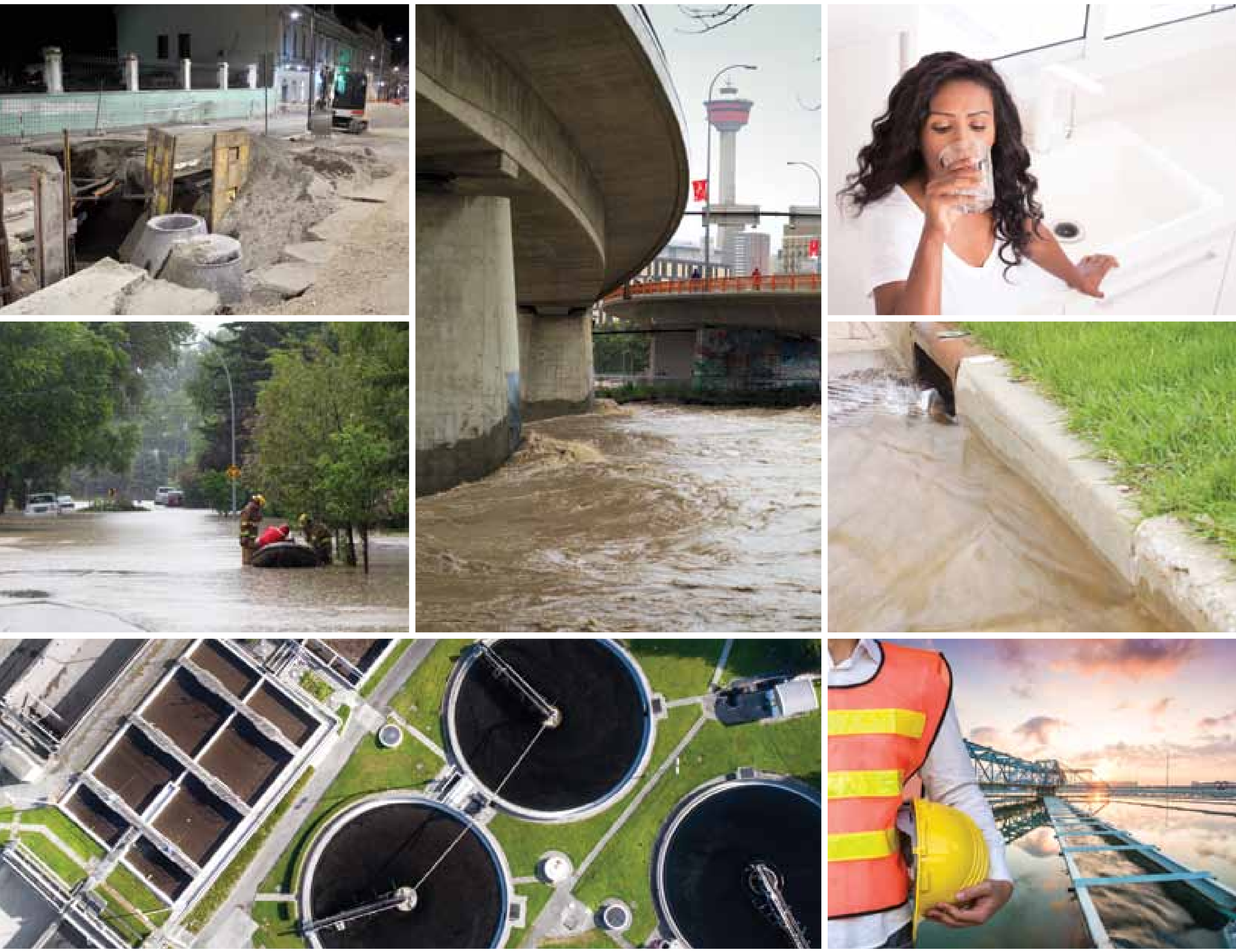

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2017

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Improving Canadian Design Standards & Procurement for Climate Resilient Infrastructure

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Improving Canadian Design Standards & Procurement for Climate Resilient Infrastructure

Outcome document of the Industry Association Policy Pitch Sessions

Part of the 8th Annual

Canadian Water Summit

Collaboration to Action:
Leadership and Investment in Canada's Blue Economy

Participating Associations and Organization

Canadian Water and Wastewater Association (CWWA) is a non-profit national body representing the common interests of Canada's public sector municipal water and wastewater services and their private sector suppliers and partners. CWWA is recognized by the federal government and national bodies as the national voice of this public service sector. CWWA was founded in 1986 by Canadian municipal water/wastewater leaders and the Federation of Canadian Municipalities. Representative: **Robert Haller**, Executive Director

