Building Great Lakes Resiliency to Eutrophication:

Lessons to inform adaptive governance of the nearshore areas of the Laurentian Great Lakes

By

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Abstract

Annex 2 of the Great Lakes Water Quality Protocol calls for the collaborative development of a 'nearshore framework', but does not provide guidance with respect to nearshore governance. This thesis bridges this gap with a series of studies on the determinants for adaptive governance that will inform implementation of the Great Lakes Water Quality Protocol 2012.

The principal focus of this work is on eutrophication, which is essentially a nearshore issue. The methodology includes a comprehensive literature review and 35 key informant interviews using a standardized questionnaire. The results assess Great Lakes governance, examine the strengths of the Great Lakes Water Quality Agreement Protocol 2012 and evaluate the effectiveness of the International Joint Commission. A major product of the research is the development of a framework for assessing adaptive capacity based on six determinants: public participation, science, networks, leadership, flexibility and resources. The framework is validated in the case study of eutrophication in Lake Erie and used to identify gaps in adaptive capacity for current eutrophication governance of Lake Erie.

The framework was then tested on two additional case studies, the Chesapeake Bay and the Baltic Sea Region. These systems are both eutrophic and are similar in many other ways to the Great Lakes. This allowed exploration of issues of scale, from local (Chesapeake Bay) to binational (the Great lakes) to transnational (the Baltic Sea).

The most important finding of this work is that the key barrier for building adaptive capacity for eutrophication governance in the Great Lakes is the lack of adequate leadership and resources. A key recommendation is therefore that the IJC be strengthened in its role to function as a collaborative leader to foster adaptive capacity. The findings from this research can inform the implementation of the Great Lakes Water Quality Protocol 2012.

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Publication List

This thesis consists of the following papers:

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Paper V

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Paper VI

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Paper VII

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Co-Authorship

This thesis was prepared in accordance with the regulations provided by the School of Graduate Studies, McMaster University for a sandwich thesis. The contribution of the co-authors for each publication that makes up this thesis is described below.

All of the papers contained in this thesis, except Paper II and Paper V, were conceptualized and written by S. Jetoo and edited by Dr. G. Krantzberg. The ideas for the thesis, the methodology were the sole work of Savitri Jetoo, with supervision from Dr. G. Krantzberg. Paper II was part of the Great Lakes Futures Project and was co-written with A. Thorn. S. Jetoo was the corresponding author, who did all revisions. S. Jetoo wrote on all parts of the paper related to water quality while A. Thorn contributed to the water quantity aspects of the paper. The other co-authors acted as mentors and editors for the paper. For paper V, Dr. V. Grover contributed to the literature review while Dr. G. Krantzberg added bits on governance in addition to editing the paper.

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Chapter 1

Background and Objectives

1.1 Eutrophication of Lake Erie

On August 2^{nd}, 2014 the town of Toledo, Ohio in the United States issued a 'do not drink' water advisory for its approximately half a million residents. Subsequently, a state of emergency was declared in some counties by Ohio's Governor. This issue captured local, regional and international attention with diverse media headlines such as "Mayor says water crisis is similar to 9/11" (Troy, 2014), "Fertilizer pollution fears bubble in wake of Toledo water crisis" (Wilson, 2014), "Toledo water crisis: Half a million people without safe drinking water as toxins contaminate Ohio city supply" (Mayhew, 2014) and "Lake Erie's Algae Bloom Crisis is putting pressure on Ohio, Farm States to tackle agricultural pollution problems" (Gallucci, 2014). These headlines, though sensational at times, bring home the dialogue on eutrophication of Lake Erie and capture some of the key insights from scientists and government officials; Lake Erie is suffering from the impact of increased nutrient enrichment (eutrophication) from a suite of sources including agriculture. The message is clear: Lake Erie is severely eutrophic, the situation is getting worse, and causality of eutrophication is complicated.

The Toledo water crisis is not the only case of toxins tainting drinking water sourced from Lake Erie. During the same month of August 2014, on the Canadian side of the Great Lakes, Pelee Island also issued a 'do not drink' water advisory due to a toxic blue green algae bloom and the algal bloom also resulted in beach closings along Pelee Island by the Windsor Essex County Health Unit (CTV Windsor, 2014). Before this, in 2013, the Ohio lakefront community of Carroll Township issued a 'do not drink' water advisory to 2000 residents due to extreme levels of microcystin, produced by the second largest bloom of algae ever measured; the microcystin levels from this bloom were at 3.56 parts per billion (ppb), much higher than the WHO recommended 1.0 ppb for drinking water (Henry, 2013). These blooms are not constant each year, for their extent and duration can vary considerably depending on various conditions. The largest bloom occurred in 2011 and extended 120 miles from Toledo to Cleveland and the levels of toxin were 1200 times the WHO threshold for safe drinking water and 50 times the threshold for safe recreational water (Michalak et al., 2013). In addition to fouling beaches and contaminating drinking water, these toxins also deplete oxygen from the water (when they die and fall to the bottom, where their tissues are digested by oxygen-consuming bacteria), degrade fish and wildlife habitat and risk animal health possibly through incidences such as avian botulism (Riley, 2015).

Eutrophication of Lake Erie is not a new problem; since the 1960s and the 1970s harmful and nuisance algal blooms were major challenges in the Great Lakes that propelled the signing of the first Great Lakes Water Quality Agreement between the United States and Canada in 1972 (Botts and Muldoon, 2005). The 1972 Great Lakes Water Quality Agreement (the Agreement) provided impetus for the reduction of phosphorus (P) loading to the lakes by establishing binational loading targets for P discharges. These targets led to measures by the government to reduce P inputs, primarily through the upgrade of sewage treatment plants, the regulation of phosphorus in detergents and the introduction of best management practices for farmlands. Due to these measures, the loading of P in Lake Erie fell from 24 000 metric tonnes in 1967 to below 10 000 metric tonnes in 1987 (Dolan and McGunagale, 2005).

However, this trend has been reversed since the mid 1990s with a systematic increase in P loading in Lake Erie and a concomitant increase in algal biomass (Bridgeman and Penamon, 2010; Conroy and Culver, 2005) and the extent of oxygen depletion zones (Burns et al., 2005; Rucinski et al., 2010). According to leading Great Lakes scientists (for example Michalak et al., 2013), the increase in strains of Microcystis sp. (which forms the toxin hepatoxin microcystin) and Anabaena sp. (which forms the neurotoxin anatoxin) are cause for alarm as even their most harmless forms can cause immense stress to the ecological structure, functioning and the aesthetics of the Great Lakes. While point source pollution was the main target in the Agreement, it is unanimously agreed that the causes of the recent outbreaks are more complex, and include increased nutrient loading from urban settings due to land use changes, accompanying population growth, increases in nonpoint sources of bioavailable phosphorus from agricultural sources, increased precipitation events including severe storms, increased temperatures, longer growing seasons and changes to water clarity caused by the presence of aquatic invasive species particularly Dreissena rostriformis bugensis (quagga mussels) and Dreissenid polymorpha (zebra mussels) (Strickland et al., 2010; Bierman et al., 2005; Vanderploeg et al., 2002; Conroy et al., 2005; IJC, 2014).

It is clear from the Toledo water crisis, and the ones that preceded it, that these algal blooms are detrimental not only to the environment but also to the beneficial uses of the Great Lakes, such as recreational beaches and fish consumption. Algal blooms are responsible for the closing of some Great Lakes beaches (Marrison, 2015), result in conditions of hypoxia and anoxia and the concomitant degradation of fish and wildlife habitat, and have caused the death of birds and fish (Shumway et al., 2003). The Toledo water crisis is a key focusing event in the dialogue on the eutrophication of Lake Erie. It can be seen as an affirmation of widespread consensus that recent efforts to address eutrophication of Great Lakes have been inadequate.

This challenge of eutrophication is not limited to the Great Lakes – nutrient over-enrichment can be found in Chesapeake Bay in the USA, in Lake Winnipeg (whose watershed is shared by the US and Canada), in the kettle ponds of Cape Cod in Massachusetts, in the Gulf of Mexico, in the Baltic Sea, and in many other systems throughout the world. This research therefore includes a comparison of the efforts, scales, and governance mechanisms in the Great Lakes, Chesapeake Bay, and the Baltic Sea, with a focus on eutrophication as an example of stressor. The primary focus of the work is however application of these concepts to the nearshore areas of the Great Lakes, in order to inform the development of a nearshore governance framework.

1.2 The Nearshore Framework

Recently there has been much emphasis on the nearshore areas of the Great Lakes due to an increased appreciation for the importance of those areas in the larger Great Lakes ecosystem. The impacts of ongoing and emerging stresses to the ecosystem are often felt in the nearshore areas (Bails et al., 2005). Some of those stresses include extensive colonization of zebra mussels in the lower lakes (Hecky et al., 2004), introduction and establishment of other aquatic invasive species (Vanderploeg et al., 2002), algal blooms in Lake Erie (US EPA and Environment Canada, 2004; IJC, 2012), toxic contaminants and hydrologic modifications (Bails et al., 2005).

The breakdown of ecosystem function due to these threats has been seen by some authors as a failure of governance, because the Great Lakes institutions were unable to effectively address the policy issues (Manno and Krantzberg, 2008). The problems signifying a decline in Great Lakes governance have been said to stem from a "lack of institutional accountability, a lack of inclusion and engagement of non-governmental civic society and a lack of distributive governance that coordinates and is flexible" (Krantzberg et al. 2007). Other authors have observed that the Great Lakes governance regime has been in decline since at least the late 1980s (Botts and Muldoon, 2005). Further, the International Joint Commission (IJC, 2011) has identified governance as a key issue in its 15th Biennial Report, noting that "there is a critical need to modify existing governance to strengthen coordination across jurisdictional lines to address ecological challenges in the nearshore".

The problems arising in the nearshore have also been attributed to the failure to manage adaptively (IJC, 2011; Bails et al., 2005). For almost 40 years, various authors have called for the use of adaptive management for addressing complex problems in large systems (Holling, 1978; Gunderson, 1999; Walters 1986; Walters and Holling, 1990; Ostrom 2007, Ostrom 2009; Olsson, Folkes and Berkes, 2004; Folke et al. 2005; Huitema et al., 2009; Engle et al., 2011), such as Great Lakes ecosystem restoration (IJC, 2011; IJC, 2009; Hartig, 1997). Thirty-six citizen groups recommended the use of the adaptive management approach for governance of the Great Lakes in their comments on governance and issues for consideration during the 2010 renegotiation of the Great Lakes Water Quality Agreement (Great Lakes United, 2010), which resulted in adaptive management being one of the principles of the Great Lakes Water Quality Protocol 2012. Despite these widespread calls for improved governance and the use of adaptive management in the Great Lakes, there is no clear indication of how these approaches can be implemented in practice. This research aims to bridge this knowledge gap by researching the governance of eutrophication, essentially a nearshore problem.

1.3 Governance

What are some of the rules for governing the nearshore areas in this increasingly uncertain environment? Given the complex interactions of climate change, aquatic invasive species and nutrient loading, what factors can aid stakeholders in the reversals of eutrophication, for instance in Lake Erie? These are questions of governance, more specifically water governance. Water governance can also be seen as one arm of environmental governance, which deals with natural resource governance and describes the collection of norms, rules and laws and organizations that determine the use and protection of natural resources (Lemos and Agrawal, 2006).

It is necessary to take a look at governance before diving into the governance of water. According to the Oxford online dictionary (2014), to govern is to “conduct the policy, actions, and affairs of (a state, organization, or people) with authority”. This definition has a dictatorial tinge that is absent from the definition of governance, stated as “the action or manner of governing a state, organization, etc.” This is reflective of the more inclusive nature of governance as compared to government, where the former includes stakeholders such as the private sector, non-governmental organizations and the public in the action of governing. There are organizations such as the World Bank that still conceptualize governance in a top down “command and control” paradigm; the World Bank defines governance as the “process by which authority is conferred on rulers, by which they make the rules, and by which those rules are enforced and modified." (World Bank, 2014). This is in stark contrast to the more participatory approach as defined by the Institute of governance (Institute on Governance, 2014) as follows "Governance determines who has power, who makes decisions, how other players make their voices heard and how account is rendered". The inclusion of voices into the decision making process represents a shift to the more inclusive and participatory rather than the more traditional controlling rule of government.

This inclusivity is reflected in the definition of water governance by the Global Water Partnership (Rogers and Hall, 2003), as "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society". The strength of this definition is that it is interdisciplinary and but on the downside, it spans multiple areas; it is a very general and broad definition that spans the disciplines of politics, economics, administration and management. The UNDP water governance facility (2014) elaborates on this definition by listing three categories of things that water governance should address including

i. key principles such as equity and efficiency in the allocation of water resources and water services, integrated water management approaches such as catchment based management,
ii. forming and implementing water policies, laws and institutions and
iii. delineating the roles of all stakeholders in water allocation, management, ownership and services, roles such as conflict resolution, clarification of the roles of government, civil society and the private sector and their responsibilities regarding ownership, management and administration of water resources and services, including issues such as rights and gender and water, dialogue and coordination, participation and conflict resolution, corruption, standards and pricing issues.

This is a more comprehensive approach to water governance that includes a wider range of actions that is necessary for effective governance of water.

The structure of water governance is characterized by a diversity of stakeholders with diverse and sectorial interests and perspectives on water management. In addition to deciding how water is allocated, water governance systems protect water from pollution through the implementation of socially acceptable allocation and regulation of water resources and services (Rogers and Hall, 2003). Tropp (2007) also recognized this inclusion of actions in describing new forms of governance as "process oriented societal co-steering through formal and informal networks, partnerships and dialogue." On a larger global stage, water governance is defined as "the development and implementation of norms, principles, rules, incentives, informative tools, and infrastructure to promote a change in behavior of actors at the global level in the area of water governance" (Pahl-Wostl et al., 2008). This is a comprehensive definition that includes the tools and norms and incentives that will lead to a change in the behavior of actors, which is ultimately what water governance is about. This definition also speaks to the global reach of water. In the wider societal context, since the water sector is inextricably linked to broader political, social and economic development, water governance is influenced by the governing regime and societal concerns (Rogers and Hall, 2003).

All these definitions of water governance illustrate that different disciplines conceptualize water governance in different ways based. There is one clear consensus emerging from the literature; traditional governance approaches characterized by the 'command and control' model and fragmented institutions and regulations can no longer maintain the resilience of complexly linked socio-ecological systems as such approaches seek to reduce uncertainty inherent in these systems rather than embrace it (Dietz et al., 2003, Gleick, 2003, Pahl-Wostl, 2009). Traditional models of governance treat each natural resource problem discretely, oblivious to the coincident or parallel effects of complex socio-ecological systems (Folke et al., 2005) plagued by "wicked problems" with no clear or linear solution, problems such as climate change or eutrophication of Lake Erie, the Baltic Sea and Chesapeake Bay An effective governance mechanism that addresses eutrophication in the Great Lakes needs to clarify roles and responsibilities of many federal and state, provincial agencies that typically operate as sectorial siloes, that go beyond working independently of the local communities and stakeholders. It is increasingly clear that siloes don't work for many water problems because of the jurisdictional complexities and interdisciplinary nature of these problems.

Disenchantment with traditional forms of water governance has led to the emergence of new paradigms for managing uncertainty in complex socio-ecological systems; models that are more inclusive and adaptive to change such as adaptive governance. Key terms emerging from this discourse include vulnerability, resilience, adaptive capacity and adaptive governance, terms that will be discussed in the next section. These discourses are more suited to a complex problem like eutrophication of Lake Erie, the Baltic Sea and Chesapeake Bay as they hold the promise of increased collaboration among local, regional and governmental actors. The local nature of the problem of eutrophication means that communities in the nearshore areas can play a significant role in generating workable solutions.

These discourses propose loose networks of actors and institutions at many levels sharing resources and information as an alternative to the top down command and control paradigm. These new governance mechanisms can facilitate integration and transmission of local, scientific and technological knowledge expeditiously and are operationalized in a flexible and redundant manner among multiple actors who work across scales to develop cooperation and synergy to solve common problems (Lemos and Agrawal, 2006). These models are especially relevant to the problem of eutrophication in the nearshore areas of the Great Lakes, the Baltic Sea and the Chesapeake Bay as they promote social learning and compromise seeking, especially relevant for the multiplicity of actors at the local, regional and federal level with a stake in nearshore governance. According to Lemos and Agrawal (2006), these new governance models also recognize that the relation between international regimes and non-state actors such as NGOs is crucial for economic and legal arrangements, and is particularly relevant for eutrophication governance of the Great lakes as it affects economic and legal arrangements in both US and Canada. However, one of the limitations of these new governance mechanisms is that they may also fail to limit the negative externalities associated with implementation deficits (Lemos and Agrawal, 2006), as implementation is usually done at a different level from policy setting, an issue that is especially relevant to the eutrophication in the nearshore areas of the Great Lakes. While the Great Lakes water quality Protocol 2012 contains an entire Annex (4) for nutrients, lack of effective implementation in the past has led to exacerbation of the problems (McLaughlin and Krantzberg, 2011). Further, there is no defined governance process or nearshore framework in the 2012 Protocol, and it is that gap that this research aims to inform.

