Adaptation to Climate Change: Understanding Water-Management Needs

Summary for a CWRA Workshop May 26 2009

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The following summary report presents a synopsis of presentations and discussions that took place at the 2009 Workshop on climate change and resulting water management needs in Ontario. The workshop was convened by the Ontario Branch of the Canadian Water Resources Association and is the second in an annual series. The 2008 workshop dealt with integrated watershed management and a CD of the 2008 workshop is available from the CWRA.

Any opinions or commentary contained in this summary that go beyond a synopsis of views expressed at the workshop are those of the authors of this summary. In these added comments we speak only for ourselves and not for the CWRA or for the participants in the workshop. The presentations, and a full set of the responses of the participants at the workshop, are included in this publication. Readers are urged to make use of this valuable material as background for their ongoing contributions to policy development in the important field of adaption to climate change.

A Synopsis of Presentations

Overview

Several themes emerged as especially important in the presentations and cut across the three discussion questions (see below). Speakers and participants emphasized the increasingly dynamic physical environment (Rob de Loë called it the “death of stationarity”). Hydrological events and event sequences may be changing in ways that are unfamiliar to us in the local setting and difficult to predict. Rob emphasized that as a result past experience and local knowledge is no longer a strong guide for future policy. Bob Walker later added the modifying comment that most expected conditions are similar to existing patterns somewhere and a search for examples of adaptive strategies that have worked in these places is worthwhile.

This high level of uncertainty pervades not only our understanding of the physical system, but also our policy framework (much of which is based on assumptions of a stable climate) and our confidence in water management alternatives and

policies. Several speakers emphasized the **new decision-making environment and communication networks** that will be necessary as we grapple with climate change. For example, Quentin Chiotti (Pollution Probe) observed that improved decision-making will require **better knowledge and data sharing**, to increase the value of data collected in a region, and decrease the potential for duplication of effort. This in turn demands **improved communication** within and between watersheds and jurisdictions, and **coordinated data collection and research programs**. Pollution Probe has supported, as a pilot project, the Ottawa Gatineau Atlas. This effort emphasizes the role of open-source data as base for informed decision making, http://www.ogwa-hydrog.ca/en/home.

Rob de Loë reminded participants that water management is already jurisdictionally complex in Canada, and the growing number of stakeholders, and transboundary implications of climate change, mean that coordination and communication across borders will be increasingly important in the future. There is a need for **strong and coordinated government leadership**, at all levels of government but especially at the provincial level. But adaptation to climate change will also require local action, for example through source water protection planning, low-water response programs, and stormwater management, creating opportunities for "mainstreaming" of climate change, a key requirement if adaptation is to be an effective policy.

As a society, we have had little experience dealing with the degree of uncertainty inherent in future climate conditions, ecosystem responses, and our ability to mitigate and adapt to climate change. We must therefore continue **to build community and institutional capacity for decision making in a dynamic and highly uncertain environment** as we confront gradual changes like ecosystem shifts and water shortages. At the same time, we will need to prepare our buildings, infrastructure, and operating policies for the more frequent extreme weather events that are expected to accompany a warmer climate. These in turn will bring associated challenges related to stormwater management, water-borne disease transmission, heat stress, and the failure of electricity transmission systems.

Chandra Sharma of TRCA and Quentin Chiotti both observed that watershed plans provide an effective framework for climate change adaptation, by providing long-range planning and implementation tools for the management of water resources and aquatic ecosystems. Quentin coupled this approach to the recommendation for reliance on a sense of place and localization of much of the specifics of adaptation as a major part of effective management. These recommendations were part of the Pollution Probe Report on new management options for Canada and reflected widespread support for localized management reported from workshops held across Canada.

An important part of the mainstreaming of adaptation is the integration of climate-change scenarios into watershed planning, creating a scientifically defensible

means to assess climate-related impacts on issues such as flood risk and infrastructure design. Using the watershed as a planning unit also allows a place-based focused on issues and strategies, and encourages effective knowledge sharing and communication among stakeholders and researchers as noted above.

TRCA's strategy for this is illustrated in Figure 1.