Canadian Water Network is a catalyst for improving linkages between researchers and diverse stakeholders responsible for public health, protecting watersheds and ecosystems, and ensuring sustainable water infrastructure. The Canadian Municipal Water Consortium (CMWC), part of CWN, is founded on national and international collaboration and knowledge sharing with leading edge water professionals. Representative: Dr. **Bu Lam**, Manager of Municipal Programs

Canadian Water Quality Association: To support and grow the health, sustainability, and credibility of the water quality industry in Canada. CWQA provides a single Canadian voice for water treatment dealers, manufacturers and stakeholders within the water treatment industry. Representative: **Kevin Wong**, CAE, Executive Director and **Aysha Muzaffar**, Program Manager

The Canadian Water Resources Association (CWRA) is a national organization of individuals and organizations from the public, private, and academic sectors that are committed to raising awareness of the value of water and to promoting responsible and effective water resource management in Canada. CWRA membership consists of water users and water resource professionals including managers, administrators, scientists, academics, students, and young professionals. Representative: **Deidre Laframboise**

Ontario Environment Industry Association (ONEIA) is the business association representing the interests of the environment industry in Ontario. Our network of thousands of contacts includes key people at environmental technology, product and service companies, law, investment and insurance firms, institutes, universities, and governments. Representative: **Irene Hassass** and **Douglas Wilton**, ONEIA Water Committee Chairs

Ontario Onsite Wastewater Association (OOWA) is a provincial not-for-profit association dedicated to promoting the benefit and value of onsite and decentralized wastewater management through education, improved standards of practice, and advocacy for sound policies across the province. Representative: **Anne Egan**, Association President

The Ontario Sewer and Watermain Construction Association is the champion the sewer and watermain industry to promote the delivery of clean water, and safe wastewater management through advocacy, education and environmentally sustainable practices to enhance the quality of like for all Ontarians. OSWCA will foster health and safety, professionalism, ethical practices, sound infrastructure investments, good governance, and fiscal responsibility. Representative: **Giovanni Cautillo**, Executive Director and CEO

Ontario Water Works Association (OWWA) is a voluntary, not-for-profit organization of water professionals, dedicated to protecting public health through the delivery of safe, sufficient, and sustainable drinking water in Ontario. OWWA has more than 1,400 members including: municipal water system managers and operators, consulting engineers, equipment manufacturers and suppliers, research scientists, chemists, hydrogeologists. OWWA is a section of the American Water Works Association (AWWA). Representative: **Michele Grenier**, Manager of Operations

Water Environment Association of Ontario: WEAO a diverse, passionate group of 1,300 technical and professional individuals working to ensure the future of our water and environment industries. WEAO is all about Ontario's water environment. From preservation and innovation to building long-lasting industry relationships, we want to make a difference. Representative: **John Presta**, WEAO Vice President

Acknowledgements

The 2017 CWS Policy Pitch Sessions were skillfully moderated by **Brenda Lucas**, Executive Director of the Southern Ontario Water Consortium. The Policy Pitch Sessions were developed by **Katherine Balpataky**, **Brenda Lucas**, and CWS Chair and Planning Director of the Prairie Climate Centre, **Hank Venema**. The outcome document was written by **Fabiola Alvarado-Revilla** and **Katherine Balpataky**.

1: Introduction

It is widely recognized that building a resilient water sector will require ambitious infrastructure spending, as well as policies and planning to support this transformation.

In the wake of the devastation of Hurricanes Harvey and Irma, and extreme weather experienced in B.C., Saskatchewan, Ontario, Quebec, and Alberta recently, recognition of the need to improve Canada's resilience to climate change is greater than ever.

Canada has demonstrated global leadership to address climate change by having ratified the historic Paris Climate Agreement. While many areas of our built environment and infrastructure are moving ahead with progress to reduce energy consumption and improve resiliency, the water sector largely lags behind.

International capital markets that have identified the opportunities that come with large scale infrastructure development are looking to invest in the solutions, and by some estimates, there is potential to access $90 trillion dollars globally to climate-proof our economies. Canada must leverage all available funding opportunities in order to address the infrastructure gap.