1.3.1 Changing Governance Lens - Social Ecological Systems (SES)

Water governance can be seen as the chain that links humans and water bodies. Humans make decisions to govern water bodies, decisions that impact both the water body and the decision maker and other stakeholders. In order to formally link the processes between humans and the environment and the feedback systems between them, the concept of Social Ecological systems (SES) was coined (Berkes and Folkes, 1998). As conceptualized by these authors, SES assumes that resources management is necessary, not just in a practical sense (for example, to target a maximum sustained yield) but rather that the management of an ecosystem requires equal emphasis on the resource and the social institutions impacting the resource. As such, SES refers to the group of social systems in which the interdependent relationships among humans are mediated through interacting ecological systems. One example would be when farming activities send nutrients into the lakes and changes the lake ecosystem, resulting in the growth of algae and impacting the drinking water supply and the ability of fish to survive in that environment. The concept of SES can be useful in the dialogue of eutrophication governance of water bodies, helping to frame the complex interactions between the human systems that impact the water body and the water body itself into a complete, unified whole, a framing within the bounds of systems analysis.

The literature on SES governance centers on the primacy of informal, self organizing and non institutional forms of governance that are driven by collaboration at various scales and that emerges to more closely match governance to the scale of the environmental problem at hand (Brunner et al., 2005; Scholz and Stiftel, 2005; Ostrom 2007; Ostrom 2009). One such informal collaboration in the Great Lakes was Great Lakes United, a group that emerged out of frustration with the inability of governmental systems to deal with problems of the Great Lakes. This resulted in a sense of Great Lakes Community, where there were more locally driven networks of individuals and communities united around Great Lakes issues (Botts and Muldoon, 2005). This in a sense was the start of the change from bureaucratic top down Great Lakes governance to the more inclusive governance that is characteristic of adaptive governance.

1.3.2 Adaptive Governance

The use of the term "adaptive governance" in the environmental context can be traced to a 2003 publication by Dietz, Ostrom and Stern. They made mention of the term in the body of the work and went on distinguish its difference to adaptive management in the reference as adaptive governance

> "conveys the difficulty of control, the need to proceed in the face of substantial uncertainty and the importance of dealing with diversity and reconciling conflict among people and groups who differ in values, interests, perspectives, power and the kinds of information they bring to situations" (Dietz, Ostrom and Stern, 2003, p1911).

This original conceptualization of adaptive governance in the context of governing the commons (the environment) described a flexible, multi-scalar, adaptive system for governing SES in a highly uncertain, changing environment where knowledge of the system can be wrong or incomplete (Dietz et al., 2003). Environmental application of the concept of adaptive governance can also be traced to two other schools of thought; literature on collaborations for environmental governance by political scientists (Brunner et al., 2005; Gunderson et al., 1995) and resiliency literature (Holling, 1973, Walker et al., 2004, Berkes et al., 2003. Folke et al., 2005).

Scholars from political science advocated for adaptive governance that integrates scientific and other types of knowledge into policies that advance open decision making structures, recognition of diverse viewpoints, the role of non traditional science and community based efforts (Brunner et al., 2005; Gunderson et al., 1995). This local scale participation in adaptive governance was further advanced by the conservation movement in the developed world, putting an emphasis on context and consensus building (Wondollect and Yaffee, 2000; Brunner et al., 2005).

Adaptive governance in the resiliency literature can be traced back to dialogue on adaptive management introduced by Holling (1978) as an alternative to the centralized expert management that was characteristic of the scientific paradigm that had no room for complexity and uncertainty inherent in ecosystems. According to Holling (1995), this 'science of the parts' was 'essentially experimental, reductionist and narrowly disciplinary', but needed 'science of the integration of the parts. …fundamentally concerned with integrative modes of inquiry and multiple sources of evidence'. Adaptive management was his answer to integration and conceptualized resource management as a systematic learning activity, where experiments were intentionally designed to improve understanding of the integrative SES (management understanding of the ecosystem and to improve the outcome of the resource e.g. fish stock).

Holling's (1973) conceptualization of resiliency is in stark contrast to the engineering definition of a preferred and restored steady state, with the aim of minimizing and controlling change to bring the system back to the original form. Holling advanced the concept of multiple steady states and persistence within systems and defined resilience as " a measure of the ability of these systems to absorb change of state variables, driving variables and parameters and still persist" (Holling, 1973, p 17). Resiliency through this lens embraces variability and redundancy and learning and focuses on policy that allows the system to embrace change, rather than controlling it (Folke, 2006). Governing an SES such as the Great Lakes for increased resilience to unexpected changes such as warming or increased precipitation is very important given how erratically and frequently these changes are occurring and how they impact eutrophication of the ecosystem. Resiliency has moved from solely ecological focus to natural resource governance (Folke, 2006). Adaptive governance is one route on the road to Great Lakes resiliency. This aligns well within the field of Civil Engineering, which is changing its paradigm of more traditional engineering approaches to encourage resilient infrastructure and adaptability to cope with a changing climate. For example, Godschalk (2003) recommends building resilient cities that recognizes cities as complex systems in which technological and social components interact and as such, the design of resilient cities needs to incorporate elements such as system redundancy, flexibility, collaboration and adaptability. It's the municipal engineering profession adapting, with its partners, to a changing environment. It involves the rethinking of design standards and nomographs in a collaborative fashion by a variety of interests and players.

According to the literature, the concept of adaptive governance has evolved as an analytical framework integrating elements of adaptive management (AM), adaptive co-management and water governance within the context of differing scales (Olsson, Folkes and Berkes, 2004; Folke et al. 2005; Huitema et al., 2009; Engle et al., 2011). Adaptive management has been dealt with widely in the literature as a management approach designed to reduce key uncertainties through the design of each management step as an opportunity for adaptive learning, where policies are treated as hypothesis that are tested through management experiments, leading to the concept of learning to manage by managing to learn (Holling, 1978;Walters, 2002; Pahl-Wostl and Sendzimir, 2005; Pahl-Wostl 2007). Adaptive management and adaptive co-management (collaboration added to adaptive management), when united with the participation of new actors and informal institutions of water governance, combine to foster cross level linkages, conditions for power sharing and ways to learn about appropriate goals (Huitema et al., 2009).

There are many definitions of adaptive governance which speak to the paradigm shift from traditional government-controlled static institutions with clear boundaries to the view of institutions as dynamic, flexible, pluralistic and adaptive to cope with the limits of predictability inherent in future climatic conditions (Berkes and Folke, 1998; Carpenter and Gunderson, 2001; Pahl-Wostl, 2007b). Adaptive governance is the facilitator of adaptive capacity and as such, adaptive capacity of institutions and communities can be increased through governance and policy approaches that are more flexible, participatory, experimental and designed for learning as these approaches contribute to building social-ecological systems resiliency under uncertainty. Adaptive governance systems facilitate these participatory approaches as under this paradigm, "systems self organize as social networks with teams and actor groups that draw on various knowledge systems and experiences for the development of a common understanding and policies" (Folke et al., 2005). Though experimental and flexible, adaptive governance systems are not ad hoc but respond to and shape ecosystem dynamics and change in informed manner (Westley et al., 2011).

Despite its many iterations and interpretations in the literature, there is little empirical evidence on experiences from on the ground implementation of adaptive governance. This points to one of the key weaknesses of this paradigm, a lack of data on actual cases of adaptive governance. According to the Stockholm Resiliency Centre (2014), adaptive governance is still an "***evolving*** research framework for analyzing the social, institutional, economical and ecological foundations of multilevel governance modes that are successful in building resilience for vast challenges posed by global change, and coupled complex adaptive SES" (author emphasis added). Further, adaptive governance is an emerging field still in its infancy with teething problems in implementation, in real world applicability and political pitfalls characteristic of adaptive theories (Medema et al., 2008). However, it could be argued that current initiatives at the national scale, aimed at re-thinking the design of urban infrastructure to improve resiliency, are an example of adaptive governance. Some of the pitfalls of adaptive approaches include the high cost of information gathering and monitoring, resistance from key players who fear increased transparency, political risk due to uncertainty of future benefits, difficulties in acquiring stable funding for experiments and the fear of failure (Lee, 1993). These weaknesses still exist and can be expected, as adaptive governance is still an evolving framework that needs further empirical evidence to substantiate the claims made in theory.

Within the adaptive theories' literature, adaptive governance and adaptive capacity are often used interchangeably, with no clear distinction. The two terms are very closely connected, as adaptive governance can be seen as the means of building adaptive capacity. Much of the literature has focused on governance for adaptive capacity in the context of climate change (Pahl-Wostl et al., 2007; IPCC 2007; Huitema et al., 2009) and as such, there are questions of applicability to other stressors, such as eutrophication; a gap that this research aims to address. Eutrophication governance fits neatly in this research theme as eutrophication in the Great Lakes is compounded by climate change and as such, it has many parallels with models for climate governance. Another important focus of this research is to help uncover the most important factors in adaptive governance that lead to more resilient real world outcomes, including engineering decisions affecting infrastructure, pollution abatement technology and operational consideration. There is also a noticeable lack of information in the literature on the ways governing for adaptive capacity affect stressors on large-scale ecosystems such as the Great Lakes and Chesapeake Bay. This research aims to address these knowledge gaps.

1.3.3 The adaptive cycle

The adaptive cycle is a heuristic conceptual model created by Gunderson and Holling (2002) through their observations of ecosystem dynamics that is useful for understanding disturbance and change and visualizing the non-linearity of social ecological systems (SES). This cycle plots the y-axis of potential and the x-axis of connectedness and shows the relationships amongst four phases: exploitation (*r*), conservation (*K*), release (*Ω*), and reorganization (*α*) (Figure 1). This figure is best explained by Carl Folke (2006, p258) as follows:

> "There are periods of exponential change (the exploitation or r phase), periods of growing stasis and rigidity (the conservation or K phase), periods of readjustments and collapse (the release or omega phase) and periods of re-organization and renewal (the alpha phase). The sequence of gradual change is followed by a sequence of rapid change, triggered by disturbance. Hence, instabilities organize the behaviours as much as do stabilities".

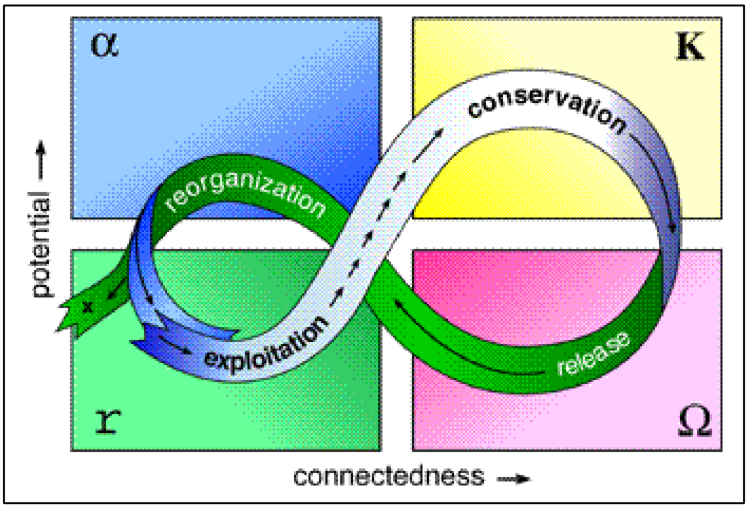

Figure 1 – The Adaptive Cycle (after Gunderson and Holling, 2002)

This metaphor of the adaptive cycle moves the dialogue from traditional ecology which focused on transitioning from occupation of recently disturbed areas (exploitation or r phase) towards a period of slow accumulation and storage of energy and material, to including two new additional functions of reorganization (alpha phase) and release (omega phase) (Gunderson and Holling, 2002). Recent engineering practice echoes this shift from a focus on linear analysis and static systems to more complex 'fuzzy' analysis better suited to dynamic systems. As applied to eutrophication of the Lake Erie, the exploitation phase speaks to the change of the ecosystem that occurs during nutrient enrichment from sources including agricultural runoff and sewage overflows and inputs of untreated sewage. This accumulation of nutrients by the Great Lakes ecosystem (the conservation phase) triggers collapse of the ecosystem, which is followed by reorganization and renewal through governance actions by stakeholder groups who launch experiments, such as the experimental lakes for conducting experiments to determine actions for return of resiliency of the ecosystem.

The adaptive cycle is useful for conceptualizing the non-linearity of SES, creatively showcasing the feedback loops that between these SES, as all SES exhibit properties of the adaptive cycle (Gunderson and Holling, 2002). SES are nested across geographic and temporal scales, a concept captured by Gunderson and Holling (2002) in proposing the term 'Panarchy'. Panarchy adds the ability to traverse scales in the adaptive cycle and conveys the idea cross scale interactions from nested cycles in three dimensions can change the space for innovation and scale (Figure 2).

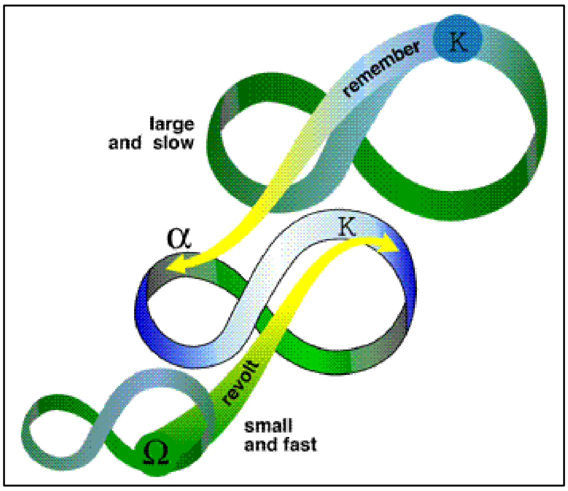

Figure 2 – Conceptual Map of 'Panarchy' (Gunderson and Holling, 2002).

Large changes across large scales of the cycles can disrupt memory of the old system, leading to a different set of conditions at new states on smaller scales; this is evident in ecological flow analysis which examines ecologically important flows at different scales and makes use of three dimensional hydraulic models that explicitly spatial variations and flow patterns important to flora and fauna (Bradford, 2008). This traversing of scales is the addition that Panarchy brings to the adaptive cycle. This concept of adaptive cycle can help in understanding why the building of adaptive capacity is necessary for buffering against large scale changes that can disrupt operations from the status quo and bring the system to operate under a new set of conditions.

1.3.4 Adaptive Capacity

According to Kashyap (2004), water governance is the ability to develop adaptive capacity, where adaptive capacity is defined as the "the ability or potential of a system to respond successfully to climate variability and change" (IPCC, 2007). A more general definition of adaptive capacity is the ability of SES to be capable of responding to both internal and external change (Carpenter and Brock, 2008). There are four general factors that build adaptive capacity in social-ecological systems (Folke et al., 2002): i. learning to live with change and uncertainty; ii. nurturing diversity for resilience; iii. Combining different types of knowledge for learning; and iv. Creating opportunity for self-organization toward social-ecological sustainability. According to Dietz et al. (2003), governance that facilitates these principles would involve many mechanisms for coordination and multiple decision-making centers. These factors are increasingly being adopted in the design of resilient cities and eco cities that are more adaptable to the impacts of climate change; New York has used this in the coastal adaptation planning, London in their climate adaptation strategy and Rotterdam in their 'Climate Proof Adaptation' Programme (Carter et al., 2015).

One such governance system is termed polycentric governance, where a governance system has multiple centers of power (polycentric) rather than one center of control (monocentric) and is more resilient and better able to cope with change and uncertainty (Huitema et al., 2009). This is because issues at different geographic scopes can be managed at different scales, polycentric systems have a high degree of overlap and redundancy that makes them less vulnerable and the large number of units facilitates experimentation that facilitates learning (Huitema et al., 2009). This concept is different from multilevel governance, which speaks to the involving of a wider range of stakeholders at all levels, making horizontal and vertical relationships very important (OECD, 2011). Polycentric governance on the other hand implies a network of different governance structures that facilitates choice alternatives. The complexities of coordinating and participating is a common challenge of both models while the polycentric paradigm has the added challenge of experimenting in real world environments and the politics of governance on a bioregional scale (Huitema et al., 2009).

In addition to governance, the IPCC (2001) has an extensive list of determinants of adaptive capacity as reported in Yohe and Tol (2002) as follows:

1. The range of available technological options for adaptation,
2. The availability of resources and their distribution across the population,
3. The structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed,
4. The stock of human capital including education and personal security,
5. The stock of social capital including the definition of property rights,
6. The system's access to risk spreading processes,
7. The ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers, themselves, and
8. The public's perceived attribution of the source of stress and the significance of exposure to its local manifestations.