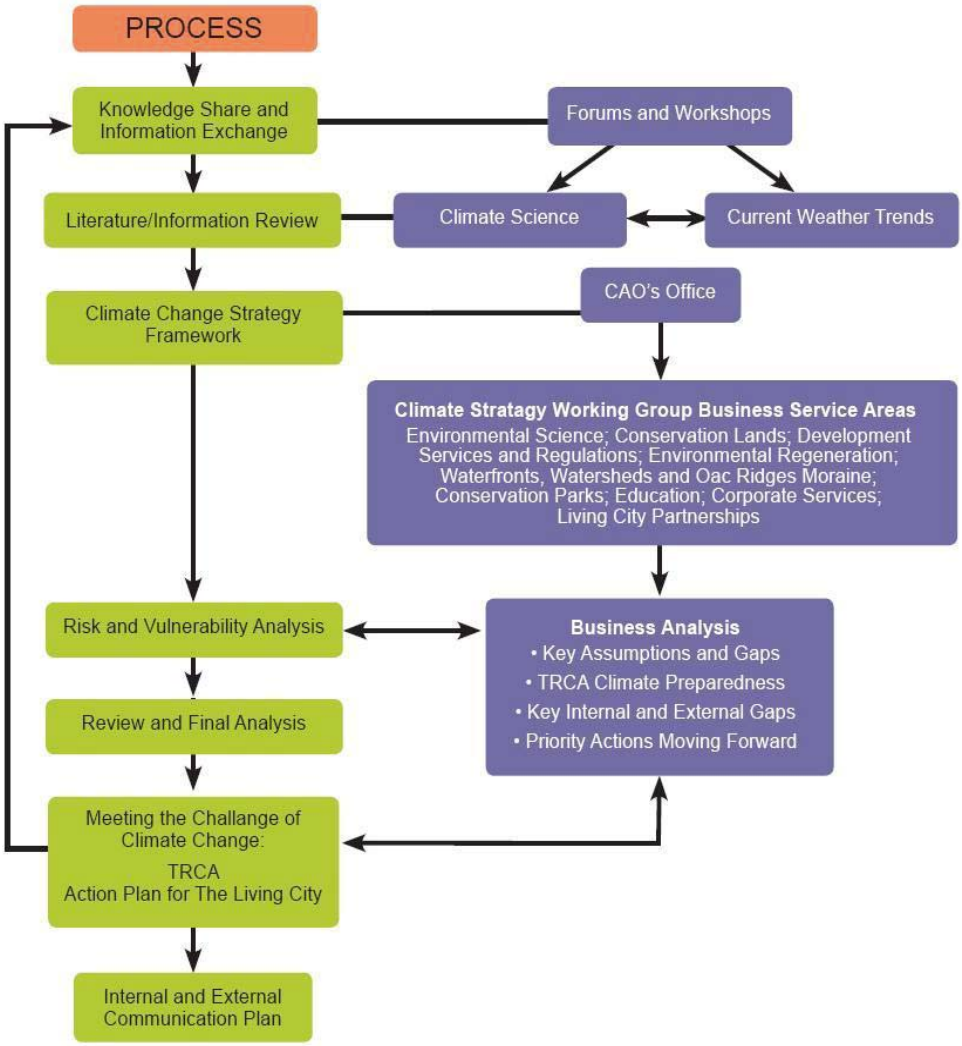

Figure 1. TRCA's strategy for the integration of climate change considerations into watershed planning initiatives (Source: Chandra Sharma, TRCA)

Even with a strong planning framework, an uncertain future means that we must "learn as we go" in our water management strategies. Wendy Leger (Environment Canada) and Rich Thomas (US Army Corps of Engineers) stressed the need for an **adaptive approach** to managing climate change. In the Upper Great Lakes Management Study direct use of future climate scenarios has been ruled out because of the unmanageable uncertainties in scenario results but adaptive management is being considered as an indirect approach to accommodate climate change. This parallels the current approach being examined for the Lake Ontario Management Plan. An adaptive-management approach has been added after difficulties developed in acceptance of a draft report that did not include AM. Obstacles to adaptive management include the need to change mandates to explicitly allow it to be considered, and the need to identify effective mechanisms to structure the collaborative actions required for adaptive management to be effective.

Rich Thomas reported that USACE is transforming itself in response to the criticism of previous USACE projects and policies in the light of New Orleans and other recent disasters. A large part of this transformation is a new emphasis on adaptive management. This is part of a general shift toward a comprehensive system approach and away from narrowly-focused single-purpose projects.

Linda Mortsch (Environment Canada) observed that effective adaptive management must begin with **a good understanding of the physical system**, and an exploration of the system's response to different hydrologic regimes and management plans. There is a need for an **effective and probably enhanced monitoring system**, to enable tracking of changes that may be subtle and gradual**. Improved computer simulation tools**, both for climate change scenarios and for local hydrologic response, may be a necessary part of an effective adaptive management strategy. Wendy Leger also noted the importance of **a set of rules, or guidance**, for changing water level regulation as climate and physical processes change, and a system for initiating alternative actions for mitigating and adapting to fluctuating water levels and climate change. Here again there is a need for **collaboration across political borders** and, as Rich Thomas pointed out, **clear designation of roles and responsibilities** for water level regulation and other aspects of water management.

The Province of Ontario has a number of important activities underway, to prepare the Province for climate change adaptation. In 2007, the Ontario Ministry of the Environment appointed an Expert Panel on Climate Change Adaptation. The report of that panel will soon be available to the public, for instance through Ontario's Environmental Registry (http://www.ebr.gov.on.ca/ERS-WEB-External/). The report is expected to emphasize actions that integrate adaptation strategies across government, and adopt a strategic approach to enable Ontario to "adapt well", by building community and institutional capacity, providing tools for managing risk, and supporting interjurisdictional collaboration.