In this document, leaders from nine leading industry associations/organizations in the water sector in Canada provide tangible and practical measures to address water infrastructure vulnerabilities. These measures are aligned with federal and provincial government objectives for making the Canadian water sector resilient to climate change and hold the potential to help Canada be a global leader in this respect. The measures focus on procurement policies and processes and related infrastructure design protocols, because these policy tools have the potential to maximize the environmental and social returns of investment in resilient infrastructure. The measures aim to ultimately, attract new funding into resilient and sustainable water infrastructure.

Each measure is associated with one or more of the groups that participated, as indicated. However, the discussions that are captured represent the broader participation of some of the 240 water professionals who participated in the eighth annual Canadian Water Summit on June 22, 2017 at the Sheraton Centre Hotel in downtown Toronto.

2: Improving design protocols to increase the water sector's resiliency to climate change

Much of Canada's water infrastructure has been in place for many years with designs based on existing climate patterns. With the effects of a changing climate, there is recognition that these designs need to be revisited to improve resiliency, safety and protection for Canadians. By training, engineers are well suited to assist in decision making and problem solving in the face of uncertainty. Some engineers and associations have even argued that there is an implicit duty for those in the practice to be involved in addressing the impacts of climate change as it pertains to their code of conduct and the PIEVC Engineering Protocol. Speaking of the protocol, one participant noted that, climate change could fall under the duty to act with "fidelity to public needs" and "knowledge of developments in the area of professional engineering relevant to any services undertaken" (see O.Reg. 941, Section 77).

Given that many members of the participating industry associations are either part of the PIEVC process or directly impacted by it, we sought to initiate a discussion around ways in which design protocols could be used to increase the water sector's resiliency to climate change. Participants were asked to identify measures that could be implemented within a short time period (immediately—two years) and would have a strong value proposition for the association members. From these discussions, seven unique measures for implementation were put forward and discussed.

Measure DP1: (ONEIA) Design and implement outcome-based design protocols

Justification: Prescriptive design protocols might not be best suited to face the varying climate-related challenges the water sector faces, as they lock-in old technologies that might no longer be fit for purpose. Prescriptive design protocols can become a hurdle in achieving resiliency, by rendering investment in infrastructure obsolete in the near future.

- Example: higher water levels (more frequent flooding around Lake Ontario) expose water to more contaminants, changing the quality of incoming water for drinking water plants. However, the design of treatment systems does not tend to consider changes in incoming water quality. Increasingly lower quality of incoming water (due to heavier rains and higher levels at water bodies) is a climate change-related challenge.

The solution: Outcome-oriented protocols are flexible and effective by allowing the use of innovative (and more tailored) solutions to meet the protocols' objectives in a cost-efficient way. In this sense, building a resilient water sector opens business opportunities for suppliers of technologies, products and services, contributing to regional economic development (a clear example of the "blue economy" at work). Outcome-based approaches are not new: the standards for drinking water quality, with guidelines set by Health Canada, are outcome-based. Right now there is only a single permitted way to achieve them.

Implementation: Because no particular solutions are prescribed, outcome-based protocols would be easier to streamline and garner support around the objective of resiliency. Solutions are already available locally: Canadian innovators and suppliers have the technology and services needed (e.g., the cleantech industry in Ontario). Implementation can be tested independently by certified third-parties, which would avoid backlog at the regulator's end.

Challenges and how to overcome them: More and better data is needed on climate and water/energy, as well as indicators of effectiveness, efficiency and life-cycle cost savings, to support evidence-based decision-making (particularly for developing and choosing specific solutions). To overcome this information challenge, the recommendations are to create a centralized knowledge sharing platform, as well as building capacity to translate data into action (including raising awareness, training, innovating, etc.) to accelerate adaptation.

Measure DP2: (OWWA + OOWA) Consider alternative approaches (particularly for wastewater infrastructure) during early planning stages and the environmental assessment process

Justification:

- Planning of water infrastructure usually comes as a reaction to other infrastructure developments (e.g., residential developments). Such a reactive approach tends to tackle project by project, not taking advantage of economies of scale. As a result, water infrastructure planning (including environmental assessment process) has prioritized the water supply side, not paying enough attention to wastewater.
- Centralization has been the dominant approach to water infrastructure. However, centralized infrastructure can render small municipalities more vulnerable to climate change (e.g., exposing them to climate events in other municipalities in the network).
- Design protocols deriving from these traditional approaches can render new investments vulnerable to climate-related future starker variations of water quality and quantity.