This list of determinants of adaptive capacity is relevant to both the biophysical environment and the socio-economic reality of the situation. For example, from an engineering perspective looking at urban cities, the adaptive capacity of the physical infrastructure includes its quality and location, such as the subways, bus networks, utilities location and supply. The adaptive capacity, from a socio-economic perspective, of a city's population, includes differences in educational levels, awareness of climate change, economic status and relative mobility.

1.3.5 Adaptive Capacity for Eutrophication Governance

This thesis is the first to advance the concept of adaptive capacity for eutrophication governance. The concept of adaptive capacity is used widely in the climate change literature and was advanced and developed by the IPCC in the third assessment report (2001). This concept of adaptive capacity is useful for eutrophication governance as it has the potential to shift the dialogue from 'firefighting' or preventing nutrient over enrichment to looking at the factors necessary to build adaptive capacity. Effective eutrophication governance of the Great Lakes would be demonstrated in the ability of the governance system to alter processes or anticipate and respond to system changes to restore Lake Erie's resiliency. This research seeks to determine whether adaptive capacity is indeed adequately positioned to move the Great Lakes ecosystem under the stressor of eutrophication from a state of vulnerability to a more resilient status, by focusing on the issue of eutrophication of Lake Erie. Eutrophication governance that leads to adaptive capacity must contribute to SES resilience through adaptive measures at different levels and scales.

The current eutrophication event in Lake Erie has all the markings of a "wicked problem". According to Xiang (2013), a wicked problem is a social system problem where information is conflicting, leading to an ill formulated problem and where vested parties disagree on norms and values and goals. Some of the characteristics of wicked problems include:

i. the problem and solutions are not clear cut
ii. there problems can be managed but not completely solved and
iii. there are conflicting values amongst stakeholder groups, which vary with time.

Due to the compounding and complex interacting impacts of aquatic invasive species, climate change, nutrient loading and complex interactions of institutions, the eutrophication of Lake Erie is a wicked problem that needs novel governance solutions. The command and control governance system can no longer work in this highly uncertain, complex environment. A new governance paradigm is needed; one that is flexible and can deal with complex interacting stressors and that can adjust to uncertainties and changes. This thesis argues that one such approach is the building of adaptive capacity for eutrophication governance.

1.4 Methodology

1. 4.1 Measurement of Adaptive Capacity

The measurement of adaptive capacity can be challenging as it is latent in nature, which means it can only be measured only after it has been mobilized or realized (Engle and Lemos, 2010). As such, adaptive capacity can only be measured based on the probability that factors can increase or decrease adaptive capacity. This is the approach taken in this study. First, this research identifies factors for governance determinants of adaptive capacity from a comprehensive literature review. These factors are then tested empirically by studying system responses to past environmental variability as representation for future environmental variability. This approach allows assessment of how these factors are (or are not) present in the system during the past disturbance (Adger et al., 2003; Smit et al. 2000). For the case of eutrophication, system responses to past eutrophication events, especially the eutrophication of Lake Erie in the 1970s and subsequent return to resiliency in the 1990s, can help in identifying governance determinants that aided system response. This approach appears in the climate adaptation literature but has not previously been applied to eutrophication. According to Adger et al. (2007), empirical knowledge from past climate related events such as flooding and droughts can be useful in elucidating coping strategies and adaptive capacity. The role of governance and institutions in dealing with change has been highlighted in such studies on climate adaptation to extreme events (Engle and Lemos, 2010).

This research assumes that adaptive capacity is present if the eutrophication event has been governed successfully. Successful governance would result in lessening of nutrient loading to the water body, and positive ecosystem response as in the case of Lake Erie. Adaptive mechanisms are such responses that reflect the four factors that build adaptive capacity in SES (Folke et al., 2002): learning to live with change and uncertainty; nurturing diversity for resilience; combining different types of knowledge for learning; and creating opportunity for self organization toward SES sustainability. Some of these responses may include regulations, legislation, policy and institutional actions that occurred during the eutrophication events. In the current study, these governance determinants of adaptive capacity are used to explore adaptive capacity in the selected case of Lake Erie where there was a past eutrophication event. While it is recognized that the past may not be a good indicator of the future in a highly uncertain environment, the focus on past eutrophication events can provide useful insight for the governance of future events. Decision makers should be able to assess and develop responses to future eutrophication events through better understanding of the determinants of adaptive capacity.

1.4.2 Qualitative Research

The research was conducted using qualitative methods. Qualitative researchers are concerned with inquiries surrounding either social structures or individual experiences (Winchester and Rofe, 2010). Qualitative research was judged to be appropriate here as it can be used to evaluate the largely subjective experiences of participants in their evaluation of the determinants of adaptive capacity present during the recovery of Lake Erie in the 1990s. The qualitative approach was chosen as it is the most appropriate method to uncover the variety of viewpoints (Henderson, 1991). Qualitative approach will allow for flexibility as the researcher is the primary instrument for data collection and analysis (Merriam, 1998). The two types of qualitative research employed are textual and oral. In this research, the former is used as a source of underlying discourse of multijurisdictional process while the latter adds richness to the data. Textual methods use documents such as research papers, institutional reports and questionnaire responses and the researchers' tools such as field notes and transcripts. Oral methods use interview data.

Interviews facilitated the gaining of access to the knowledge of experts of eutrophication in the Great Lakes, the Baltic Seas and Chesapeake Bay in order to capture their knowledge and understanding of the determinants of adaptive capacity as applied to the eutrophication of the water body in their purview. For the purposes of this research, an expert was identified as someone who was knowledgeable about the water body under investigation by their involvement in prior projects (such as involvement in eutrophication issues in Lake Erie as identified in relevant literature) or by their position in an institution whose mandate included some aspect of eutrophication governance of the water body under consideration. The expert interview allowed the researcher access to the knowledge of the key stakeholders who possessed the technical knowledge and who also manage the consequence of this knowledge in practical decisions on eutrophication governance. This is consistent with the definition in the literature, where an expert is defined as a person who has knowledge about a given subject, knowledge that was acquired through training, research or skills and knowledge that others defer to for interpretation by the experts (Martin et al., 2012). Each expert interviewed was asked to identify and recommend another expert who could add another dimension or additional knowledge from a different perspective on the subject under investigation; this is termed “snowball” sampling (Mathison, 1988).

The interview process started with a literature review to identify organizations relevant to the eutrophication of the water body of interest. The next step was to make a list of these organizations and deciding what information was needed from this organization. These organizations were then investigated using the internet, scholarly literature and government reports to identify relevant personnel. The researcher then designed the study to determine what information was needed and the mode of extracting this information from the expert. Upon obtaining ethics approval, the researcher contacted the expert and set up a time for the interview. The interview was recorded using hand notes and then transcribed into word and stored for coding. This information was then analyzed to inform this research.

1.4.3 Case Study Methodology

A methodology is defined as “a theory of what can be researched, how it is to be researched and to what advantage” (Baxter, 2010, p.82). A case study methodology was chosen for this research. Qualitative research case studies are employed to explain phenomena when contextual variables are important (Yin, 2009). Case study research focuses on a single instance of a phenomenon in order to explain it (Baxter, 2010). The theory on adaptive capacity as described in the literature was first used to derive determinants of adaptive capacity. Those determinants were then tested in a data-driven approach by key informant interviews of persons who were involved in Lake Erie eutrophication governance in the 1980s-1990s. The depth of understanding derived from these interviews will help to academic understanding of the determinants of adaptive capacity for eutrophication governance. aid in solving the problem of governance in the Great Lakes by broadening One of the advantages of using the case study approach is that it facilitates the use of multiple sources (documents, questionnaires and interviews) of data, which can then be triangulated for a more robust understanding of governance in the Great Lakes Region. As Mathison (1988) suggests, data triangulation can help to show how various data sources and methods lead to a convergent conclusion about the phenomenon being studied.

1.4.4 Data Transcription and Analysis

The three broad tasks for data analysis included data reduction, data display and conclusion drawing for verification (Thomas, 2006). Data was reduced, evaluated, organized and analyzed using thematic coding (analyzing the data for recurring patterns or themes). Interviews were transcribed into computerized text documents and stored electronically with a hard copy backup. Latent analytical coding was conducted to reflect the themes of effective governance. In contrast to semantic coding (recording what the interview said or wrote), latent coding explores underlying themes or concepts. Coding was done with NVIVO, a qualitative research data analysis software package, making use of the interview questions and transcripts to identify macro and micro level codes. Coding aids were utilized including a codebook with list of macro and micro codes, a whiteboard and highlighters for identifying themes. The researcher immersed completely in the coding by allocating time that was spent only on coding and avoiding distractions. Coding was also discussed with the research supervisor. A colleague in the research field was requested to code the first transcript in parallel. This enhanced the reliability of the data (Cope, 2010). The macro codes were then used as headings in the report, while micro codes were used as sub headings. Participants were given the opportunity to verify their statements and also a copy of the report for their comments (if they so requested). Taped recordings were destroyed at the completion of the study and written information and the field work diary will be kept for a period of three years.

1.4.5 Research Ethics and Research Rigour

This research was approved by the McMaster Research Ethics Board. The researcher spent considerable time on the design of this research in order to ensure a rigorous approach. Lincoln and Guba's (1985) criteria of credibility, transferability, dependability and confirmability (Baxter and Eyles, 1997) for research rigour have been employed in this study design. To assure authentic representations and thus credibility in this study, a strategy of purposive sampling, peer review and member checking was used. Purposeful sampling and thick (detailed) descriptions of research methods, using examples to illustrate each determinant of adaptive capacity, also provide assurance that the findings are applicable outside the Great Lake context.

The plausibility of design (dependability) of the research was enhanced through the use of field notes and audio recordings with verbatim accounts and narratives. Peer checking was used in data analysis and the researcher's supervisor and supervisory committee functioned as auditors of the process. For confirmability (the degree to which findings are determined by the respondents and not by the researcher's biases or motivations) the researcher was conscious of her role as an instrument through which the experts views were interpreted. To minimize any bias on her part, an audit trail was established through raw data, field notes and researcher journal, audio tapes, transcripts and coding notes. She was also conscious of her role as a novice researcher and consulted with her supervisor and peers continually.

1.4.6 Detailed Methodology

The following are the steps that were undertaken during this research:

1. The determinants of adaptive capacity were developed through a thorough review of the literature on governance and adaptive capacity using research articles from databases and institutional reports;
2. This data was tested and complemented through a series of key informant interviews conducted with Great Lakes experts who were part of the Lake Erie eutrophication governance process from the 1970s to the 1990s. This enabled the theory-driven determinants to be validated so that determinants that were not useful could be removed.
3. This iterative process lead to the compilation of the final list of determinants of adaptive capacity for eutrophication governance.

4. The presence of these determinants was assessed in similarly chosen water bodies under the stressor of eutrophication. In selecting these cases, the following were considered:
   - The context – to be comparable, the cases had to be of similar developmental context to the Great Lakes
   - The scale – since scale is one of the factors to be considered, it was deemed important to select comparator cases that were solely national and also international, to contrast against the binational Great Lakes.
   - The access – it was important that these jurisdictions were accessible to the researcher to be able to conduct interviews.

Using these criteria, the Chesapeake Bay in the US and the Baltic Sea were chosen as comparison cases.

5. The determinants for adaptive capacity for eutrophication governance were assessed through literature review and semi structured interviews with key stakeholders in Chesapeake Bay and the Baltic Sea.
6. Conclusions were drawn and recommendations developed to inform the structure and operation of an effective nearshore governance/management system for the Laurentian Great Lakes.

1.5 Research Goals

The fundamental research question asked by this thesis is as follows: *What are the governance determinants of adaptive capacity and resilience to eutrophication?*

The overall objective of this thesis is to contribute knowledge for the development of the Great Lakes Nearshore Framework, as set out in the Great Lakes Water Quality Agreement Protocol (US and Canada, 2012). More specifically, this thesis aims to guide the development of a nearshore governance framework. It is also intended to contribute to comparative water research for, as noted by Wescoat (2009), "…in light of critical water problems faced in every region of the world, the next twenty years will require a major shift from largely implicit comparisons to rigorous comparative analyses". Additionally, this research is intended to guide policy options by providing recommendations on building Great Lakes ecosystem resilience to eutrophication through enhanced adaptive governance capacity. These goals are achieved through the following objectives:

1. Contribute to the dialogue on the need for a nearshore governance framework, including identification of the challenges in framework development and the type of thinking that is needed to advance its

development. {Chapter Two}

2. Identify the recurring themes in the history of Great Lakes governance that impact its sustainability and use them to imagine future potential scenarios, including a best-case scenario of a sustainable Great Lakes and St. Lawrence River Basin with robust governance in place, the status-quo scenario of business as usual and, a worst-case scenario of poor governance that contributes to potential ecological disaster. {Chapter Three}

3. Analyze the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the Great Lakes Water Quality Agreement Protocol 2012 to aid in deducing strategies to maximize strengths and opportunities and minimize weaknesses and threats to achieving the purpose of the Protocol and in the development of the nearshore governance framework. {Chapter Four}

4. Acquire evidence from primary and secondary literature to assess the effectiveness and potential leadership role of the International Joint Commission as a transboundary bi-national governance institution involved in implementation of the Great Lakes Water Quality Agreement Protocol 2012. {Chapter Five}

5. Link eutrophication to public health so as to frame eutrophication governance under the public health lens to motivate key stakeholders to take action; use the water safety planning approach, and the Toledo drinking water crisis as a case study to demonstrate that a risk management approach could help with prevention of contamination of the water supply and ultimately, with lessening nutrient enrichment of source waters {Chapter Six}

6. Propose a framework for assessing the presence of adaptive capacity for eutrophication governance based on determinants of adaptive capacity derived from literature; validate these determinants thorough semi structured interviews in a baseline case of Lake Erie that went from severe eutrophication to restoration of resiliency. {Chapter Seven}

7. Using the framework developed in Chapter Seven, analyze the adaptive capacity for eutrophication governance in the Chesapeake Bay and Baltic Sea regions and compare these two cases; develop recommendations to inform governance reform in the Great Lakes.

{Chapter Eight}

8. Conclusion and Recommendations {Chapter Nine}

This thesis follows the format for McMaster University Sandwich thesis. Each chapter was written so that it can be published independently and as such, there is overlap. In particular, chapter 1 which sets the introduction and introduces the thesis, will have many overlaps with other chapters in the thesis. Papers that were not assigned section numbers in published manuscripts were formatted in accordance with the rest of this thesis and hence assigned section numbers.

1.6 Contribution to Scholarship

The concept of adaptive capacity has been especially prominent in the field of climate change, but has been less widely applied in other areas of investigation. In particular, the literature contains no evidence of research on adaptive capacity as it relates to the stressor of eutrophication. This research fills that gap by contributing to the theory of adaptive capacity as it applies to eutrophication and its governance. It also serves to advance the dialogue on eutrophication and the building of ecosystem resilience through implementation of strong adaptive capacity determinants. Further, it has a methodological contribution as it advances and tests a framework for assessing the determinants of adaptive capacity for eutrophication governance. The comparative studies serve to test the determinants of adaptive capacity and provide deeper empirical insights into adaptive capacity at different scales: at the local level in the case of the Chesapeake Bay, at the binational level in the case of the Great Lakes and at the transboundary international level in the Baltic Sea. This research is also significant for other reasons:

- It demonstrates how adaptive governance can be built and operationalized through adaptive capacity to restore ecosystem resiliency;

- It advances understanding of how adaptive capacity differs at different scales; at the local scale of the Chesapeake Bay, at the binational scale as in the case of the Great Lakes and at the international scale as in the case of the Baltic Sea;

- It contributes methodologically to the conceptualization of the determinants of adaptive capacity.

- It adds empirical data to a small body of comparative research in water governance.

1.7 Contribution to Engineering

The challenges to the Great Lakes ecosystem posed by eutrophication clearly reflect the changing world in which we live, and demonstrate that traditional engineering solutions such as pollution abatement technology are no longer sufficient to solve these complex, "wicked" issues. As a discipline, civil engineering has already begun to embrace this complexity through an expanded vision of the engineer's role in planning, management, and policy development. Nowhere is this more evident than in Section 1 of the Professional Engineers Act (RSO 1990: Ch.28), which defines the "practice of professional engineering" as meaning "any act of planning, designing, composing, evaluating, advising, reporting, directing or supervising that requires the application of engineering principles and concerns the safeguarding of life, health, property, economic interests, the public welfare or the environment, or the managing of any such act." The current research is consistent with this vision, linking water quality impairment (traditionally approached with end-of-pipe solutions) to the social and economic systems necessary for better planning, evaluating, advising and reporting systems. It demonstrates that responsible engineering practice is enriched by the application of engineering principles in this broader context of safeguarding economic, public and environmental welfare.