Kathleen O'Neill (MOE) asked the question "Why is adaptation needed in Ontario?" And answered that the most compelling reason is economics with flood damage claims the current hot-spot of attention. Kathleen presented some outcomes of the Ministry's Climate Change Adaptation Summit, held in the spring of 2008. These findings were consistent with the points made by other speakers, and include:

- The need to integrate water management considerations into policies that affect the flow or availability of water resources
- Assessment of how changes in water supply would influence or be influenced by new activities or infrastructure
- Strengthening of watershed associations
- Improved water conservation, and economic valuations of water
- Care to ensure that policies do not provide counter-productive incentives, for example compensation to rebuild flooded houses on the same flood plain

Both Quentin Chiotti and Kathleen O'Neil emphasized the importance of two federal reports that emphasized the need for adaptation to climate change and set out the breadth of possible threats for all parts of Canada and all sectors of society. The two reports are Health Canada's Report "Human Health in a Changing Climate" and NRCAN's Canada Country Report 1998 from Impact to Adaptation. Key findings, as noted by Quentin, were: (1) Climate changes have been demonstrated, and apply to all Canadian Regions; (2) Changes will have the net effect of exacerbating current problems, and (3) Capacity to adapt is highly uneven among various sectors of society.

Discussion Questions

Following the presentations, participants discussed three core questions related to water management under climate change. These were:

> *Thinking about current water resource management issues and practices in Ontario discuss the following questions.*
>
> 1. Based on the current understanding of climate change what candidate adaptation strategies should be for immediate implementation?
>
> 2. What are the critical knowledge gaps preventing advancement of climate change adaptation and what further efforts are needed to fill these gaps?

3. What legislative, regulatory or policy changes are required in order to adapt to climate change? What is currently being done, and what more is needed?

Participants' responses to these questions are discussed in the following sections.

1. Based on the current understanding of climate change what candidate adaptation strategies should be for immediate implementation?

Better understanding of physical and social systems

Virtually every speaker and many participants emphasized the need for better understanding of the physical system. For example, Bob Walker (EBNFlo) itemized several key actions that are necessary as a basis for adaptation, including improved global and regional climate models; intensive monitoring at the local scale; standardized procedures for assessment of the impact of climate change; and establishment of effective networks for the sharing of information, data, and dialogue about climate change. Bob also noted the need for better estimates of human socio-economic futures, which will influence the ways that water is used in the future, and the amount and location of use.

Linda Mortsch made the point that this understanding cannot realistically be separated from human use of the resource, including the location and density of urban development and issues of social vulnerability and ability to cope with stress or change. Hazard analysis must include not only changes in the physical system (for example changes in flooding patterns) but also the number of people and structures that would be affected by that hazard.

Initiate no-regrets actions immediately

Several speakers, including Bob Walker and Chandra Sharma, noted the importance of undertaking "no-regrets" actions immediately. For example, water conservation makes sense regardless of climate, as does reduction of wasteful practices such as spray irrigation and excessive lawn watering. Full-cost pricing of water – requiring assignment of a true economic value to the resource – is similarly a common-sense strategy.

Some water management issues are already well understood and actions to address them are already underway. These include strategies to maintain base flows and reduce peak flows where flooding is an issue. Elimination of ponding wherever possible reduces associated heating and evaporative water loss, while encouraging infiltration, especially in high and medium potential recharge areas, reduces runoff and associated impacts on urban streams. Initiatives such as

these should continue as part of climate change adaptation, as their importance will only increase under climate change.

Chandra Sharma added that comprehensive stormwater management planning, aimed at reducing flows at the source, is another no-regrets action, as is management to encourage a robust and resilient natural heritage system. Adaptive design strategies, such as those used along the Lake Ontario shoreline and in the lower Don River, allow management actions to be modified as information about the system is acquired, and are therefore consistent with the adaptive management approach advocated by several speakers. Other "no regrets" actions cited by TRCA include enhancing greenspace and retention of an urban tree canopy, and improving public education and awareness of climate change impacts on water resources.

Recognize the system is dynamic (non-steady), not static (steady state); periodically review water management issues and goals

Most speakers, but especially Rob de Loë, Bob Walker, Wendy Leger, and Rich Thomas, noted the importance of formally recognizing that our water systems are dynamic, not static. Many of our policies and practices are based on the assumption of steady-state systems, but successful adaptation to climate change will require that we re-evaluate our watershed management goals to reflect inevitable and continual change. This likely means establishment of interim goals, with re-evaluation of those goals and any existing or emerging issues on a routine basis – again, consistent with adaptive management.

Put effective policies in place

Cindy Toth of the Town of Oakville observed that an effective policy framework is essential for adaptation to climate change. Good policies begin with clear definitions, for example of terms like "climate change", "adaptation", and "mitigation". And, as also noted by Wendy Leger, there is a need for a clear set of rules and action triggers. Cindy suggested that these might include a risk/vulnerability assessment framework that would allow assessments to be implemented at specified operational levels, and specific policies governing residential water management issues such as sewer backup protection and downspout disconnection. Local governments must also be prepared with health-related policies guiding action on diseases such as West Nile Virus and Lyme disease, on shade requirements, and communication to the public on heat and smog alerts, and air quality (e.g., AQHI). Policies may also be necessary to protect the interests of vulnerable people, such as the homeless, the elderly, and others who may be at higher risk of heat and air quality impairment.