The solution: the following alternative approaches allow incorporating adaptation and mitigation into the early stages of infrastructure planning, thus supporting long-term resiliency:

- a source-to-tap-to-source approach, which can harness wastewater as a resource;
- a decentralized approach, which can provide more flexibility for specific municipalities to address the particular climate change challenges that they face, without being exposed to vulnerabilities of other areas/components of a wider water system.

Implementation:

- Importantly, decentralized infrastructure does not necessarily imply decentralized management: the benefits of centralized management can coexist with the benefits of decentralized infrastructure. Smart technologies (e.g., sensors, smart pumps, remote control systems) can play an important role in enabling this "hybrid" approach.
- These alternative approaches can be more successfully introduced at the policy planning stage, in order to influence new protocols, and/or modify existing ones that municipalities can implement.
- The implementation of both approaches would require further training of staff.
- These approaches allow for flexible protocols where re-development (and retrofitting) becomes a cost-efficient solution in the long-run, compared to new developments altogether.

Measure DP3: (CWQA) Enable and encourage decentralized systems (smarter and smaller networked infrastructure)

Justification: Current design protocols are based on drinking water and sewage policies that were initially informed by statistics of the 50's and earlier. Relying on specifications no longer suited to the current context hinders adaptation by not facilitating the use of new technologies.

The solution: Decentralized water systems can be more integral (i.e., source-tap-toilet-tap), resource-efficient (e.g. net zero requirements can be easily built in), and adaptable to climate events, thus being more sustainable.

Implementation: In order to ensure the same standard of quality across different locations, this measure can be successfully implemented through performance-based standards, approved and enforced by the government, and of mandatory compliance by providers of equipment for smart, small networked infrastructure. A way of operationalizing this is through government-backed product certification.

- For example, decentralized systems can be enabled with the development, codification and adoption of standards for rainwater harvesting, greywater management.
- The implementation of this measure would be successful with the participation of small and big municipalities, as well as First Nations. At higher levels, there is already interest on this type of measure by the Insurance Board of Canada, and the National Research Center.
- It was acknowledged that decentralized system may require more human resources to manage (but that may not be so bad).

Measure DP4: (WEAO) Require local climate modelling to be considered in design standards.

Justification: The resiliency of long-term infrastructure investment depends greatly on how adapted it is to future conditions. Expected future conditions include more severe weather episodes at a greater frequency (e.g., severity and frequency of storms is expected to increase, which impacts the saturation of soil). However, current design protocols are based on data usually half a century old. Furthermore, effects will be felt at a local level, whilst policy decisions and design protocols are made at higher levels. Whilst climate zone considerations are built into the building code, they are not as prevalent in other design tools (such as the National Master Specification (NMS).

The solution: To conduct local climate modelling in order to predict long-term changes in temperatures, precipitation, and weather patterns for a specific service area. That way, new design standards and protocols informed by such predictions would increase infrastructure resiliency at the local, and thus higher, level.

Implementation: The technology and the need for local climate modelling exist. Some challenges could arise around the lack of appropriate data, and structuring financing packages that dedicate more funds to modelling. Better informing government agencies, the general public and the private sector about the benefits of climate modelling would enable financing this measure, which in turn would improve the amount and quality of available data.

Measure DP5: (CWN) Design for actual needs, incorporating acceptable tolerance for "safe to fail" rather than "failsafe" design

Justification: Designing systems to withstand climate uncertainty is challenging, and building infrastructure to never fail (i.e. be "failsafe") can be costly and difficult. Given the increasing intensity and frequency of extreme weather, some degree of system failure is inevitable, but if systems are planned and designed appropriately, the impacts due to system failure can be minimized.

The solution: This measure is an outcome-based and systems approach to infrastructure. Shifting the thinking of design objectives from "failsafe" to "safe to fail" presents an opportunity to improve climate resiliency in water systems. By establishing what are acceptable levels of system failure, and modelling how systems behave under different weather scenarios, systems can be designed to "fail safely" in extreme weather. This will limit the impacts of severe climatic events to water systems.

Implementation: This measure will be more effective the more understanding there is about climate conditions, and thus about possible future scenarios. Implementation of such an approach is multilevel. On one hand, policies at the provincial level need to incorporate this approach to steer municipalities to look at various buffer options. On the other hand, municipalities already have bodies, such as engineering offices, that can act as oversight bodies locally. Smart technologies, relying on sensors, would be important on informing about failure levels in real-time, which can trigger buffering measures instantly (for example, Ottawa has sensors for flood levels, which inform flow diversion).