There is an increasing recognition among engineers that water resources and civil engineers cannot do their jobs without an interdisciplinary education and practice (Duderstadt, 2008; Grigg, 2013). As society faces complex challenges, such as threats to urban infrastructure due to the increased frequency of extreme weather events characteristic of climate change, it is increasingly apparent that traditional, narrowly focused engineering approaches are inadequate and that multi-disciplinary knowledge of social and ecological systems are needed by engineers to confront technical issues. In the words of Grigg (2013):

> "There is broad agreement about the need for civil engineers to know about key issues such as how government sets policy, how major laws, such as the Clean Water Act, were developed, and how the gas tax relates to the size of the U.S. debt and tax burden. ABET addresses these issues with criteria about broad education, knowledge of contemporary issues, and multidisciplinary teamwork, but civil engineering educators and advisors are faced with many demands for the curriculum and seem unsure about how to include them in program

> design and as- sessment as compared to topics of science, mathematics, and engineering". (Grigg, 2013, p.4)

As Gleick (2000) and others have argued, effective water management in a changing climate calls for new thinking and new actions. Gleick argues that "Part of the problem, …also lies in the prevalence of old thinking among water planners and managers…Water resource planning in a democratic society must involve more than simply deciding what big project to build next or evaluating which scheme is the most cost-effective from a narrow economic perspective." This thesis contributes to this multidisciplinary lens needed in engineering by demonstrating a practical framework for development of adaptive – and interdisciplinary – governance systems for the Great Lakes. This work advances thinking, not only about management of eutrophication, but also about how consideration of social, economic, physical, and biological systems can enrich development of adaptive governance to address a problem of mutual concern..

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Chapter 2

Donning our thinking hats for the development of the Great Lakes nearshore framework

Savitri Jetoo and Gail Krantzberg

2.1 Introduction

Recently there has been much emphasis on the nearshore areas of the Great Lakes due to an increased appreciation for the importance of those areas in the larger Great Lakes ecosystem. The impacts of ongoing and emerging stresses to the ecosystem are often felt in the nearshore areas (Bails et al, 2005). Some of those stresses include extensive colonization of zebra mussels in the lower lakes (Hecky et al., 2004), invasion by other aquatic invasive species (Vanderploeget al, 2002), algal blooms in Lake Erie (US EPA and Environment Canada, 2004; IJC, 2012), nonpoint source loadings of nutrients, pathogens and contaminants, particularly during more frequent severe storm events, toxic contaminants and hydrologic modifications (Bails et al, 2005).

The breakdown of ecosystem function resulting from these threats has been seen as a failure of governance as the Great Lakes institutions were unable to effectively address the policy issues (Manno and Krantzberg, 2008). The problems signifying a decline in Great Lakes governance have been said to stem from a "lack of institutional accountability, a lack of inclusion and engagement of non-governmental civic society and a lack of distributive governance that coordinates and is flexible" (Krantzberg et al. 2007). The Great Lakes governance regime has been in decline since at least the late 1980s (Botts and Muldoon, 2005). Further, the International Joint Commission (IJC, 2011) identified governance as a key issue in its 15th Biennial Report, noting that "there is a critical need to modify existing governance to strengthen coordination across jurisdictional lines to address ecological challenges in the nearshore".

2.2 The Nearshore Framework

This call for attention to the nearshore areas has resulted in new language under Annex 2 in the 2012 Great Lakes Water Quality Protocol: "develop, within three years of entry into force of this Agreement, an integrated nearshore framework to be implemented collaboratively through the Lakewide Management process for each Great Lake." If approached inclusively by the Great Lakes Executive Committee[1], this new specific direction in the Protocol could signal an opportunity for stakeholders to work together in designing a nearshore governance framework that is flexible to respond nimbly to changes in the environment and proactive in anticipating mitigative measures to address future challenges. A nearshore governance framework is envisioned as a conceptual structure that shows the scale, the arrangement and flows of information and the relationship between central practitioners in the Great Lakes nearshore regions to facilitate cooperative decision making that increases the capacity for program and policy implementation leading to a sustainable Great Lakes basin ecosystem.

2.3 The Six Thinking Hats for the Nearshore Framework

The creation of a nearshore governance framework is challenging as it involves considerations of uncertain, complex problems such as climate change, and co-management decision making that crosses political boundaries. A successful framework will require innovative thinking, beyond the habitual thinking style by Great Lakes Stakeholders. Such thinking as proposed by Edward DeBono's (1999) 'Six thinking hats' can be useful for the development of the nearshore governance framework as it breaks the task at hand into different components using symbolic hats, each of which highlight one feature of the problem. This process simplifies thinking by allowing the user to think about one thing at a time while allowing for the categorizing of feelings regarding a problem, thus separating facts from biases and concerns and allowing a switch in thinking (DeBono, 1999). DeBono's six thinking hats method has been used extensively to spur organizational creativity. Postprogram analysis has shown that these methods significantly improved idea generation for effective problem solving (Birdi, 2005). Further, in the study conducted, the six thinking hats method scored higher in improvements in work related idea generation than other thinking models (Birdi, 2005). As such, this model would be useful for the generation of ideas by stakeholders for the visioning of the nearshore framework.

The six thinking hats can allow for the development of the nearshore

[1] Under Article 5: "The Parties hereby establish a Great Lakes Executive Committee to help coordinate, implement, review and report on programs, practices and measures undertaken to achieve the purpose of this Agreement"

framework while transcending the rut of bureaucratic, top down governance. This method can be used as a framework for the group creative process in brainstorming nearshore governance processes. It can foster parallel thinking if all stakeholders adopt this method, creating a shared focus and more efficient process. These hats can be applied to the development of the nearshore governance framework as follows:

2.3.1 White Hat – Objective facts for the development of the nearshore governance framework.

The nearshore areas of the Great Lakes are home to over 34 million persons and as a result of the associated activities, the anthropogenic effects are detrimental to the Great Lakes ecosystem. This is evident in the 43 (now 39) Areas of Concern (AOCs) located in the nearshore areas of the Great Lakes. These AOCs span eight states, one province, two federal governments, numerous municipalities, First nations' reserves and Native American lands. This is an illustration of the complexity of governance, with the multiplicity of actors and actions required that must be taken into consideration in the development of a practical and pragmatic framework.

2.3.2 Red Hat – Intuitive view for a nearshore governance framework.

With the red thinking hat on, the deterioration of the nearshore area seems to follow from the overall focus on the open waters of the Great Lakes Water Quality Agreement prior to the 2012 Great Lakes Protocol (the Protocol). With the inclusion of the nearshore zone in the Protocol, it would follow that more resources will be allocated to address the issue for implementation of the Protocol to proceed. Resources would be required to harness stakeholder support and engagement in the development of sustainable restoration and protection interventions. The Great Lakes Futures Project [http://www.uwo.ca/biology/glfp/index.html accessed October 4, 2013] is one example applying Red Hat thinking towards Great Lakes Restoration. This project was a transboundary, multidisciplinary endeavour that used scenario analysis to examine alternative futures for the Great Lakes-St. Lawrence River Basin. Participants (including university students mentored by faculty members, government and nongovernment organizations) critiqued the current state of the basin and envisioned alternative scenarios for the future, creating a vision and pathway for the future that can be useful for decision makers.

2.3.3 Black Hat – Challenges to the development of the nearshore governance framework.

There are many challenges to the development of a nearshore framework. Some of these include:

- The multiplicity of actors and disciplines involved in the protection and restoration efforts means that there are differing perspectives and conceptual backgrounds that must be taken into account.
- Nearshore degradation is as a result of complex interdependent processes exacerbated by a changing climate for which there are no proven standards of governance.
- The nearshore spans many scales from local, to regional, to transboundary with many interactions across a range of spatial and temporal scales. As such, the nearshore governance framework needs flexibility to adjust to different levels of complexity.
- First nations and Native American inputs are critical for the development of a comprehensive nearshore governance framework. Input has to be solicited in a way that is non-invasive and respects the traditions and customs of these stewards of the Great Lakes.
- The nature of the problem in the nearshore is uncertain and changing at any given instant. This is challenging to the development of a nearshore governance framework as it needs to include mechanisms to accommodate these changes.
- There is no fixed definition of what constitutes the nearshore areas of the Great Lakes.
- The term governance itself is often not well understood. The elements needed for sustainable governance of the great lakes have been identified as “active public participation, ecosystem based management, multi-jurisdictional collaboration and a

shared sense of responsibility for stewardship by the people and their leaders" (Manno and Krantzberg, 2008, 163)

2.3.4 Yellow Hat – Optimistic outlook for a nearshore governance framework.

For the first time, the Great Lakes Water Quality Protocol (2012) includes the need for an Integrated Great Lakes Nearshore Assessment and Management Framework in Annex 2, the Lakewide Management Annex. The Protocol is realistic in allocating three years for the development of the framework. Included in the nine bulleted items for what the nearshore framework will encompass is the development of a collaborative model to engage stakeholders and agencies that are involved in restoration activities. There is an opportunity in the non-prescriptive nature of the wording of the latter terms which invites development of a nearshore framework that is free from prescriptive solutions and free to explore adaptive management solutions. There is also an opportunity to engage the Great Lakes community in the development of this framework. One such community is the Great Lakes Policy Research Network, which is a collaborative transboundary network formed to address the existing gap in generating policy knowledge focused on the Great Lakes [http://www.greatlakespolicyresearch.org/, accessed October 4, 2013]. The network aims to improve policy outcomes by engaging Great Lakes stakeholders in three research priority areas: transboundary governance capacity and policy implementation challenges, elite and public opinion about Great Lakes issues and engagement of governmental, non-governmental and other stakeholders in policy issues. This represents a ready pool of resources to be utilized in the development of a nearshore governance framework.

2.3.5 Green Hat – Creativity and new ideas for a nearshore governance framework.

There are many successful transboundary governance regimes that can be examined for lessons in the development of a nearshore governance framework for the Great Lakes. Any framework must be adaptive, that is, have the ability to self-adjust after a period of systematic monitoring and review and incorporate this feedback into the system. Lessons can be learnt from regimes that are multi-jurisdictional, have well-defined governance systems and are well equipped to undertake comprehensive self-evaluations. There may be an opportunity to learn from marine coastal management initiatives if the nearshore is redefined as the coastal zone of the Great Lakes. This will allow for lessons learnt from integrated coastal zone management (ICZM) initiatives such as the European Union demonstration projects and their eight principles of good ICZM (Rupprecht Consult, 2006).. Another out of the box thinking approach is the idea of a governance index that allows for comparison of governance approaches across basin, region and the world. Such an index can be developed qualitatively using reasoned judgement of Great Lakes experts.

2.3.6 Blue Hat – Organizing, process control for a nearshore governance framework

This is the practical aspects of the development of the nearshore governance framework. The methodology that will be used by the authors includes the definition of what constitutes good governance in nearshore areas, the use of questionnaires and key informant interviews to solicit the views of experts and key stakeholders and the ultimate development of an adaptive nearshore governance framework. The development of such a framework is the first step in the quest for better governance of the Great Lakes. Engagement and positive involvement of stakeholders is central to this process to build ownership and advance implementation, and ultimately determine the success of any governance framework for decision making that will lead to a resilient Great Lakes Basin ecosystem.

2.4 Conclusion and Recommendation

The sporting of these thinking hats will allow for processes that will lead to the inclusive development of a nearshore governance framework that can guide decision making to improve the nearshore areas of the Great Lakes. It is envisioned that this governance framework will benefit from working with existing institutional mechanisms for a more participatory, integrated and flexible approach that can respond to the integrated sources of stress that are degrading the nearshore areas. This governance framework must recognise the value of the Great Lakes ecosystem while representing the diverse interests in the basin. The nearshore governance framework will only be successful if it fosters a sense of community, a sense of belonging of all stakeholders in the basin. Or in the famous words of Aldo Leopold “We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect”. Ultimately the nearshore areas will only be restored when we who live and dwell in the Great Lakes basin recognise the entire basin as our home.

To advance these ideas into the realm of implementation we suggest that a coordinating body such as the IJC, in cooperation with the Great Lakes Executive committee identify a representative cross section of stakeholders for input in the process of defining or re-defining the nearshore zone. This could be undertaken as a concerted effort at an IJC semiannual meeting, where the Parties and informed stakeholders gather to assess progess in addressing priority areas of policy development and delivery. Getting a common vision for what is meant by the 'nearshore framework' could include parsing the concept into operational nearshore monitoring programs, nearshore governance structures, and nearshore coordination of project design and implementation. Achieving consensus on the definition of the nearshore governance framework in particular can result in an engaged Great Lakes community of stakeholders who participate in the development, testing, monitoring, evaluation and adjusting collaborative governance arrangements in a formalize, continual fashion.

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Chapter 3

Governance and Geopolitics as Drivers of Change in the Great Lakes-St. Lawrence Basin

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Abstract:

This article provides an overview of governance and geopolitics as drivers of change in the Great Lakes-St Lawrence Basin. It separates regional conditions into two themes, water quantity and water quality, tracing historical trends since 1963. This study of the history of Great Lakes governance and geopolitics reveals recurrent themes that impact the sustainability of the resource: institutional fragmentation, the changing relationship between federal and sub-national levels of government in Canada and the US, governance capacity, and the impact of geopolitics on governance. These themes are explored to imagine the future under three potential scenarios: a best-case scenario of a sustainable Great Lakes and St. Lawrence River Basin with robust governance in place, the status-quo scenario of business as usual and, a worst-case scenario of poor governance that contributes to potential ecological disaster.

Key Words: Governance, Geopolitics, Federalism, Institutions, Policy

3.1 Introduction

Governance of the Great Lakes has been a challenge historically and is likely to become more problematic in the future as new challenges such as climate change manifest themselves. This article presents an attempt to imagine this future based on an analysis of Great Lakes governance since 1963. Governance can be difficult to define as it is used in a multitude of different ways. While different interpretations abound, most agree that the basic characteristic of governance is the migration of power from the central state up into supranational institutions, horizontally to non-state actors, and down to sub-national levels of government and non-state actors (Hooghe & Marks, 2003; Pierre & Peters, 2000; Savoie, 1995). Governance, therefore, poses both challenges and opportunities because of the movement of power and inclusion of new actors. The challenges to governance in the Great Lakes region can be distilled into four central problems that have undermined many of the efforts to recover and protect the socio-ecological integrity of the region. Moving forward, these will be the problems that must be overcome if the governance regimes of the Great Lakes are to successfully meet the challenges posed by the other drivers of change in the region. Effective and adaptive Great Lakes governance is the key to a sustainable and healthy Great Lakes ecosystem.

The first, and arguably the most significant, governance problem is institutional fragmentation (Bakker and Cook, 2011; Camacho, 2008; Flaherty, Pacheco, and Issac-Renton, 2011; Hall, 2006). The Great Lakes Basin is shared by two federal governments, two provinces, eight states, regional organizations, over 120 First Nations and tribes, hundreds of local governments, and many nongovernmental organizations including industial, non-profit, and academic (Hildebrand et al, 2002). The shared jurisdictional nature of the Great Lakes creates a significant challenge to effective ecosystem governance. Horizontal relations between the two federal governments, among states and provinces, and among municipalities in cross-border regions like Detroit-Windsor and Western New York-Southern Ontario require significant cooperation.

A second problem confronting effective Great Lakes governance is the changing relationship between federal and sub-national levels of government in Canada and the US. The initial Great Lakes Water Quality Agreement, signed in 1972 by Prime Minister Pierre Trudeau and President Richard Nixon, signaled that Great Lakes protection would be a significant and ongoing federal priority. However, since that Agreement, a persistent trend of decentralization, which is the movement of power from the federal to sub-national governments, has occurred that threatens the potential success of a coordinated ecosystem governance of the Great Lakes (Botts and Muldoon, 2005). As the locus of policy development and implementation moved from the federal to sub-national levels in both countries, Great Lakes governance is increasingly difficult. This vertical tension in Great Lakes governance exacerbates the horizontal challenge of institutional fragmentation by making coordination more difficult. While it is not always necessary or even desirable for federal governments to take leadership in all areas of Great Lakes governance, sub-national leadership must come with the capacity, fiscal and otherwise, to effectively make and implement decisions. The downloading of authority without the downloading of capacity ultimately undermines effective governance.

A third problem is governance capacity, namely the capacity to implement the decisions made within a governance regime, which includes expertise, resources such as funding and personnel, and an informed and engaged public. Governments at all levels face significant challenges in deploying resources for environmental protection, which often leads to significant implementation gaps. This is especially true within the Great Lakes, because many of the agreements and compacts are signed at the federal or sub-national level, but implementation is left to lower levels of government. The lack of a defined role for non-governmental actors in Great Lakes policy has often exacerbated this problem. The changing level of engagement is exemplified in the lack of public participation in the 1972 Great Lakes Water Quality Agreement and their later inclusion in planning committees in the 2012 Protocol.