Review and where necessary upgrade infrastructure

Several speakers drew attention to the need for review of infrastructure capacity in light of climate change. Cindy Toth suggested that such upgrades should

include sewers, culverts, and stormwater management ponds, which might have been designed for fewer extreme events and/or smaller flow volumes. Buildings should also be reviewed for weather resistance, for example to tornadoes, and new buildings should be designed with extreme weather impacts in mind.

2. What are the critical knowledge gaps preventing advancement of climate change adaptation and what further efforts are needed to fill these gaps?

Chronic shortages of field-level data

Speakers and participants identified a lack of sufficient field-level data as one of the most important knowledge gaps preventing progress on climate change adaptation. Adaptation will require detailed knowledge of meteorology, hydrology, and the physical characteristics of lakes and rivers, as a basis for understanding the physical system and its likely response to change. We need to be able to estimate the impact of climate change on important hydrologic processes such as evapotranspiration and depth and duration of snowpack. What will be our future storm patterns in terms of frequency (risk) and storm characteristics? How will the distribution of wet and dry days change? And following from these questions about the physical system are important questions about the effectiveness of our current management approaches: How will older stormwater management infrastructure perform in the future, in a warmer climate with more extreme weather events? How effective will low-impact development measures (intended primarily to handle smaller, routine storms) be? Will we be able to meet water supply requirements? Several speakers, notably Bob Walker, Chandra Sharma, and Cindy Toth, observed that current monitoring programs are probably not adequate to meet this data need. While we have a reasonable regional understanding of hydrologic systems, we currently lack the detailed, local-level system understanding that will be necessary to evaluate climate impacts on specific locations. Enhanced data sets will also be necessary to support computer simulation modeling, both of climate scenarios and of management alternatives and methodologies, and are important in the development of new design standards for infrastructure that incorporate climate change impacts. Some of this work is already underway in municipalities like Toronto and Oakville, but chronic shortages of field-level data continue to constrain our ability to understand water systems and prepare for climate change adaptation.

Dealing with high levels of uncertainty

A recurring theme in this workshop, as in other forums where climate change is discussed, is the high level of uncertainty that accompanies our projections of climate change. But as Bob Walker, Chandra Sharma, Linda Mortsch, and other speakers pointed out, there is also great uncertainty about human demographics, including the size and composition of the population over the next century, when

climate change will be most apparent; the location and form of future development; human consumption patterns, not only of water but of land, energy, and other resources; and the role, scale, and location of water-related industries such as agriculture and fisheries. This uncertainty makes it challenging to construct realistic scenarios for assessment of impacts under climate change, both in the selection of future climates and in the estimation of population growth and water demand.

Uncertainty also accompanies the interpretation of modeling results. How much predictive error is acceptable at a local scale? A regional scale? What tools are available for assessing uncertainty (error) in modeled results? If there are numerous plausible outcomes (as is likely to be the case), how should acceptable risk levels be determined?

This pervasive uncertainty is not only a challenge for decision-makers; it is also a challenge for the public, who may not understand why simple linear solutions are not forthcoming. We currently lack the tools and terminology for communicating uncertainty to the public. Improved public communication about uncertainty will therefore be an essential component of successful adaptation to climate change.

Lack of appropriate model policies (TRCA)

A changing climate has significant implications for the design standards municipalities and others use for buildings, flood control structures, and stormwater management infrastructure. Chandra Sharma pointed out that we currently lack standards and guidelines to support appropriate adaptation measures for these structures in a changing climate.

This issue also speaks to the need for better sharing of knowledge and experience among jurisdictions. Chandra noted that inter-agency cooperation is currently weak in Ontario, and may need to be strengthened for the development of effective model policies.

3. What legislative, regulatory or policy changes are required in order to adapt to climate change? What is currently being done, and what more is needed?

Enhance routine monitoring programs

Bob Walker stressed the need for policies that support and indeed require the collection of high-resolution data for climate change assessment at the local level. Chandra Sharma observed that the Ontario Ministry of Natural Resources is collaborating with Conservation Ontario on the review of ground and surface water monitoring networks in the province. More work needs to be done, however, to provide the enhanced science and modeling capacity needed to

assist end users with climate change projection data for the development of science-based defensible decisions.

Require climate change impact assessment as part of all water resource studies and implementation programs

In the past, water resource studies such as watershed management plans rarely incorporated climate change scenarios; rather, climate was assumed to be stationary. Bob Walker suggested that climate change impact assessment should in future be a required part of all water resource studies, and should include evaluation of measures to respond to anticipated climate change.