Challenges to implementation:

- Defining what is acceptable failure will vary according to local conditions;
- defining suitable failure buffers that allow offsetting by adjacent systems (i.e., an optimization problem), and the methods through which to offset failure.

Measure DP6: (OSWCA) Reuse of native fill in backfill trench excavation to increase permeability and improve resiliency

Justification: Current specifications require a cement like material, called "U-fill," that has a zero compaction ratio, and does not allow for water absorption. Usually, municipalities' terms of reference require to discard the soil excavated to form the trench—soil is seen as waste.

The solution: To reuse the native soil in the backfill of trench excavation. It is more environmentally friendly because it is not invasive, allows for ground permeability, and diminishes carbon emissions from the transportation of waste to dumpsites (usually hundreds of kilometers away).

Implementation: This is a cost-effective and easy to implement solution. Hamilton and Kingston have already implemented this measure. Municipal specifications for secondary and tertiary roadways need to be amended to allow this solution. For example, this measure is not appropriate for primary roads which require zero tolerance to compaction. Changing the language, and seeing soil as a resource, an asset (rather than waste), will be important in changing the behaviour of designers and municipalities away from old practices and towards a more resilient approach. Even if using soil as backfill results in compaction issues, it is still more cost-effective to dig and pave the road again than digging through concrete and trucking the waste away after the initial excavation.

Challenges to implementation and how to overcome them: The benefits of this measure will become more evident by conducting a full life-cycle cost analysis. Such an analysis would reveal the long-term value of soil as an asset and of reusing it.

Measure DP7: (CWWA) Build optimization into design, and require the optimization of performance to prolong the life of existing infrastructure before replacing it

Justification: Usually there are insufficient funds to cover all water infrastructure needs. When new funds are granted, mega-projects tend to be prioritized. However, in many cases, the existing infrastructure does not need to be replaced.

The solution: To practice performance-based asset management by optimizing existing infrastructure around resiliency objectives, instead of replacing it. The return on investment in optimization is thus maximized, compared to building new infrastructure. A clear example is the cost-effectiveness of leakage management via pressure control compared to replacing leaking pipes (taking into account that there are examples in Canada where 30 per cent to 40 per cent of water supply is lost to leaking pipes).

Implementation: A life-cycle assessment of existing assets informs the implementation of this measure. Asset maintenance takes on a major role under this approach. Smart water technologies (e.g., sensors and software that allow virtual mapping of the water distribution network) show potential for monitoring the state of the assets. The leadership of government, as owners of public assets and as promoters of technology incubators (green tech) is essential. The involvement of heads of finance in demanding performance-based asset management is key, as is the engagement of engineering companies with this type of asset management and related technologies. Knowledge sharing between the different actors is crucial.

3. Improving procurement processes to increase the water sector's resiliency to climate change

Measure P1: (ONEIA) Require reporting of municipal energy consumption data to inform procurement, evaluate energy efficiency, and to inform the development of innovations tailored to energy needs

Justification: At the present time, water is not a central priority in global discussions. However, climate change implications first manifest in the water cycle. As well, the water sector's energy use and wastewater contributes to greenhouse gas (GHG) emissions. Thus, for the water sector to attract funding for resiliency, water issues must be framed in relation to energy. Data regarding the municipal water sector's energy use exists, but they are often collected by multiple agencies for different purposes under different standards. Thus, much of it cannot be used or transformed into information that supports real-time decision-making. The need for water data is high: policymakers need it in order to enact innovative rate structures or fund utility projects; businesses, in order to improve their awareness of water risks in their areas of operation; lending institutions and insurers, in order to quantify their customers water risks and security; individual customers want to see their water usage at a higher resolution than monthly.

The solution: To build water data infrastructure that enables sustainable water resource management (particularly regarding energy), that informs procurement processes for accessing resiliency funds, as well as providers of innovative solutions. Such water data infrastructure offers open, shared, and integrated public water data in an "internet of water" system. There is potential to provide better information about the water-energy nexus, support cost-efficiency regarding water's energy use and GHG emissions, and thus water efficiency.

- Benefits: Water utilities will see benefits of better water data in energy and water conservation, such as avoiding new infrastructure costs (e.g., point of use). The environment will benefit from more water left in the system; and the rate-payers will benefit from precision rate-setting, and lower costs.