The fourth problem is the effect of geopolitics on Great Lakes governance. This problem is distinct, because the other three are endogenous to the forms of governance within the Great Lakes Basin. Geopolitics is best conceptualized as an exogenous influence on Great Lakes governance. Although the geopolitical reality of North America is dominated by the US, the International Joint Commission (IJC) is based on norms of power sharing: bi-nationalism that grants equal decision-making authority to each nation regardless of size or relative power and regardless of national interest. The IJC comprises six members, three of whom are appointed by the President of the US, with the advice and approval of the Senate, and three of whom are appointed by the Governor in Council of Canada on the advice of the Prime Minister. IJC commissioners must act impartially in reviewing problems and deciding issues, rather than representing the views of their respective governments. This suggests that, at least at the time the IJC was established, the equitable sharing of water as a common resource took precedence over pure power politics. Contemporary Great Lakes geopolitics, however, is more complex. The North American geopolitical reality now accounts for more global concerns with more actors and interests in the mix. The implications are far-reaching and pose challenges for the norms embodied in binantional agreements as well as for other issues linked to water such as international trade.

These four governance problems form the points of analysis for the following article about the history and future of Great Lakes governance. Although the governance of water quantity and quality are intrinsically related, they represent distinctly different governance challenges and are treated separately in the following analysis. The article proceeds in two sections. First, the article traces the evolution of water quantity and water quality governance since 1963, examining historical trends and institutions. Second, governance in the Great Lakes-St. Lawrence Region is projected into 2063 through the consideration of best, status-quo, and worst-case scenarios. It should be noted that this is a limited survey of the vast set of institutions and processes of governance in the Great Lakes region and focuses exclusively on the institutions of water quality and quantity governance. These can be thought of as representative institutions that illustrate the serious challenges faced by the broader set of institutions in the basin.

3.2 A History of Great Lakes Governance

3.2.1 The Boundary Waters Treaty: The Beginning of Bi-National Cooperation

The Boundary Waters Treaty of 1909 (Treaty) (The International Joint Commission, 2014) is one of the earliest innovations in global trans-boundary water governance that greatly influences international structures for governance (Muldoon, 2012). The water resources management challenges in the shared US-Canadian basin is illustrated by problems such as the Chicago Diversion, by irrigation disputes west of the Great Lakes, and with infrastructure development projects such as hydropower and navigational canals (Botts and Muldoon, 2005). At this juncture, US-Canadian relations were evolving from issue specific programs to the recognition that more regulations and institutions were needed for a comprehensive basin-wide approach.

The Treaty has been described as visionary as it transcends political boundaries to focus attention on ecosystems; it established the IJC under

Article VI as a bi-national body to prevent disputes around the boundary waters (Botts and Muldoon, 2005). The IJC investigates specific situations (Botts and Muldoon, 2005) and makes impartial recommendations to the US and Canadian governments. The IJC may act only on references submitted jointly by both countries, which significantly curtails its authority to act independently (Hall, 2006; Palay, 2009; Tarlock, 2008). The IJC has not overcome the fundamental problem of coordination between the two federal governments and the respective sub-national governments that has plagued attempts to protect the Great Lakes basin ecosystem because it was not vested with the power to do so.

3.2.2 Great Lakes Basin Compact, 1968

The Great Lakes Basin Compact was an early attempt by the sub-national entities to assist with management of the Great Lakes. It was negotiated between the eight riparian states (New York, Pennsylvania, Ohio, Michigan, Illinois, Indiana, Minnesota, and Wisconsin) with participation by Ontario and Quebec and was a response to rising environmental concern about the Great Lakes as well as the opening of the St. Lawrence Seaway. The Compact created the Great Lakes Commission that had the authority to recommend that the states take action on a range of water quantity and quality issues. While the states are required to consider the recommendations, because they are non-binding, some have criticized the Compact for its failure to directly impact state water management (Hall, 2006; Palay, 2009). While the Compact was a significant first step in regional governance, it provides an early illustration of some of the above-referenced challenges. The reluctance of the state and provincial governments to be bound by regional standards and the absence of direct federal regulation of water quantity continue to play a role in the difficulty of creating effective consumption rules in the Great Lakes St. Lawrence River Basin. The Compact did, however, provide a model for a congressionally approved sub-national governance entity that would be utilized in the future to create a more effective regulatory regime.

3.2.3 The Great Lakes Water Quality Agreement, 1972

The growing public and scientific consciousness about water pollution provided the impetus for the Canadian and US governments to negotiate a bilateral agreement to address the issue. Pursuant to the Treaty, the Great Lakes Water Quality Agreement (GLWQA) was signed in 1972. The GLWQA evolved to meet contemporary challenges through substantial revisions in 1987 and Protocols in 1987 and 2012. Institutions such as the Great Lakes Regional Office were created to implement the programs under the various versions of the GLWQA. There is agreement regarding the success of the 1972 GLWQA in reversing the declining ecosystem (Botts and Muldoon, 2005; Krantzberg, 2008). The following are indicators of success of the GLWQA: bi-nationalism; promotion of community participation, equality and parity in structure and obligations; common objectives such as joint phosphorous reduction targets; joint fact-finding and research; accountability and openness in information exchange; and flexibility and adaptability to changing circumstances (Botts and Muldoon, 2005).

The 1972 GLWQA was a promise of institutional integration as the federal governments cooperated under a bi-national framework where common interests superseded narrow partisan ones. There was also collaboration by states and provinces on phosphorous control (Botts and Muldoon, 2005). The IJC used expert boards over the years to report on specific issues in the GLWQA. The inclusion of expert boards to guide decision-making represented an important step in participatory governance. It facilitated the sharing of ideas and merging of expertise in a neutral location away from the confines of routine obligations in organizational offices, a significant step in fostering institutional collaboration by engaging institutional actors away from agency roles (Krantzberg, 2012b). The Water Quality Board published reports that evaluated government programs, but this role was seen as a conflict of interest, because members of the board were evaluating the parties' programs, which were in effect their own programs (National Research Council of the US and the Royal Society of Canada, 1985).

The GLWQA spurred federal-provincial cooperation in Canada. While the federal governments were negotiating the GLWQA, Canada and Ontario were working on the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (COA), with the first COA signed in 1971 to aid Canada in meeting requirements of the GLWQA. The COA was revised in 1976, 1982, extended in 1991, and renewed in 1994, 2002, and 2007 (Environment Canada, 2012) and boosted governance capacity as it represented program coordination. There was, however, no similar mechanism for cooperation between the US federal government and states.

3.2.4 The Great Lakes Water Quality Agreement, 1978

The 1978 GLWQA was more comprehensive than the 1972 GLWQA, introducing the concept of ecosystem management for the virtual elimination of toxic contaminants and recognizing human health as a concern. This was driven by the results of the Pollution from Land Use Reference Group, which was tasked by the IJC to study pollution from land use activities, and the results confirmed the significance of pollution from non-point sources (Manno, 1993; Mason, 1980; Grima and Mason, 1983). This was a significant gain in Great Lakes governance as science was guiding policy. There were new programs and deadlines for municipal and industrial contaminants, abatement inventory, land based sources, airborne substances, persistent toxic substances, and monitoring (Botts and Muldoon, 2005). The 1978 GLWQA also represented a step toward more accountability for Great Lakes governance by reporting to the public on the progress towards achieving clearly set objectives and transparent evaluation of works executed. It also was a step towards more integration of actors, because the ecosystem approach recognized the interactions of air, water, land and all living organisms. A weakness, however, was that the operationalization of this ecosystem approach remained undefined. Successful implementation of the ecosystem approach has the potential of fostering institutional integration.

3.2.5 Great Lakes Charter, 1985

The 1980s brought concern over water shortages and drought throughout North America and raised the specter of large water diversions and the large-scale export of water from the Great Lakes (Bakenova, 2008; Palay, 2009). The fear of loss of control led to the Great Lakes Charter in 1985. The Charter was a cooperative agreement between the eight Great Lakes states with input from Ontario and Quebec. The Charter committed each state and province to regulate any new consumption or large diversion, to provide prior notice to all signatories of any new large diversion or consumption, and to create a database of all large consumptive uses (Hall, 2006).

While the Charter represented a comprehensive attempt to manage water diversions and consumption in the Great Lakes Basin, the lack of formal mechanisms for approvals of large diversions and the fact that the Charter had no force of law have led many to characterize the agreement as ineffective (Camacho, 2008; Frerichs and Easter, 1990; Hall, 2006; Palay, 2009). The Charter once again illustrates the challenges associated with the changing relationship between the federal and state governments. There was no federal leadership, so negotiation had to occur among states. This led to a "handshake" agreement with no legal repercussions (Hall, 2006; Palay, 2009).

3.2.6 Water Resources Development Act, 1986

Section 1109 of the Water Resources Development Act, 1986 (WRDA) was enacted by Congress to provide states with the power to limit diversions of water from the Great Lakes-St. Lawrence River Basin. Under the WRDA, each Great Lakes governor had a veto over any proposed out-of-basin diversion. However, like the Charter, there was no standard for how a diversion was deemed acceptable, which has led many to suggest that regional politics would trump sound policy-making in the decision process (Hall, 2006; Palay, 2009). The WRDA also provided no limits on in-basin consumption; it was only a partial remedy to problems of water management in the basin. WRDA, therefore, does not assist in overcoming the fundamental challenge posed by institutional fragmentation and the lack of federal engagement to provide for a standardized model of in-basin consumptive practices. However, it did provide the space for the states to negotiate the more substantive Compact and Agreement detailed below.

3.2.7 The Great Lakes Water Quality Agreement Protocol, 1987

The Great Lakes governance framework changed significantly in 1987 with the GLWQA Protocol, which created the Bi-national Executive Committee (BEC), allowing Environment Canada and USEPA to consult directly semiannually. These changes severely restricted the IJC’s leadership role, as the federal governments took over reporting on the state of the lakes and reduced the IJC’s budget (Krantzberg et al., 2007), a manifestation of geopolitical realities in the Great Lakes region. The BEC took over the role of the IJC in reporting on the state of the lakes by creating State of the Lakes Ecosystem Conference in 1990. The BEC was viewed as entrenched in administrative institutions with no authority or accountability, serving merely as an information exchange forum with no ability to set bi-national programs (Krantzberg et al., 2007). Further, the State of the Lakes Ecosystem Conference was criticized as having a long list of indicators that are not aligned with the objectives of the GLWQA Protocol and does not provide information that the IJC needs, leading to a loss of accountability and transparency (Jackson and Sloan, 2008). Ultimately, BEC contributed to the decline in accountability processes for achieving the purpose of the GLWQA Protocol (Weinberger, 2006). These changes resulted in considerable institutional fragmentation, as the senior bureaucrats that made up the BEC acted as agency representatives, and technical and program managers were no longer able to step out of parochial roles to reach consensus, undermining the spirit of bi-nationalism (Valiante et al., 1997).

The 1987 GLWQA Protocol introduced the development and implementation of lake-wide management plans (LAMPs) and the development and implementation of Remedial Action Plans (RAPS). These were created by the IJC boards and adopted by the government, signaling a more participatory governance regime. Annex 2 detailed the process for addressing issues in the geographic Areas of Concern (AOCs), with the specific stipulation that the public would be involved in the development of RAPs. This was a revolutionary approach to governance, as RAPs could not proceed without decisions by community groups because it was assumed that tradeoffs involved in RAPs require public understanding (Muldoon, 2012). This approach was contrary to traditional top-down natural resources management. Through the inclusion and active participation of diverse stakeholders, RAPs facilitated collaboration between government and the public. According to Krantzberg (2012), RAPs "achieved inclusivity which nurtures legitimacy, accountability, and can galvanize distributed decision making" (p. 260). Both RAPs and LAMPs suffered from scarcity of resources, which significantly reduced their capacity. The progress of some RAPs has been slow because of staff reductions and budget cutbacks at federal, state and provincial agencies; withdrawal of lead agency coordination; and the challenges of dealing with contaminated sediments (Krantzberg and Houghton, 1996, SPAC, 1997). The RAP process also illustrates the institutional weakness of the IJC, which must rely on buy-in from various levels of government to implement programs.

3.2.8 The Great Lakes Regional Collaboration

President George W. Bush issued an Executive Order in 2004 that established a federal Interagency Task Force comprised of eleven US Cabinet and agency heads who engaged over 1500 federal, state, and local public officials and nongovernmental stakeholders to develop a restoration blueprint released in 2005 entitled, "The Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes" (Crane, 2012). The Governors and Premiers (through the Council of Great Lakes Governors) came up with a list of priorities for Great Lakes restoration and protection. The strategy highlighted the need for action on aquatic invasive species, habitat conservation, near-shore waters, cleaning up AOCs, reduction of polluted runoff, toxic substances, increased monitoring, and long-term sustainable economic growth and development (US Federal Interagency Task Force, 2010). The strategy was viewed as a success because it established a restoration agenda and helped forge a visible, united partnership for Great Lakes restoration. It was an example of successful institutional collaboration in the Great Lakes- St. Lawrence River Basin. One of the shining achievements of this collaboration is the Great Lakes Restoration Initiative (GLRI), a multi-million commitment from 2010-2014 by President Obama in 2009 for addressing key ecosystem problems with focused efforts in five major areas: toxic substances and areas of concern, invasive species, nearshore health and nonpoint source pollution, habitat and wildlife protection and restoration and accountability, education, monitoring, evaluation, communication and partnerships (US Federal Interagency Task Force, 2010).

3.2.9 Great Lakes-St. Lawrence River Basin Compact and Agreement, 2008

The Great Lakes-St. Lawrence River Basin Water Resources Compact (2008 Compact) and the companion Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (2008 Agreement) that includes Ontario and Quebec in a non-binding parallel agreement were signed in 2005 and became law in 2008 after a lengthy negotiation process and engagement with stakeholders. Together, the 2008 Compact and 2008 Agreement created a set of common standards for state and provincial water management programs and out-of-basin diversions, encompassing both surface and ground water. The 2008 Compact, consented to by Congress in 2008, has the full force of federal law (Hall, 2006; Palay, 2009; Squillace, 2006). The 2008 Agreement is not yet fully in force because Ontario has failed to enact the necessary legal requirements. Views on the significance of these instruments are mixed. Some suggest that the 2008 Compact and Agreement represent a new and effective form of horizontal federalism that combines the flexibility of state implementation of regulations that will be best suited to regional realities with the power of the federal government to adjudicate between states and create common and enforceable standards of practice (Hall, 2006). Others suggest that the 2008 Compact and Agreement represents an unnecessarily complex intrusion into state authority, which will ultimately prove inadequate for managing the complex realities of protecting the Great Lakes (Squillace, 2006). Evaluation of the success of the 2008 Agreement demonstrates some reason for optimism but reveals that significant problems and disagreements still exist, especially about the success of implementation and the role of stakeholders (Gosman, 2011).

3.2.10 GLWQA Review Process, 2010

Interested stakeholders conducted a review of the 1987 GLWQA Protocol in working groups co-chaired bi-nationally (Krantzberg, 2012b). The key finding of this review process suggested that the current form of the GLWQA was outdated because it was impotent in addressing contemporary challenges. On June 13, 2009, the Canadian Foreign Minister and the US Secretary of State announced that negotiations would begin on the review of the GLWQA (Babbage, 2009). The first bi-national public webinar was hosted in January 2010 but was not archived and there were no answers to questions leading to a sense of frustration by participants (Krantzberg, 2012b). Canada established a stakeholder panel in January 2010 to advise on the negotiations, but no such entity was established to advise the US government during this process. No draft agreement was produced for public input and the public was excluded from the negotiations for revised GLWQA.

However, citizen engagement has been central in the Great Lakes regime, and relying exclusively on national governments for compliance ignores the potentially powerful role that citizens can and do play in environmental law and policy (Hall, 2007). In fact, the important role of citizen engagement in the renegotiation process was clearly recognized at the time of the last revisions to the GLWQA. In 1987, the then vice-president of Great Lakes United, a Great Lakes NGO, received an invitation from the then Secretary of State for External Affairs of Canada to be an observer on the renegotiation of the 1978 GLWQA (Manno, 1993).

3.2.11 The Great Lakes Water Quality Agreement Protocol, 2012

The 2012 Great Lakes Water Quality Agreement (GLWQA) Protocol was signed on September 7, 2012. The Protocol retained an ecosystem focus and included many of the concerns raised by the public in the following 10 Annexes: Areas of Concern, Lakewide Management, Chemicals of Mutual Concern, Nutrients, Discharges from Vessels, Habitat and Species, Aquatic Invasive Species, Groundwater, Climate Change, and Science. The 2012 agreement was significantly different and broader than the revisions of 1987 and 1978 and there was much more focus on governance-related issues. The 2012 GLWQA Protocol allowed for public engagement through a Great Lakes Public Forum, which was to be established within one year, repeating every three years. The first public forum was held over a two day period in

September 2013 in Milwaukee, USA where the public was briefed on the states of the lakes and IJC's assessment of progress and allowed to provide comments. The 2012 GLWQA Protocol established a Great Lakes Executive Committee (GLEC) to help implement the Agreement. The GLEC included representatives from a broad array of stakeholders including tribal governments, First Nations, metis, municipal governments, watershed management agencies and local public agencies. These groups are required to provide input regarding the implementation of the Annexes. These mechanisms represent significant expectations for better working arrangements, better federalism and more engagement of NGOs and citizens. One of the weaknesses of the 2012 GLWQA Protocol is that it does not articulate the form of engagement of these stakeholder groups; for example, will each group have a seat at the table? If not, this means that decision-making will be kept within the agencies, which are often invested in existing systems with little chance to break from the confines of legal and regulatory frameworks. This suggests the 2012 GLWQA Protocol may not be successful in overcoming institutional fragmentation or increasing governance capacity through successful engagement with stakeholders and sub national actors.