Chandra Sharma observed that the Ontario Regional Adaptation Collaborative is currently considering climate change impacts in the development of source protection plans and associated policies. In addition, Engineers Canada is developing an Engineering Protocol for the assessment of the vulnerability of infrastructure to climate change. In a similar vein, the Ontario Ministry of the Environment is embarking on a review of its stormwater management guidelines, with a view to incorporating climate change considerations.

The Ontario Society of Professional Engineers, in collaboration with Environment Canada, 10 conservation authorities, municipalities, and several provincial ministries, has undertaken a pilot project in Southern Ontario to develop a new approach to IDF curves. This pilot project will use Regional Frequency Analysis to screen data, identify homogeneous regions, choose appropriate frequency distributions for rainfall data, and estimate the regional frequency and duration of storms. The approach may however be constrained by a lack of sufficient rainfall stations, and/or stations with too short a period of data record. Nevertheless, Bob Walker pointed out that pilot projects like this, especially if undertaken in high-impact areas, will be valuable in testing the feasibility of alternative approaches, and will help to raise awareness of implementation issues in climate change adaptation.

Mainstream adaptation

All speakers noted the importance of “mainstreaming” adaptation to climate change - integrating climate change considerations into routine water management planning and decision-making. Some of this is already underway, as described earlier, for example with the Ontario Regional Adaptation Collaborative’s work on source protection plans and associated policies. Several other important initiatives are underway. For example, York Region, TRCA, and the Canadian Standards Association have a joint project to explore opportunities for mainstreaming adaptation.

Kathleen O’Neill described a number of the Ontario Ministry of the Environment’s activities aimed at mainstreaming adaptation. She told the group that the Ministry’s Expert Panel on Climate Change Adaptation will be providing advice to

the Province on adaptation and mitigation activities in areas such as public health, environment infrastructure, and the economy. The Panel has examined a number of provincial programs and policies related to water, including the Permit to Take Water, water conservation and efficiency, the Low Water Response Program, and water monitoring programs, and will be providing advice to the Province in their report. (At the time of writing, that report has been completed but is not yet public.) The Ministry will also be developing a climate change adaptation strategy for the Lake Simcoe watershed, in collaboration with MNR, OMAFRA, First Nation and Metis communities, the Lake Simcoe and Region Conservation Authority, and local municipalities, as part of the Lake Simcoe Protection Plan under the Lake Simcoe Protection Act (2008).

While initiatives like this are promising, Chandra Sharma pointed out that we still lack a national or provincial framework for climate adaptation. Given the number of agencies and stakeholder groups involved in Canadian water management, an effective framework for collaboration and information sharing will be essential for successful adaptation.

Cindy Toth described some of the activities underway in the Town of Oakville that are intended to mainstream adaptation. The Town now formally acknowledges climate change at Council and at the senior staff level, and has begun environmental scans on climate change impacts and risk assessment, including implications for municipal policy. In addition, the Livable Oakville plan defines and recognizes climate change, the community's impact on the environment (ecological footprint), and the need for adaptive environmental management of subwatersheds.

The Town has also taken formal steps to integrate climate change considerations into municipal infrastructure planning. They have increased the level of stormwater control in upper Oakville from the 1:100 year storm to the Regional storm, a level that requires significantly more volume control than the previous policy. Other initiatives include a requirement that predevelopment water balance conditions must be met in post-development scenarios, and incorporation of enhanced risk assessment, identification of homes at risk, and capacity limitations (bottlenecks) in the Town's Flood Prioritization Study/Plan. Taking responsibility for ongoing monitoring Oakville has established its own network of four meteorological stations, one for each quadrant of the town The Association of Municipalities in Ontario (AMO) has a Climate Change Working Group. The initiatives taken by cities such as Oakville provide are valuable guidance to this working group.

Strengthen Policy Framework

In addition to mainstreaming adaptation, so that climate change considerations are integrated into existing policies, there is a need to strengthen the current water management policy framework overall. Some of the weaknesses in the current framework have been known for many years, but they are increasingly

important in light of a changing climate.

Chandra Sharma identified the following policy areas that should be addressed as part of a climate change adaptation strategy:

- Effective land use policies to support water policies, possibly as part of the province's Growth Plan
- Provincial policies or regulations to deal with the replacement of ageing and inadequate municipal stormwater management infrastructure
- Comprehensive and integrated review and update of the *Municipal Act, Planning Act and Conservation Authorities Act*

In addition, Chandra suggested the need to build a "community of practice" – a pool of technical expertise with sufficient resources to support organizations as they prepare for climate change adaptation.

Cindy Toth pointed out the need to harmonize federal, provincial, and local policies, for example provincial codes and design standards, for climate change adaptation. This could be part of a national or provincial framework for adaptation, as suggested by Chandra Sharma.