Implementation:

- Translate existing data into practical information for the sector on energy and GHGs. This requires investment in tools to improve data interpretation, conversion, and application in various municipalities and jurisdictions.
- Develop new standards using specific, measurable, and time-bound criteria for better data collection and for informed decision making (e.g., a water data catalog that identifies all existing public water data maintained by states). In particular, funding must be allocated to develop standards for the water-energy nexus (pumping, distribution, treatment and other related parameters).

- Establish the right financial or other incentives based on the collected information to encourage more collaboration in sharing risks during the technology adoption process, including municipalities, and their utilities, which so far have only reported on energy usage and energy reduction goals voluntarily). Technology exists to integrate this data into intelligent systems that incorporate the data with procurement and asset management programs.

Challenges to implementation: The are inherent risks and a financial outlay to pursue new technologies. Often, cost-benefit analyses of these risks and the business case are supported by data. Engaging consulting engineering firms to support innovation in procurement processes is crucial.

Measure P2: (CWWA + CWN) Design and implement outcomes-based procurement

Justification: Traditional procurement processes are prescriptive, providing very detailed requirements for how infrastructure should be built (including the choice of technologies). However, climate change poses new types of challenges to water infrastructure, requiring innovative solutions. Thus, traditional prescriptive procurement processes are no longer fit for the purpose.

The solution: Outcomes-based procurement processes, similar to those used in public-private partnerships (PPPs), could have significant advantages for improving climate resiliency by rewarding innovation. The public client sets resiliency objectives in the request for proposals' specifications, and leaves it to the bidders to come up with innovative solutions. This type of process would open the doors for considering new technologies.

Implementation: Establish a database of clean-technology companies in Canada specifying their offerings for the water sector (similar to MERX listing of tenders). Project tenders could be posted there as well.

Challenges and how to overcome them: To enshrine the commitment to innovation in procurement processes in this way would discourage setbacks by changes of administration. The majority of PPP models are used for large projects, so there is a need to adapt them to fit the needs of small communities as well.

Measure P3: (OWWA) Require consideration of life-cycle costs

Justification: The "lowest bid wins" approach has prevailed in public procurement processes, translating into limited funding and short-term planning horizons. However, the cheapest bids rarely deliver long-lasting, resilient solutions. Lowest-cost approaches also do not reward innovation.

The solution: Incorporate life-cycle cost (LCC) assessments in procurement, together with appropriate weighting of technical and financial factors. When full operation and maintenance costs are considered, innovative technologies can become more attractive, compared to maintenance-heavy traditional infrastructures. This would eliminate the "lowest bid wins" approach, contributing to ensure the resilience of infrastructure. Tax-payers and the individual user would benefit financially and by having access to resilient infrastructure.

Implementation: Criteria for LCC assessment of project proposals during procurement must be clear and include areas such as energy, water, chemical consumption, GHG emissions, as well as labour and maintenance requirements. Multi-stakeholder perspectives need to be included in the evaluation to ensure that externalities are internalized and that the contracted project benefits the community in the long-term.

Challenges and how to overcome them: Established financial and political practices around procurement would pose a lag in implementation. Training staff in charge of procurement, as well as of consulting engineers supporting the client, and the potential providers, could change the culture around procurement.

Measure P4: (OSWCA) Implement asset management to increase the efficiency of procurement processes (financially, and in terms of resiliency)

Justification: Scheduling of the procurement of new projects is usually based on algorithms that predict which infrastructure is oldest and needs to be replaced before they fail. However, the actual condition of most water infrastructure is usually not known. Some infrastructure might only need to be repaired rather than replaced. Currently there are no standards for asset management across types of water infrastructure.

The solution: Define a standardized method of asset management that informs municipalities what to replace and when. Asset management is a building block to get budgeting, prioritization, planning, scheduling, and procurement right: if asset management is deficient, the other processes will be inefficient. When asset management is done appropriately, funds that would have otherwise be spent in new infrastructure can be invested to meet more pressing infrastructure needs. This would maximize the impact of investment. In that sense, this measure reflects a proactive, rather than a reactive approach by asset owners. This measure contributes to resiliency by keeping infrastructure in good condition to withstand climatic events, thus reducing the frequency of emergencies.