3.3 Historical to Future Histories

The above brief history of Great Lakes governance demonstrates the central governance problems that impact the sustainability of this vital and shared resource: institutional fragmentation, the tension between the federal and sub-national levels of government, governance capacity, and the growing importance of geopolitics. Although predicting the future is at best difficult, the consequences of not attempting to envision the consequences of actions taken today are potentially dire. To meet this challenge, three potential scenarios are discussed: a status-quo case scenario based on an extrapolation of existing conditions, a best-case scenario of adaptive governance that promotes sustainability, and a worst-case scenario of poor governance that contributes to potential ecological and socioeconomic disaster in the Great Lakes-St. Lawrence River Basin. Two points of clarification are necessary. First, these scenarios are not based on assumptions that factors such as climate change inevitably lead to disaster. If a governance regime is stable and robust, climate change or other ecological stressors can be mitigated. Poor governance, on the other hand, does not require an event such as climate change to lead to catastrophe. The Aral Sea disaster was not the result of global climate change but instead the result of a fundamental failure of governance (Annin, 2006). Second, these scenarios are based on the assumption that future governance of the Great Lakes is path dependent. That is, future governance in the basin will be grounded within the bounds created by previous decisions and events (Pierson, 2000). Thus, the problems that were crucial in the historical development of Great Lakes governance will continue to be of central importance.

In addition to the consideration of the four key themes of identified above, the relationship between governance and geopolitics as a driver of change and the other drivers of change in this special issue is important. Tables 3.1 and 3.2 illustrate the potential impact of the other drivers of change on governance and geopolitics and the impact of governance and geopolitics on the other drivers. While the following discussion will not consider many of these relationships directly, it is important to recognize that the Great Lakes is an integrated system in which all of the drivers identified in the Futures project are deeply intertwined.

Driver	Geopolitics	Governance
Climate Change	• Increased temperature increases demand for water which intensifies strain on the bi-national relationship between Canada and the US, undermining future cooperation	• Drought conditions in other regions cause greater demand for out of region diversions which may become impossible to resist under the current governance structure
Water Quantity	• If water levels in the basin drop significantly, the bi-national relationship may be significantly strained leading to a relationship based on power politics	• Reductions in the available water will strain cooperative agreements such as the Compact and Agreement possibly leading to the failure of cooperation altogether
Economy	• The increasing diversity of economic conditions in the region make agreements on common priorities increasingly difficult	• Without a robust economy, the region is further drained of the resources necessary for effective governance leading to decreasing governance capacity
Energy	• The changing mix of energy production in both countries will contribute to further difficulty in aligning national interests in the Great Lakes making future negotiations difficult	• The increased production of unconventional energy leads to even greater regulatory fragmentation and threats to water quality
Biological and Chemical Contaminants	• If the Great Lakes-St. Lawrence River Basin water becomes undrinkable/unusable, the US and Canada would have to access water from other parts of the world, leading to global conflict in places such as the Antarctic and the Arctic (Canada could make claim to large volumes water in this region, much to the dismay of the US and Russia, among others)	• The increasing complexity of contaminants in the basin make the formulation and implementation of new water quality agreements more difficult
Aquatic Invasive Species	• Since invasive species and trade in species are both linked to globalization of market forces, trade embargos with countries around the world to stem the tide of invasives could be created and would damage or strain global relations. • Trade embargo differences between Canada and the US would strain bi-national cooperation between both nations if either does not agree with the embargo.	• The introduction of new species in the basin further challenges the fragmented governance system requiring new cooperative agreements which may be difficult to negotiate and enforce
Demographics and Societal Values	• Growing nations like China, India, Brazil and other newly emerging economies may shift the global geopolitical balance towards strained relations and conflict over water. • Influx of immigrants to the region who don't value water is possible, thus creating a mindset that the basin's water is a commodity, rather than a natural resource. But, if immigrants originate from regions where water is held in high value and/or is more spiritual, the Great Lakes-St. Lawrence River Basin may have a brighter future, where conservation and mitigation are highlighted.	• Increasing migration increases the regions population and places greater strain on water resources leading to greater conflict between water users

Table 3.1 – Influence of other Drivers on Geopolitics and Governance

Geopolitics and Governance	Climate Change	Water Quantity	Energy	Economy	Biological and Chemical Contaminants	Aquatic Invasive Species	Demographics and Societal Values
Institutional fragmentation	Discrete institutions can hinder flexible, coordinated responses to the uncertainties of climate change impacts.	The absence of cooperation in institutions can generate increased competition and demand for water.	Disjointed energy policy is potentially fostered, with no concerted effort to shift to renewable energy.	Federal protectionist strategies/bilateralism lead to stagnation. Dated environment versus economy views exist and water quality declines.	Lack of coordination leads to inadequate resources and increased proliferation of chemicals of mutual concern.	Failure to create cooperative standards makes the system susceptible to invasion and supports the proliferation of invading species.	Unmanaged growth leads to further sprawl and environmental damage; Societal values prioritize short-term economic gain over sustainable growth.
Challenges of federalism	Difference in water quality and quality mandates at the federal/state/provincial levels can lead to potential problems in an uncertain climate scenario where water quantity and quality issues will coincide.	The Great Lakes Compact resolves conflicts and allows states and provinces to govern water quantity. The Boundary Waters Treaty resolves transboundary water conflicts at the federal level.	Provincial energy policy is largely integrated with the US, while regional and global competitiveness is the Canadian federal focus. Broad based energy policy absence at the US federal level has led to debate of issues like fracking and electric generation sites.	Tensions between the federal and state/provincial governments can arise over energy policies and development.	The federal government has enacted polices for banning the use of chemicals such as DDT, however, more federal legislation is needed for chemicals of mutual concern.	In the US an executive order by the President attempts to coordinate federal/states responsibilities regarding aquatic invasive species. In Canada, this is largely regulated federally.	Regulation of immigration policy is at the federal level, while land planning and housing is at the state/provincial. This can lead to tensions in protection, where federally more persons are allocated to the province/state than it can accommodate.
Governance Capacity	Policies for green jobs, renewable energy and reducing emissions can contribute to successful climate change adaptation.	Cooperative agreements such as the Great Lakes Compact can prevent competition and lead to water demand management.	Energy policy drives renewable energy investment and dominant energy sources.	Policies for a green economy can stimulate economic growth while protecting the Great Lakes-St. Lawrence River Basin.	Agreements such as the GLWQA 2012 Annex 3 can result in coordinated programs for reduction of chemicals of mutual concern.	Regulations for ballast water can lead to prevention of new species.	Policies for sustainable planning and low impact development can mitigate the impact of population growth in the region.
Geopolitics	Asymmetrical power balances and different commitments to slowing greenhouse gas emissions	Sub-national leadership in water quantity management make it is relatively immune to geopolitical changes. But, demands	Changes in geopolitical realities could see greater demand for energy produced in the Great Lakes region which could	Significant changes in energy prices due to geopolitical instability could alter the conditions for economic recovery in	If the bi-national character of the Canada-US relationship erodes, further cooperation may become impossible.	Fearing the consequences of trade restrictions, the US and Canada may be reluctant to enforce policies aimed at reducing	Shifts in geopolitical conditions can further exacerbate push factors of migration to the region.

by each federal government make cooperation difficult.	from regions of the US for basin water could strain the bi-national relationship with the potential for unilateral diversions.	lead to greater environmental strain from unconventional extraction.	the region.		invasive species such as ballast water restrictions.

Table 3.2 – Impacts of Geopolitics and Governance on other Drivers in the GLB

3.4 Status Quo Scenario

3.4.1 Institutional Fragmentation

The complexity of jurisdictions and institutions responsible for governance in the Great Lakes-St. Lawrence River Basin creates a fundamental problem of coordination. Successful cooperation between actors in the basin is the key to a robust and sustainable governance regime. Interspersed in the history of Great Lakes water quality governance are promises of institutional integration evinced by examples such as the Great Lakes Regional Collaboration and successful RAPs such as Collingwood Harbour. This emergence of an integrative approach to Great Lakes governance has been fostered by innovations in ecosystem management driven by environmental policy professionals within the Great Lakes Basin (Peterson et al., 1986; Stoker, 1991). These professionals also constitute the various advisory boards of the IJC and are employed by sub-national and regional agencies, nongovernmental organizations, and industry and are increasingly advocating for cooperative approaches to environmental management. In the status-quo scenario, these professionals continue to advocate for more cooperative management, but participation continues to be sporadic contributing to the continued fragmentation that has characterized much of the governance history of the Great Lakes.

Management of water quantity in the Great Lakes region has relied on a governance regime created at the sub-national level with the most recent regime created by the 2008 Great Lakes-St. Lawrence River Basin Water Resources Compact and Agreement. Calls for out-of-region diversions have been universally unpopular in both Canada and the US (Annin, 2006; Bakenova, 2008; Flaherty et al., 2011; Heinmiller, 2003). Because no serious economically feasible large-scale out-of-region diversions have been proposed, and no political pressure to support those diversions has materialized, it has been relatively easy for governments to coordinate over agreements preventing those diversions (Tarlock, 2008). In the status quo scenario, no serious demands for out-of-region demands for water are made and the 2008 Compact and Agreement is sufficient to beat back attempts to divert Great Lakes water out of the region.

Conversely, regulating in-region but out-of-basin diversions, inter-basin transfers, and in-basin consumption has proven far more complex. The 2008 Compact and Agreement create a framework that must be implemented by states and should be implemented by the provinces, providing a set of standards that must be applied to all new water uses and including commitments to use water efficiently (Hall, 2006). However, in-basin consumption is still managed by individual states and provinces with weak regional oversight, and there are only reporting requirements and not limits for most existing uses. While the 2008 Compact and Agreement are a promising start, without changes to the status quo, governance of water quantity in the basin will not be sufficient. Proposed diversions to communities within Great Lakes States but outside of the basin such as the current one in Waukesha, Wisconsin may strain relations between states and provinces making cooperation more difficult. It remains to seen if the 2008 Compact and Agreement alone will be sufficient to meet these challenges. By 2063, the increasing institutional fragmentation of jurisdictions in the Great Lakes basin will lead to ever-diverging water quantity management regimes in each state and province which will inevitably lead to conflict between those jurisdictions.

3.4.2 Challenges of Federalism

The changing relationship between the federal and sub-national governments of both Canada and the US has proven a key challenge to the management of the Great Lakes. Great Lakes water policy in the Unites States is essentially split between distinct regimes for water quality and quantity. US water quality governance largely is a federal concern with the Clean Water Act of 1987 as the key piece of legislation (Sproule-Jones, 2002). Water quantity concerns are largely managed at the state level with little interference by the federal level (Galloway and Pentland, 2005). Canadian Great Lakes governance primarily occurs at the provincial level, reflecting Canadian environmental policy generally. While the federal government has constitutional authority to enact protection for the Great Lakes, as in other areas of environmental policy, it has chosen to pursue this in limited fashion (Bakker and Cook, 2011; Galloway and Pentland, 2005; Harrison, 1996). In the status quo scenario, lack of cooperation between levels of government and federal disinterest contribute to inefficiency and a lack of coordination that exacerbates the institutional fragmentation described above. While federal leadership is not required, federal participation is important because the federal level of government in both countries have significant fiscal and legal capacity. The 2008 Compact and Agreement clearly illustrates the importance of legal capacity. The 2008 Compact between states has the full force of federal law thereby creating enforceable rules for water quantity management, however, the constitutional check on states signing binding compacts with foreign powers means the 2008 Agreement between the states and provinces does not have the same force. In this scenario, both cooperation and conflict between levels of government continue to be ad-hoc with little attempt to institutionalize relationships, which further undermines the consistency of responses to new and existing challenges. In particular, without coordination, the capacity to implement what policies exist is threated as federal withdrawal leads to significant implementation gaps because of the overstrained resources of sub-national actors. Without clear relationships between the levels of government in both countries,, the harmonization of policies across the basin becomes more difficult. By 2063, this failure to institutionalize cooperation between levels of government will lead to such a diversity of regimes that cooperation becomes impossible.

3.4.3 Governance Capacity

The successful governance of environmental resources such as the Great Lakes requires significant capacity to create and implement policy and an engaged public capable of monitoring the success of that governance. Long term trends of cutting funding for research have reduced this capacity (Goldenberg, 2012; Johns, 2009). For instance, the Natural Sciences and Engineering Council (NSERC) funding was cut by M$15 for the 2012-2013 fiscal year and will be cut by M$30 thereafter due to the Government of Canada spending review (NSERC, 2012). If the trend of cutting back on resources for environmental protection continues, capacity to execute programs at all levels of government will be limited. In Canada, the federal role is limited by constitutional constraints; it has limited its role further by facilitating rather than leading, by consulting rather than deciding, by studying rather than acting, and by relying on others rather than directly intervening (Canadian Commissioner of Environment and Sustainable Development, 2001). If the status quo of spending cuts continues, future resources will in all likelihood be insufficient to meet emerging challenges such as climate change.

The participation of citizens and other stakeholders in Great Lakes governance has been hailed in the past for the creation of a Great Lakes Community (Botts and Muldoon, 2005). However, this sense of community has been eroding with many pointing to the need for increased participation by stakeholders at all levels (Hall, 2007; Flaherty, Pacheo-Vega, and Issac-Renton, 2011; Johns, 2009; Krantzberg, 2012a). Stakeholders at every level, including citizens, local governments, tribes and first nations, environmental and industry groups, and provincial and state governments must be included in the processes of goal setting and implementation if governance capacity is to increase. The status quo of ad-hoc participation by stakeholders will not be sufficient to meet future challenges. By 2063, the exclusion of these groups from meaningful participation will inevitably lead to significant governance failures.

3.4.4 Geopolitics

The challenge posed by geopolitical factors may be the most problematic moving into the future. The first and most obvious influence of geopolitics on Great Lakes Basin governance is the role of international trade agreements such as the North American Free Trade Agreement and the Global Agreement on Tariffs and Trade. These trade regimes seek to limit national discrimination of foreign goods and services. The concern of some, particularly environmental opponents of these agreements, suggest that these agreements constrain the ability of Canada and the US to limit or ban outright bulk exports of water or large diversions from the Great Lakes (Annin, 2006; Tarlock, 2006; Olson, 2006). In order for this threat to manifest itself, water in the Great Lakes Basin would need to be considered a commodity that would then trigger the anti-protectionist clauses of those agreements. However, many have argued that arrangements such as the 2008 Compact and Agreement, which ban out-of-basin diversions and provides states with regulatory power to limit withdrawals, do not fall under the jurisdiction of any trade regime (Tarlock, 2006, 2008). It seems likely that this will become a more contentious argument only if demands for Great Lakes water increase because of events such as climate change (Olson, 2006). In the status quo scenario, the public's documented opposition to exports will be sufficient to deter large-scale bulk export.

3.5 Best-Case Scenario

3.5.1 Institutional Fragmentation

In the best-case scenario, there is an increased recognition of the shortcomings of the existing, fragmented approaches to water quality governance that were accompanied by the development of alternative approaches for integration. The participation of a multitude of stakeholders is expanded and matured into the future to realize the promise of coordinated Great Lakes Management (as outlined in Article 2 of the 2012 GLWQA

Protocol). Representatives from Federal Governments, State and Provincial Governments, Tribal Governments, First Nations, Metis, Municipal Governments, watershed management agencies and other local public agencies (as outline in Article 5 of the GLWQA Protocol) have a large representation on the Great Lakes Executive Committee which is centered on watershed governance units that are coordinated on natural, physical geographic boundaries and transcend political and jurisdictional limitations as conceptualized in Integrated Water Resources Management (IWRM). In the best-case scenario, integrated water resources management (IWRM) as defined by the Global Water Partnership (GWP, 2000) is a reality: integrated water resources management is present when there is coordinated development and management of water and related resources. Further, the level of coordination that was heightened by the Great Lakes Regional Collaboration continues and improves both vertical and horizontal relationships.