Improve communication; build community and institutional capacity

As noted previously, improved public communication and strengthened community and institutional capacity are essential for successful climate change adaptation. Cindy Toth observed that this may be a significant challenge. People differ in their level of understanding of climate change and the uncertainty involved. Some may not believe that climate change is a reality. In the absence of persuasive local data, it may be difficult to impose enhanced standards, for example for stormwater management infrastructure, if they entail higher capital and operating costs. For that reason, it is essential that governments at all levels share data and knowledge, and collaborate on public communication strategies. There are a growing number of organizations working on climate change, making it difficult for municipal staff to track and consolidate information. A provincially coordinated policy framework and data-sharing system would simplify this task for local governments.

Results from the Workshop Breakout Session

In the afternoon participants at the workshop were asked to add their individual responses to the three questions. Three randomly selected groups of participants were formed and each group provided answers to each of the three questions. Participants with a variety of experiences and interests were present in each group. Provincial ministries were represented as were municipal and conservation authorities, educators, consultants, interested citizens.

The three questions were set out earlier in this summary. One question dealt with appropriate initiatives that could be taken immediately to respond to current understanding of the likely effects of climate change on water-related systems. The second question asked for identification of gaps in knowledge that prevented development of effective and appropriate long-term adaptation strategies. The third question looked at legislative and regulatory actions that would be required for governments at all levels to come to grips with climate change.

The three questions and the responses to each question are presented in detail in the attached appendix. Each question resulted in a rich variety of responses. There were 15 suggestions for available adaptation strategies, 24 separate knowledge gaps specified, and 23 recommendations for legislative/policy changes that either were needed or had already been instituted. There is very strong correspondence between the answers provided by the participants and the suggestions made in the various presentations.

Three types of adaptation initiatives were strongly supported. The first was **adoption of new stormwater management techniques** that are focused on control of overland flow volumes, recovery of predevelopment water balance, and maintenance or enhancement of infiltration and recharge to groundwater. This appears to result from an understanding of participants that climate change was likely to result in more high-intensity rain events and resultant increased problems of flooding and stream erosion if not properly dealt with.

A second popular adaptive strategy was a much-increased effort to implement a wide range of **water conservation** actions and policies. This response likely results from an expectation that climate-change will result in more and longer periods of dry weather including more frequent and severe droughts. Water conservation provides both more resilience in the water taking through an enhanced ability to function without interruption in periods of restricted ability of a source to supply water, and more resilience in the natural flow system by retaining more water in the system (reduced abstractions).

The third popular choice was for engagement in **community outreach and public participation** programs to build understanding of the vulnerability of water supply and conveyance systems to climate change and the need to have more resilient systems. The rationale for this is to encourage a culture of acceptance of the need for change and a willingness to adjust expectations to the reality of scarcity.

Participants were very engaged with the topic of knowledge gaps. They identified a wide variety of actions needed to overcome gaps. It is clear there was a strong consensus that **development of public policy on climate change** was very important and that a very large amount of work has to be done before long-term and effective responses are developed. Implicit in the responses is an

understanding that much more funding, and a much more coordinated effort among all levels of government is required to fill the gaps in knowledge.

A recurrent theme was the absolutely essential requirement **for long-term comprehensive monitoring** to both provide a baseline from which change can be measured and to quantify the rate and direction of change. The large natural variability in the needed data, both spatially and temporally, and the likelihood of enhanced variability in the future make this monitoring a technically challenging task. Adequate long-term funding, careful coordination and quality control on data collection, and full and easy access to all data are all key features. Australia was cited as a country that has risen to this challenge with the identification of a central agency for coordination of data collection and a very large budget of hundreds of millions of dollars allocated to the task over the next ten years.

Although not as frequently cited explicitly as monitoring, the role of **analysis and modeling of climate change** to fill knowledge gaps was also emphasized in the responses. As outlined in the morning presentations the first results from model projections of local (watershed-scale) effects resulting from various climate scenarios are just now becoming available. Much more work is needed to allow trustworthy downscaling from global climate-model results to regional and local scales and to reduce the uncertainty in the model representation of precipitation. Currently the temperature projections of models are much more consistent among models than the precipitation projections.

Better understanding of the **ability of various adaptive strategies to mitigate the effects of climate change** and to meet their intended performance standards was another highlighted need. The need for effective **education of decision makers and the public** using the new knowledge gained from additional research, monitoring and study was emphasized. The extent of change, the vulnerability to change and the requirement to accept and adapt to the reality of variability are some of the key messages to be delivered and understood.

The suggestions for **changes in legislation, regulation and policy** were formed around the common theme of full appreciation of the magnitude of the problems posed and making adequate adjustments to accommodate the full extent of changes needed. Changes in many pieces of legislation will be needed to make consideration of climate-change and adaptation compulsory Altering regulations and standards to facilitate acceptance of new approaches (after adequate confirmation of effectiveness) was strongly supported.

To make the necessary changes in legislation and regulations some form of **directed oversight** is needed. One suggestion was to form a **Federal/Provincial/Territorial Council of Ministers of Water** on the governance side and a Water Science Board to oversee the knowledge-generation aspects.