Implementation: Municipalities implement this measure and are the main beneficiaries. Carrying out physical checks eliminates the uncertainty inherent in the algorithm-based approach. New solutions allowing for remote sensing are making the physical checks easier and more accurate with minimum disruption (for example, Peel region has implemented one of this solutions to map the condition of their water distribution network).

Challenges and how to overcome them: Learning how to use new technologies.

Measure P5: (CWQA) Modernizing the National Master Specification (NMS) to integrate climate resiliency

Justification: The NMS is the basic guideline for public works. However, many consulting firms do not rely on the NMS because it is outdated. Instead, they use their own guidelines as reference, which might not be up to date either.

The solution: Modernize the National Master Specification to integrate climate resiliency as a primary objective. Then, harmonize the NMS to building codes and create performance criteria. In that way, the overall system used to build and support infrastructure is aligned and more efficient.

Implementation: Use the existing consensus-based standards development process for product performance as a foundation. Engaging policy-makers is key, as well as engineering consultants who are hired to develop specifications.

Challenges and how to overcome them: Entrenched practices slowing the adoption of innovation can be overcome with staff training in charge of project specifications.

It was suggested that the building code is more flexible and well-suited to manage resiliency, climate change, and energy efficiency measures. Harmonizing the NMS with the Code would close any design gaps and forces the process to an objective based/performance based approach.

Measure P6: (OOWA) Minimize the timeframe for granting environmental approvals

Justification: The current length of time for environmental approvals slows down investment in Ontario businesses—it can take years to do any expansion that requires water and wastewater approvals. This is particularly a problem for smaller municipalities, where decentralized systems are more common.

The solution: Reducing the turnaround time for environmental approvals (whilst maintaining their level of quality) would expedite procurement processes, which in turn would benefit local economies with faster materialization of investments. This measure is particularly relevant for decentralized systems.

Implementation: The Ministry of Environment could implement three avenues for environmental impact assesments: standard, expedite, or a new peer-reviewed process (paid for by the client). This new process would consist of a pre-qualified group of consultants (audited by MOECC) that carry out the assessment. The result of the assessment would still require a final government approval.

Measure P7: (WEAO) Require consideration of future design limits and requirements in procurement process by providing an allowance of time for planning and engineering.

Justification: Better knowledge of the potential risks in specific project locations is necessary for effective risk mitigation, it would serve to adapt the design and procurement strategy accordingly. However, it is difficult to map potential risks for a specific project context. Still, a certain level of risk mapping can be achieved and integrated into design and procurement processes if these allowed enough time for that purpose.

The solution: To state the future design limits in procurement documents in order to identify the expectations by each level of government asking for the service (i.e., request for proposal for engineering design which would allow time/tasks to conduct alternative designs to meet future climate resiliency factors required.)

Implemetation: Ensure that there is enough time in the process so engineering for resiliency is conducted.

4: Conclusions

The following are the themes cross-cutting two or more measures, regarding design protocols and procurement processes:

Common context: The need to maximize the impact of investment in infrastructure is the starting point for many of the measures, in the context of scarce funding to address various pressing water infrastructure needs.

Alternative approaches to design protocols and procurement processes for water infrastructure resiliency: Overall, the traditional approach to infrastructure needs to change in order to incorporate resiliency to climate change as an objective. The following are three different dimensions of the change of approach:

- an outcomes-based approach offers both flexibility in trying innovative solutions adapted to specific environments, as well as clear performance objectives for resilient infrastructure;
- a life-cycle approach, particularly to assess project's overall costs (capital and operational), can better show the long-term value of resilient infrastructure;
- the local level can take a more proactive role in the context of decentralized approaches, and as a source of solutions better adapted to the local context.

The importance of data: for supporting decision-making. Better granularity of data, whether about climatic conditions, about water usage or the condition of water infrastructure, is much needed for better targetting capital and operational expenditure (maximizing the impact of available funds). Better and more data relies on newer methods for data collection, processing, analysis and synthesis, such as smart technologies.

The importance of education and training: in preparation for, and during, the implementation of new alternative approaches and solutions. This is necessary across the board, from the public, the utilities and municipalities (who will be in charge of implementing changes), to policy-makers, and private sector providers.

The organizers of the Canadian Water Summit wish to acknowledge and thank the representatives from each industry association who participated in these sessions for the knowledge and success in engaging participants in a national dialogue on these issues. We look forward to continuing this dialogue with federal and provincial decision-makers through the dissemination of this report, and in discussions at the **2018 Canadian Water Summit, June 20-23 in Vancouver, B.C.**

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