In the best-case scenario for water quantity in the Great Lakes, the 2008 Compact and Agreement create a basis for increasing cooperation. Out-of-region transfers can be managed well under the status quo scenario because of the significant public opposition to major water diversions and exports and the institutional support for this opposition such as WRDA. However, even in the best-case scenario, in-basin transfers and in-basin consumption will constitute the major points of conflict. Only with an adaptive and resilient governance regime in place, this challenge can be met successfully. Although evaluation of the 2008 Compact and Agreement suggests that it has been unevenly applied, the commitment to collective management of the Great Lakes ecosystem is in itself a positive development (Gosman, 2011). In the best-case scenario in the short term, the 2008 Compact and Agreement will be sufficient to manage new in-basin diversions and consumptive uses. In the long term, the 2008 Compact and Agreement provides a strong foundation on which to build greater cooperation, much as the original compact in 1968 provided a model for future agreements. 2063 may see a fully integrated governance regime in which institutions of decision-making are matched to the appropriate ecological scale.

3.5.2 Challenges of Federalism

Under the best-case scenario, the primary governance structure for water quantity and quality in the Basin is federalism that creates clear roles between levels of government and encourages active and institutionalized cooperation between states and provinces. The COA is a successful example of an institutionalized and clear relationship between levels of government, as senior Canadian officials believe that it has effectively facilitated federal-provincial cooperation in the Great Lakes (Ishco and Durfee, 1995). Hall's definition of cooperative horizontal federalism illustrates the latter component and is defined as a constitutional mechanism for states and provinces to individually implement programs to meet common regional environmental standards with regional resources and enforcement (2006). The best example of cooperative horizontal federalism is the 2008 Compact and Agreement. In the best-case scenario, by 2063, a strong cooperative structure will emerge which enables the states and provinces to combine the regulation of water quantity and quality but tailor programs to their needs under regionally developed frameworks. Federal and regional participation could counter any lack of commitment by an individual state or province. This will require greater cooperation between the various levels of government on both sides of the border.

3.5.3 Governance Capacity

In the best-case scenario, governance is less bureaucratic and more participatory, with decision making occurring at the ecosystem level where municipalities are the leaders of a growing Great Lakes community. By 2063, the role of the nongovernmental actors has increased with members of public interest groups being part of the negotiation of the 1987 Protocol (Manno, 1993). This pubic interest and growing Great Lakes community can be harnessed to augment governance capacity. This Great Lakes community can be a valuable resource in surmounting the key governance challenges, serving as a vehicle for institutional integration. The strong nongovernmental community developed as a result of the formal institutions that have been given legitimacy by active community involvement (Valiante et al., 1997). It is this synergy between these actors that is most important for Great Lakes restoration. The next fifty years will see the further integration of these stakeholders into real and sustained participation that recognizes the value of all stakeholder perspectives.

Under the best-case scenario, funding will be augmented with state, provincial, municipal and private sector funding. This will lead to greater collaboration in issues under the GLRI such as aquatic invasive species, cleaning up contaminated sediment, improved near-shore health, restoration of degraded wetlands, and conservation of fish and wildlife (US Federal Interagency Task Force, 2010). Increased funding results in stronger capacity at the municipal levels, where best practices are used for sustainable development and land use. There is increased investment in human capital, which boosts adaptive governance capacity with more collaboration among all levels of government and between science and policy experts.

Historically most of the Great Lakes policies and institutions have been reactive to problems. Unlike the BWT, which can be seen as visionary, other reactive measures have not been able to resolve the issues fully. In the best case scenario with augmented funding – it is hoped that the policies guided by profound science and research are more pro-active and projects such as future scenarios can aid into coming up with more proactive policies in protecting the lakes in the future.

3.5.4 Geopolitics

In a globally connected world where pollutants such as dichlorophenyltrichloroethane (DDT) are emitted in one country but pollute waters continents away, agreements such as the 2004 Stockholm Convention on Organic Pollutants signal a new era of international cooperation to deal with wicked environmental problems. In addressing the issue of toxins in its biennial reports, the IJC had recommended a comprehensive international approach as it recognized that sources of toxins originated outside the confines of the Great Lakes Basin. This legacy of the Great Lakes actors in contributing and influencing a major international agreement is a sign of hope for the future of international cooperation on governance related to global complex stressors such as aquatic invasive species, airborne pollutants and water scarcity. Here, then, the US and Canada can lead the world in solving complex environmental problems.

In the best-case scenario for the management of water quantity in the Great Lakes Basin, consumption management becomes a priority in all states and provinces. In this circumstance, claims that the water of the Great Lakes is fully allocated will carry weight, reducing calls for large diversions and the bulk export of water from the lakes (Tarlock, 2006). Better water management practices will also relieve pressure from US-Canadian relations if conditions of water scarcity become endemic.

3.6 Worst-Case Scenario

3.6.1 Institutional Fragmentation

While there are many actors working to protect the Great Lakes, there is consensus that the governance structure of the Great Lakes is fragmented (Botts and Muldoon, 2005; Jackson and Kraft Sloan, 2008; Manno and

Krantzberg, 2008). If implementation of the 2012 GLWQA Protocol is not viewed as a national priority by the US and Canadian governments, there could be further fragmentation. This will lead to a worsening of water quality in the Great Lakes, with increased eutrophication, aquatic invasive species and increasingly adverse effects of wicked problems such as climate change. The federal governments and provinces become increasingly polarized and there is increased distrust and lack of information sharing. This is a future characterized by top down, command and control governance, with less engagement of stakeholders. Consequently, governments are less able to fund programs that seek to improve the impaired Great Lakes Basin ecosystem.

This worst-case scenario that envisions substantial stressors to the existing governance regime could be devastating to the Great Lakes ecosystem. The first, and perhaps most significant difference, is the potential failure of the 2008 Compact and Agreement to resist out-of-basin diversions and stem ecosystem degradation. Some debate exists about the ability or willingness of Congress to overturn the Compact or individual states' willingness to forgo the advantages of participation (Hall, 2006). However, this should be weighed against potential future pressure generated by events such as climate change that will create a significant and sustained demand for out-of-basin diversions to regions desperately in need of water. While the Compact and Agreement represents an attempt to limit out of basin diversions when little demand for those diversions exists, it remains to be seen if it can resist calls to share a resource desperately needed by other regions of the country.

Attempts to manage in-basin consumption will be similarly challenged by a worst-case scenario. If new and significant ecological challenges occur, the ability of the Compact and Agreement to meet these challenges is questionable. In the worst-case scenario of significant climate change, new competition and conflict between regional users will quickly undermine the current governance regime (Camacho, 2008; Tarlock, 2008). Unregulated competition between users of a shared resource can quickly result in a tragedy of the commons (Hardin, 1968). Problems such as global climate change require coordinated responses to complex ecosystem problems, and without adaptive governance systems, these challenges will likely overwhelm existing institutions. In this grim scenario, those living in 2063 will witness spiraling competition between Great Lakes jurisdictions leading to total ecological failure.

3.6.2 Challenges to Federalism

Without real changes to the relationship between levels of government in the basin, the above scenario becomes more likely and the consequences more dire. As demands for water from the basin increase, and the potential for decreasing availability with climate change, the minimal coordination required to manage those demands will increase. The so called ‘water wars’ of the western US provide ample evidence of the conflicts this can engender. Furthermore, with the conflict over the Apalachicola-Chattahoochee-Flint river basin between Georgia and Florida, these type of conflicts are moving east (Ruhl, 2005). The failure of the compact between Florida, Alabama, and Georgia should be a warning that benign cooperation is difficult under the strains of intense competition (Ruhl, 2005). Without real engagement between the different levels of government, and strong cooperative relationships between states and provinces, increasing conflict over ever more scarce resources can lead to conflict escalating to the federal levels that will undermine any attempts to protect the Great Lakes basin.

3.6.3 Governance Capacity

Under this scenario, the US and Canadian governments at all scales have cut funding to Great Lakes programs including funding to the GLRI and these cuts will continue into the future. Federal cuts on the US and Canadian sides in the 1990s that slowed progress on restoration programs (Manno and Krantzberg, 2008) will also continue. In this worst-case projection, this downward trend of funding for Great Lakes programs continues with a consequent lack of action on key issues. The tipping point of irreversible change will be reached when historical stressors combine with new ones, complicating the traditional responses between sources of stress and ecosystem response (Bails et al., 2005). Under this scenario, ecosystem degradation will continue with escalating sources of stress as public engagement wanes due to lack of capacity building programs.

3.6.4 Geopolitics

The worst-case scenario is one of increasing water scarcity without the governance mechanisms capable of adapting. Central to many of the future threats to the Great Lakes ecosystem is the underlying assumption that as water pollution and scarcity become a reality, demands for access to Great Lakes water will be more common and persistent. Greater scarcity of globally available water can stem from a diverse set of factors such as environmental degradation, population growth, poor water management practices, and climate change. While there has been significant research on the potential for environmental degradation or resources scarcity to cause inter or intra-state violence, much research on water scarcity suggests that it is more likely to lead to cooperation than conflict (Dalby 2003; Durfee and Shamir, 2006). If open conflict in the Great Lakes region is unlikely, global water scarcity in the future could lead to at least two other potential problems.

The first potential problem is a rise in regional tensions that could fracture the largely cooperative bi-national management of the Great Lakes. The trans-boundary nature of the Great Lakes region has led to the creation of what Bradley Karkkainen (2004) terms a “post-sovereign” form of governance in which there is a deep collaboration amongst multiple state and non-state actors. This complex system has evolved under conditions of perceived abundance of water for uses within the Great Lakes region. However, under conditions of growing scarcity, it is unclear whether voluntary, collaborative processes can overcome the self interest of stakeholders (Karkkainen, 2004). Collaborative, trans-boundary institutions such as the IJC can be effective systems for managing trans-boundary environmental problems but may prove less effective under conditions of growing scarcity and conflicts over access. We need only look to the evolution of Canada-US border policy in the immediate post 9-11 environment to imagine that, given the appropriate catalyst, the US will flex its muscle in the region, paying little heed to the norms of power sharing created under the IJC.

The second potential problem created by global water scarcity is the potential call for the large-scale bulk export of water from the Great Lakes to other regions outside North America. Much public attention has focused on a number of plans to transport bulk water to regions such as the Middle East where water is far scarcer (Annin, 2006; Bakenova, 2008). While the potential threat of these exports is questionable, these issues are likely to continue to garner public attention and may grow into a substantial threat to effective Great Lakes governance under conditions of water scarcity. In 2063, the demand for water exports and diversions may overcome the increasingly fragmented governance regime with the result of further, and possibly irrevocable, damage to an already fragile ecosystem.

3.7 Conclusion

The historical analysis and future projections presented here demonstrate that governance and geopolitics will continue to be significant influences on Great Lakes sustainability. These problems of governance impact not only water quality and quantity, but also the successful implementation of policies regarding the other potential drivers of change in the Great Lakes Basin. Governance can therefore be imagined as a meta-driver that profoundly influences the degree to which the challenges posed by the other drivers of change will be successfully managed in the future. It remains to be seen whether this highly fragmented set of institutions, with tensions between national and sub-national levels of government, challenges to governance capacity, and geopolitical concerns can adapt to meet the inevitably more complex challenges of the future. New environmental problems, changing economic and demographic conditions, and the ever-growing possibility of genuine water scarcity in the future will strain existing governance regimes and make the sustainable governance of the Great Lakes Basin more challenging then ever.

3.7.1 Recommendations

No governance regime is perfect, but in order to avoid the worst-case scenarios detailed above, several key recommendations are clear. First, the increasing cooperation between jurisdictions evident in agreements such as the 2008 Compact and Agreement and the 2012 Protocol must be encouraged in order to overcome the institutional fragmentation that has characterized governance in the basin. Second, the relationship between the states and provinces and their respective federal governments need to be strengthened. Harmonization of policies across the basin can only be achieved with the sustained interest of the Canadian and US federal governments. Third, the recent trend of reduced funding for Great Lakes protection must be reversed, and the engagement of all stakeholders in the basin must be institutionalized. Only through the reliable commitment of resources will further degradation of the basin ecosystem be avoided. Finally, there must be a recommitment to the bi-national character of the IJC in order to avoid destructive conflict and competition between Canada and the US. Small changes made today will inevitably have profound consequences in 2063.

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Chapter 4

A SWOT analysis of the Great Lakes Water Quality Protocol 2012: The good, the bad and the opportunity

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Abstract:

Since the signing of the Great Lakes Water Quality Protocol by Canada and the United States on September 7, 2012, there has been no review of it in the literature. This paper aims to fill that gap by conducting a Strength, Weakness, Opportunity and Threats (SWOT) analysis that will aid in deducing strategies to maximize the strengths and opportunities and minimize the weaknesses and threats to achieving the purpose of the Protocol. The review found that the Protocol has maintained the basic visionary infrastructure retaining the purpose and main objectives while broadening the scope to include three new Annexes; Aquatic Invasive Species, Habitat and Species and Climate change. Weaknesses include instances of ambiguous language, the separate treatment of groundwater, lack of Annex on Indigenous engagement and discrepancies between the principles and the Annexes. A key threat remains the lack of resources for the implementation of the Protocol.

4.1 Introduction

The Laurentian Great Lakes is the largest freshwater body in the world, accounting for 20 percent of the world's total freshwater (Environment Canada and US EPA, 2004). It is the most important water source in North America having social, economic and environmental significance. The lakes' basin houses 40 million North Americans. However, while the lakes have provided social and economic benefits to the residents, there have been the antithetical harmful anthropogenic effects that triggered the degradation of the lakes ecosystem. Recognition of this effect of humans on the lakes led to the signing of the 1972 Great Lakes Water Quality Agreement. Implementation of the Agreement was credited with environmental benefits such as reduction of phosphorous inputs into Lake Erie and the concomitant reduction in eutrophication.

Despite this success, the lakes ecosystem is still being degraded. Some argue (Manno and Krantzberg, 2008) that the snail pace of amending the agreement, long after the stipulated time frame is one contributing factor. The calls to amend the 1987 agreement were first answered with the commencement of the review process in 2004 and a review report issued in 2007 (binational.net, 2013). This finally culminated in an amended Great Lakes Water Quality Protocol in 2012 (The Protocol). Since the signing of the Protocol on September 7, 2012, there has been no comprehensive review of its content to date. This paper aims to undertake that review with a Strength, Weakness, Opportunities and Threats (SWOT) analysis that can prove useful for decision makers in the implementation of the agreement.

4.2 The Great Lakes Water Quality Agreement through the years

As a result of pollution events during the 1960s and the public outcry on environmental disasters such as the fires on the Cuyahoga River and the hypoxic condition of Lake Erie, there was increasing emphasis on the environment that led to the signing of the first Great Lakes Water Quality Agreement in 1972 (Botts and Muldoon, 2005). This first agreement focused on the reduction of phosphorous to address massive algal blooms that depleted oxygen and let to dying of fish and disruption of food webs. Successful implementation actions included the upgrading of sewage treatment plants, elimination of phosphorous in household detergents and the control of point source industrial pollutants (Botts and Muldoon, 2005). The agreement called for review every six years, a time frame that was not always adhered to (Figure 4.1). The first review led to the 1978 agreement. While the 1972 agreement was "determined to restore and enhance water quality in the Great Lakes System", the 1978 agreement introduced the ecosystem approach through the explicit purpose "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem.

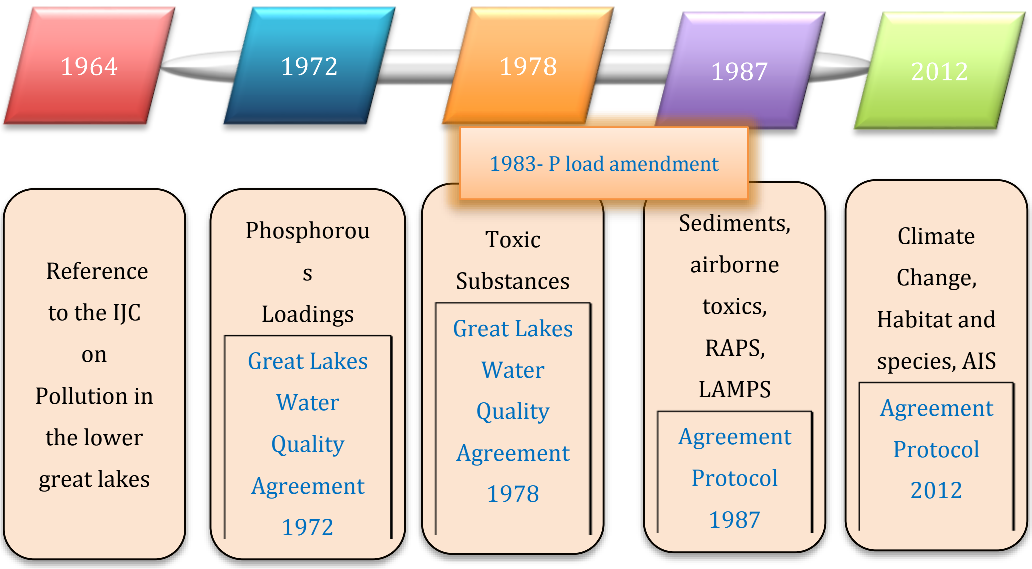

Figure 4.1 The Great Lakes Water Quality Agreement through the years

This agreement was credited with the introduction of the ecosystem approach on the global scale and was used by the US Commission for Ocean Policy in their recommendations for Oceans and Coasts in 2004 (US Commission for Ocean Policy, 2004). This ecosystem approach was based on the premise that all components of the environment were interconnected and that human health and environmental quality issues should be treated in an integrated manner (IJC, 2013). The 1978 Agreement also addressed the challenge of persistent toxic substances and listed priority toxic chemicals that needed urgent action. It called for virtual elimination through 'zero discharge' of inputs. This agreement was further amended in 1983 to include a Phosphorous load reduction supplement to Annex 3 which outlined basin wide phosphorous reduction plans.