Report Summary

The presentations at the workshop and the contributions from participants in the breakout session together form a useful pool of information and policy suggestions related to understanding the needs for altered and expanded water-management policies in Ontario to correctly answer the challenges posed by climate change. Taken together with an ever-expanding list of other sources of guidance they can make a substantial contribution to the process of policy development

This workshop presented a snapshot of an ever-evolving scene. There is much ongoing work in the overall area of adaptation to climate change. Before the end of 2009 it is expected that a guidance manual for methods of analysis of the hydrological effects of climate change will be made available by MOE as part of the Source Water Protection Program.

As noted previously, the report of the Ministry of the Environment's Expert Panel on Climate Change Adaptation is expected shortly, and will address policy options for a provincial adaptation strategy

At the CWRA Annual Meeting at Quebec City in June 2009 several excellent papers were presented on hydrological analyses of expected results from climate-change. The abstracts of these papers are available on the CWRA website and enquiries could be made of the authors on the availability of the full paper.

We congratulate the presenters and the participants at the workshop for their insights and guidance on a major topic of vital concern not only to water managers but to everyone. Your hard work has helped to bring clarity and breadth of scope that are badly needed in the difficult task ahead. We have selected three policy areas to emphasize.

The workshop presentations and discussion uniformly emphasized the widespread realization among water-management professionals that adaptation to climate change must be made a central and integrated part of water-management planning and the implementation of water management strategies. The science of climate change supports the urgency of action and evidence is emerging of possible consequences of failing to act, especially in the specific field of increasing flood damage.

New or modified governance structures and instruments are needed that emphasize, encourage and/pr require adaptive management and its corollary of collaborative stakeholder engagement. Flexibility in guidelines and regulations, subject to appropriate confirmation of effectiveness, are required in the approval of installations and policies.

Gaps in data and analytic knowledge are a serious barrier to effective decision-making. Adequate resources of money and staff need to be applied on a continuing basis both to fill this gap and to provide the feedback from monitoring that is a key element of adaptive management. Effective open access to this data and the accompanying analysis is a key to building collaborative action and public support for changes in policy,

Appendix 1

Response of Workshop Participants to Breakout Questions

1. Based on the current understanding of climate change what candidate adaptation strategies should be considered for immediate implementation?

1.1 Improve land use (less impervious area) by encouraging more compact urban segments with smaller housing units, higher areal density, better public-transportation infrastructure.

1.2 Fully integrate watershed plans (with water-balance-matching requirements) into Official Plans for municipalities.

1.3 Adopt Low Impact Development techniques for stormwater-control systems. The larger role of infiltration in such systems helps mitigate the destructive effects of both more severe high-intensity rain events and longer drought intervals. **3/3 groups**

1.4 Increase the capacity of overland flow routes in urban areas to contain more extreme flow peaks, also allow more area for SWM storages.

1.5 Manage stormwater through Stormwater Utilities to provide dedicated funding from user fees, discourage creation of overland stormwater discharges and to emphasize the resource value of stormwater.

1.6 Increase effectiveness and efficiency of water transmission and storage systems through better management of storage, optimal allocation of water, reducing wasted water from pipe leakage and other sources of wasting of water.

1.7 Aggressively implement water conservation to reduce the withdrawals from natural-flow and thus build resilience in both the supply system and the natural-flow system. Techniques include re-use of renovated wastewater, rainwater harvesting, low-flush toilets, and economic incentives to use less (example increasing costs for “extra” units of water taken). **3/3 groups**

1.8 Conduct pilot-scale demonstration projects for improved water management and have an information exchange to make results widely available.

1.9 Federal and provincial governments should coordinate a set of standard protocols and new design standards for adaptation measures and combine this with a data collection system to track climate change and the effectiveness of adaptive measures.

1.10 Give priority to measures that provide immediate benefits beyond better adaptability to climate change.

1.11 Implement regulations that give priority place to green-energy sources.

1.12 Provide legislative support, including specific economic incentives, for system elements that provide adaptability and resilience.

1.13 Engage in community outreach and public participation programs to build understanding of the vulnerability of water supply and conveyance systems to climate change and the need to have more resilient systems. Encourage culture of acceptance of needed change. **3/3 groups**.

1.14 Try an event equivalent to “earth-hour” for energy conservation, but for water conservation.

1.15 Include climate change and adaptability as a core element in water resources courses at colleges and universities.

2 .What are the critical knowledge gaps preventing advancement of climate change adaptation and what further efforts are needed to fill these gaps?

Gaps

2.1 Poor understanding of the contributions of human activities to climate change.

2.2 Lack of modeling techniques capable of identifying local impacts of projected climate change.

2.3 Lack of awareness by public and policy makers of the extent of potential effects of climate change on water availability, the destructiveness of these effects, and the vulnerability of people to these effects. **2/3 groups**.

2.4 Lack of good-quality hydrometeorological and hydrological data on existing water quality and quantity to establish baselines. Precipitation and evaporation measurements are of key importance but the measurement network is extremely patchy and intermittent. **2/3 groups**

2.5 Lack of continuity and co-ordination in data collection. Both are needed to overcome gaps in information.

2.6 Lack of leadership in establishing who should collect and communicate data and what standards are needed for useful good-quality data.

2.7 Inadequate confirmation that Low Impact Development designs meet performance requirements.

2.8 Lack of appropriate design criteria and design tools such as flows for dam and dyke design, modified IDF curves for future climate scenarios.

2.9 Lack of good understanding of the interactions between groundwater and surface flows and how these interactions will be altered by climate change.

2.10 Lack of agreed critical-threshold criteria that establish which effects cause substantial damage.

2.11 Lack of understanding of how future water needs may change for various sectors (household, manufacturing, industries).

2.12 Lack of understanding of the possible effects of how changes in energy policies may alter the vulnerability of water systems to climate change.

2.13 Lack of an entry point for science knowledge in the political process.

2.14 Retention of rigid policies and regulations that inhibit adoption of new, better-in -.adaptation technologies. Treaties such as NAFTA may hinder new adaptive strategies. **2/3 groups.**

Required efforts

2.15 Creating widespread understanding and acceptance of variability as the norm for decision-making in water management.

2.16 Acceptance of responsibility for building sustainability and the need to invest now in capital works that can sustain future generations.

2.17 Establishing grass-roots advisory committees for local adoption of adaptive policies.

2.18 Continuing public education to raise awareness of areas of vulnerability i.e. new flood lines.

2.19 Conducting research that will result in design tools and measures of performance of new tools such as LID measures.

2.20 Defining most vulnerable areas where growth/landuse/water demand are likely to produce the most difficulties in terms of human response to possible future scenarios.

2.21 Making available information on local effects obtained by downscaling of global climate-change scenarios to the regional and local level.

2.22 Creating a template for data interpretation and applying it uniformly using local data.

2.23 Expanding the network of monitoring stations, maintaining the network long term (for continuity), and adding integrated ecosystem monitoring to flow rate and water quality monitoring. A central coordination agency with adequate funding is required. Possible models are the Australian Meteorological Service or in Canada in a different field Statistics Canada.

2.24 Adopting an approval system that can respond quickly to innovations following successful piloting (while maintaining the precautionary principle). The problem has been tackled with some success in medicine. **2/3 groups.**

3. What legislative, regulatory or policy changes are required in order to adapt to climate change? [What is currently being done and what more is needed?]

Changes Needed

3.1 Establish a Federal/Provincial Council of Water Ministers and a Water Sciences Board to give leadership in adaptation strategies to climate change

3.2 Commitment shared by all levels of government to coordinated comprehensive long-term monitoring with accountability for taking action if monitoring shows climate-change impacts.

3.3 Amend various acts to require inclusion in all planning of compulsory consideration of water conservation and compulsory provisions for adaptation/mitigation of effects of climate change; in particular require water conservation and climate-change-impacts to be included in all watershed and subwatershed planning. **3/3 groups**.

3.4 Review all legislation, regulations and policy documents (one example Permit to Take Water) to create an enabling environment that includes a broad interpretation of the scope of “water conservation”, use of sustainable-life-cycle analysis in costing of projects and incentive programs to encourage selection of flexible/diverse systems. **2/3 groups**

3.5 Amend legislation to conform to real adaptive management with an explicit recognition of variability and of the occurrence of some failures. **2/3 groups**

3.6 Produce new design standards for infrastructure that acknowledge requirements for adaptability and resilience in response to climate change.

3.7 Amend Provincial Policy Statement and shoreline regulations to allow for effects of climate change (an example - more winter wave erosion with longer ice-free periods)

3.8 Review flood-plain policy in light of climate change effects.

3.9 Introduce the policy of producer responsibility for dealing with all “waste” products.

3.10 Federal Fisheries Act needs revision (set new limits) to allow for climate change.

3.11 Add more coordination to Great Lakes management, within Canada and between Canada and the United States, to recognize climate-change effects.

3.12 Update Official Plans and related policies to establish sustainable limits for growth; make separate analysis of different land uses (separate residential from commercial), examine the cumulative and interactive effects of growth and climate change.

3.13 Develop transitional policies during the period of change in policies.

Current Actions

3.14 CEAA now requires impact of climate change to be included in analysis.

3.15 Approval process under the Aggregate Act now requires a review of effects of climate change.

3.16 Source water protection studies now require an analysis of future scenarios with climate change considered.

3.17 Incentive programs exist to reduce energy use (and emissions of greenhouse gases) an example is encouragement of solar, wind and geothermal installations

3.18 Conservation Authority and the City of London have adjusted IDF curves for climate change.

3.19 An example of potential for change is Okotoks, AB. This city has total green design and an upper limit population.

3.20 Permit to take water requires compulsory consideration of water conservation.

3.21 Ontario Power Generation has a guaranteed price for green energy.

3.22 City of Vaughan has tax incentives for high-efficiency buildings.

3.23 City of Toronto has by-law with incentives for green roofs.