The next amendment by protocol in 1987 further elucidated the concept of ecosystem management through the incorporation of Lakewide ecosystem objectives and Remedial Action Plans (RAPS). This version included new annexes for non-point source pollution, contaminated groundwater, air quality and coordinated research and development. Another new annex, Lakewide Management Plans (LaMP) was introduced to address contamination of whole lakes by persistent toxic substances.

There were major changes to the governance arrangement in this version of the agreement. Some of the new annexes required that the governments provided biennial progress reports on environmental quality to the International Joint Commission (IJC), thereby removing the data collection and reporting responsibility of the IJC's Water Quality Board. The Binational

Executive Committee (BEC) was formed by the governments to meet twice a year to coordinate work plans. Some argue that the creation of the BEC lead to duplication of functions and eroded the IJC's authority, which proved detrimental to the effectiveness of the agreement (Botts and Muldoon, 2005). This growing dissatisfaction spurred renewed calls for the review of the Agreement, which was due for long past the 1992 renewal timeline.

4.2.1 The Great Lakes Water Quality Agreement Review Process

The IJC's 12^{th} Biennial Report issued a strong call for the renewal of the Agreement by reminding readers that the Agreement was not updated or changed in more than 17 years, while science and technology has grown in leaps and bounds and as such, "we need to keep pace with what we know and review the Agreement with an eye toward a sustainable future" (IJC, 2004).

The governments finally got on board with the review process in 2006 and called upon the IJC to facilitate public participation (IJC, 2013). Key timelines in the review process is shown in Table 4.1.

Date	Event
April 2004	IJC 12th biennial report calling for review
May 2006	Formal commencement of the review process
2007	Canada and the US completed review of 1987 Agreement and concluded that the agreement is outdated and cannot address current water quality threats.
June 13, 2009	the Canadian Minister of Foreign and U.S. Secretary of State announced that the two countries would begin negotiations to amend the Agreement
January 2010	U.S. EPA's Great Lakes National Program Office (GLNPO) and Environment Canada announcement of a binational webinar for Great Lakes partners, stakeholders and the public.
January 27,2010	First formal negotiating session for amending the GLWQA concluded by senior Environment Canada, Foreign Affairs and International Trade Canada and US Department of State and the U.S. Environmental Protection Agency
April 8, 2010	Environment Canada, Foreign Affairs and International Trade Canada, the U.S. Department of State and the U.S. Environmental Protection Agency officials met for the second formal negotiating session for amending the GLWQA
June 2010	Series of public binational webinars hosted by government of US and Canada
July 2010	Deadline for written public comments
Fall 2010	Planned in person meetings, one in Canada and one in US. These did not occur at that time.
June 16,17, 2011	Third formal negotiating session for amending the GLWQA concluded by senior Environment Canada, Foreign Affairs and International Trade Canada and US Department of State and the U.S. Environmental Protection Agency
October 24, 25, 2011	Fourth formal negotiating session for amending the GLWQA concluded by senior Environment Canada, Foreign Affairs and International Trade Canada and US Department of State and the U.S. Environmental Protection Agency
September 2011	Conference calls held at request of several dozen NGOs to discuss governance, toxic substances, nutrients, climate change, habitat and species protection, aquatic invasive species, and the coordination of science and research in the Great Lakes region
September 7, 2012	Signing of the Protocol in Washington by Canada's Environment Minister Peter Kent and the US EPA's Administrator Lisa Jackson.

Table 4.1: Key Milestones leading up to the signing of the Great Lakes Water Quality Protocol 2012 (US and Canada Binational, 2014)

4.3 The Great Lakes Water Quality Protocol 2012

The Great Lakes Water Quality Protocol 2012 (the Protocol) was signed on September 7, 2012 by Canadian Environmental Minister Peter Kent and USEPA Commissioner and the United States Environmental Protection Agency Administrator Lisa P Jackson (IJC, 2013). The purpose of the 1987 agreement was kept in the Protocol but its scope was expanded to include contemporary issues such as climate change, aquatic invasive species and habitat and species and the nearshore areas of the Great Lakes. One key inclusion is the opportunity for engagement of tribal governments, First Nations, Metis, municipal governments and the broader public in the Great Lakes Executive Committee. There was further clarification of the roles and responsibility of the IJC under the Protocol.

The Protocol consists of two main sections, the Articles and the Annexes. Much like the previous versions of the Agreement, the Articles contains definitions, purpose, goals, general objectives and institutional arrangements (see Table 4.2). The Annexes contains more specific objectives and unlike previous versions of the agreement, the Protocol contains three new Annexes for Climate change, Habitat and Species and Aquatic Invasive Species (see Table 4.3).

Article	1972	1978	1987	2012
1	Definitions	Definitions	Definitions	Definitions
2	General Water Quality Objectives	Purpose	Purpose	Purpose, principles and approaches
3	Specific Water Quality Objectives	General Objectives	General objectives	General and specific objectives
4	Standards and Other Regulatory Requirements	Specific Objectives	Specific Objectives	Implementation
5	Programs and Other Measures	Standards, Other Regulatory Requirements, and Research	Standards, Other Regulatory Requirements, and Research	Consultation, management and review
6	Powers, Responsibilities and Functions of the IJC	Programs and Other Measures	Programs and Other Measures	Notification and response
7	Joint Institutions	Powers, Responsibilities and Functions of the IJC	Powers, Responsibilities and Functions of the IJC	International Joint Commission
8	Submission and Exchange of Information	Joint Institutions and Regional Office	Joint Institutions and Regional Office	Commission Boards and Regional Office
9	Consultation and Review	Submission and Exchange of Information	Submission and Exchange of Information	Existing rights and obligations
10.	Implementation	Consultation and Review	Consultation and Review	Integration Clause
11.		Implementation	Implementation	Amendment
12.		Existing Rights and Obligations	Existing Rights and Obligations	Entry into force and termination
13.		Amendment	Amendment	Supersession
14.			Entry into force and termination	
15.			Supersession	

Table 4.2: At a Glance -changes in the Articles of the Great Lakes Water Quality Agreement 1972-2012

Annexes	1972	1978	1987	2012
1	Specific Water Quality Objectives	Specific Objectives Specific objectives supplement to Annex 1	Specific Objectives Specific objectives supplement to Annex 1	Areas of Concern
2	Control of Phosphorous	Remedial Action Plans and Lakewide Management Plans	Remedial Action Plans and Lakewide Management Plans	Lakewide Management
3	Vessel Design, Construction and Operation	Control of Phosphorous Phosphorous Load Reduction Supplement	Control of Phosphorous Phosphorous Load Reduction Supplement	Chemicals of Mutual Concern
4	Vessel Wastes	Discharges of Oil and Hazardous Polluting Substances from Vessels	Discharges of Oil and Hazardous Polluting Substances from Vessels	Nutrients
5	Studies of pollution from shipping sources	Discharges of Vessel Wastes	Discharges of Vessel Wastes	Discharge from vessels
6	Identification and Disposal of Polluted Dredged Soil	Review of Pollution from Shipping Sources	Review of Pollution from Shipping Sources	Aquatic Invasive Species
7	Discharges from onshore and offshore facilities	Dredging	Dredging	Habitat and Species
8	Joint contingency plan	Discharges from Onshore and Offshore Facilities	Discharges from Onshore and Offshore Facilities	Groundwater
9		Joint Contingency Plan	Joint Contingency Plan	Climate change impacts
10		Hazardous Polluting Substances Appendix 1 – Hazardous Polluting Substances Appendix 2 – Potential Hazardous Polluting Substances	Hazardous Polluting Substances Appendix 1 – Hazardous Polluting Substances Appendix 2 – Potential Hazardous Polluting Substances	Science
11.		Surveillance and Monitoring	Surveillance and Monitoring	

12.		Persistent Toxic Substances	Persistent Toxic Substances	
13.		Pollution from Non-Point Sources	Pollution from Non-Point Sources	
14.		Contaminated Sediment	Contaminated Sediment	
15.		Airborne Toxic Substances	Airborne Toxic Substances	
16.		Pollution from Contaminated Groundwater	Pollution from Contaminated Groundwater	
17.		Research and Development	Research and Development *Terms of reference for the Joint Institutions and the Great Lakes Regional Office*	

Table 4.3: At a Glance -changes in the Annexes of the Great Lakes Water Quality Agreement 1972-2012

4.4 Methodology: The Use of SWOT

The Strength, Weakness, Opportunity, Threat (SWOT) methodology was developed by the Stanford Research Institute (SRI) in the 1960s to aid in strategic planning of businesses (Panagiotou, 2003). . It involves an analysis of the current and future situation; there is an internal scan to determine the strengths and weaknesses that are embedded in the system and an external environmental scan to determine the opportunities and threats that are external to the system that can be harnessed (opportunities) or hinder (threats) the attainment of the objectives. When applied to the Protocol, strengths and weaknesses are factors within the Protocol while opportunities and threats are external to the Protocol.

The SWOT analysis was conducted by the authors through a document analysis, a thorough review of the Protocol and literature relevant to the Great Lakes Water Quality Agreement. It is envisioned that this SWOT analysis will prove useful for implementation of the Protocol by inviting decision makers to consider important aspects of the internal and external aspects of the Protocol.

4.5 SWOT of the Protocol: The Strengths of the Great Lakes Water Quality Protocol

This section discusses the strengths of the Great Lakes Water Quality Protocol compared to the previous Agreement. These are elements within the Protocol that are promising for the execution of its reaffirmed commitment "to protect, restore, and enhance water quality of the Waters of the Great Lakes and ….to prevent further pollution and degradation of the Great Lakes ecosystem".

4.5.1 Retained Purpose of the Agreement

The purpose of the agreement has changed slightly as "to restore and maintain the chemical, physical and biological integrity of the Waters of the Great Lakes". The change is in the last few words, where 'basin ecosystem' was dropped from the purpose of the agreement. While seemingly insignificant, one wonders why these words were removed. Is this a signal that the ecosystem approach is no longer important? This does not seem to be the case as it is recognized in the introduction that restoration and enhancement of the waters of the Great Lakes depends on "the application of the ecosystem approach to the management of the water quality that addresses individually and cumulatively all sources of stress to the Great Lakes Basin Ecosystem" (US and Canada, 2012). This was reaffirmed in clause 1 Article 2, which articulates that measures should be developed for better understanding of the Great Lakes Basin Ecosystem. For all intents and purposes, the purpose of the Protocol has not changed and its strength lies in the goal to maintain the integrity of the waters of the Great Lakes.

4.5.2 Binationalism

The Protocol retains the foundation that the earlier Agreements were built on; principles such as binationalism and cooperative action. The preamble to the Protocol captures this in the recognition that "the Agreement between the United States of America and Canada on Great Lakes Water Quality provide a vital framework for binational consultation and cooperative action to restore, protect and enhance the water quality of the Great Lakes to promote the ecological health of the Great Lakes Basin" (US and Canada, 2012). This vision of binationalism is reflected throughout the wording of the Protocol, from the reaffirmation of commitment to the Boundary Waters Treaty of 1909 to the inclusive definition of State and Provincial Government to the specification of that the Parties agree to maximize efforts to cooperate and collaborate in the Purpose of the Agreement.

4.5.3 Contemporary Focus

The Protocol includes contemporary concepts in Article 2, clause 4, Principles and approaches. The concept of a systematic process of adaptive management has been included. This is forward looking, as there was no mention of this concept in the 1987 Protocol. The Protocol also includes concepts from the *Rio Declaration on Environment and Development* such as "polluter pays" and the "precautionary approach". This is a signal that the Protocol is cognizant of the wider environment and has incorporated contemporary principles from international proceedings.

4.5.4 Broadened Scope -New Annexes

The Protocol heeded the calls of the public and the IJC to incorporate previously unaddressed issues such as climate change with the inclusion of three new annexes; climate change, habitat and species and aquatic invasive species. It was recognized in the introduction that the Protocol is placing emphasis on addressing new and emerging threats to the waters of the Great Lakes.

4.5.5 Indigenous People Involvement

The need for involvement of indigenous people was articulated by the Great Lakes Science Advisory Board (SAB) in the 1997-1999 Priorities report and reiterated in the 2003-2005 Priorities Report (IJC, 2006). The SAB issued a call to that the Parties be briefed on the importance of traditional ecological knowledge and for mechanisms to be put in place to facilitate contribution of this knowledge by the aboriginal people (IJC, 2006). Perhaps heeding this call, for the first time the Protocol included the involvement of the First Nations, Metis and Tribes of America. This is articulated in the introduction which recognized that while governments are responsible for decision making, the involvement of the First Nations, Tribal Government and Metis is essential. There is also a definition of Tribal Government in Article 1-Definitions, as the government of tribe recognized by either Canada or the United States and located in the Great Lakes Basin. The word ‘Tribal’ occurs 34 times in the Protocol, with zero mention in the 1987 version of the Agreement.

Indigenous persons’ involvement is also called for in the achievement of the Specific Objectives in Article 3, Clause B. More specifically, the Tribal Governments, First Nations and Metis are invited to have representation in the Great Lakes Executive Committee (GLEC), which is envisioned to help the Parties in achieving the purpose of the agreement thorough coordination and implementation of measures.

4.5.6 Relevant to Tar Sands Shipping

Tar sands are a current emerging environmental issue as it grows in popularity among oil refiners for being a significantly cheaper source of crude oil. While crude petroleum shipped on the Great Lakes in 2011 was approximately 1% of the overall volume of Petroleum products shipped on the Great Lakes waterways (USACE, 2011), this figure is likely to increase. The United States and Canadian tar sands refineries are expecting to receive increased volumes of Canadian tar sands crude oil and shipping across the Great Lakes is one potential way of moving it out of these refineries. Calumet Specialty Products Partners L.P. (2013) issued a press release on its intent to ship tar sands crude across the Great Lakes by building a loading dock. According to Canadian pipeline builder Enbridge, the current pipeline transportation infrastructure is unable to transport the current supply to the markets (Draker, 2013).

As such, it is crucial that there are provisions for safe crude transport around the Great Lakes. Article 4 Clause 2a (V), talks of implementation of programs and other measures to pollution prevention, control and abatement programs for both onshore and offshore facilities, preventing discharge of harmful quantities of oil and hazardous polluting substances (US and Canada, 2012). Article 6 (c) speaks to notification of activities that could cause a pollution incident with significant cumulative impact such as oil and gas drilling and oil and gas pipelines. Annex 5 on Discharges from Vessels expounds in detail under subsection Discharges on the prevention of pollution from oil and Hazardous Polluting Substances. This Annex includes stipulations for regulations for vessel design to contain spills, retaining oily wastes, off-loading retained oily substances, hose and other appurtenances for loading and offloading and suitable lighting. These measures are all proactive as they range from notification of planned shipping activities to regulations to minimize the probability of discharges into the waters of the Great Lakes. However, it is noted that these measures do not pertain to pipelines, a very myopic omission.

4.5.7 Role of the International Joint Commission

During the initial stages of the Agreement the International Joint Commission (IJC) was lauded for its efforts as visible improvements was seen in the Lakes. However, the 1987 Protocol brought many changes that affected the functioning of the IJC. The parties now met bi-yearly with each other and provided reports directly to the IJC, instead of through the WQB. The forming of the Binational Executive Committee (BEC) to carry out some of the functions previously undertaken by the WQB was seen as a retreat from the IJC

One of the strengths of the Protocol is in the clear depicting of the role of the IJC, which retains its oversight, public information and investigative roles. Article 7 clause k clearly outlines the triennial reporting requirement utilizing the Boards, to the parties. Further, Article 8 Clauses 3 and 4 speaks to the roles of the WQB and the Science Advisory Boards (SAB), The WQB is the principle policy advisor to the IJC assessing progress of the Parties while the SAB will provide advice on science and research matters. The shift from biennial to triennial reporting will allow the IJC time to gather and assess data and provide more comprehensive report. These changes will likely be welcomed by the Great Lakes Community who attributed the lack of comprehensive data reporting that failed to document the true state of the Great Lakes ecosystem since the early 1990s as a direct result of the curtailed function of the IJC (CELA, 2006).

4.5.8 Nearshore Focus

Traditionally, the Great Lakes Water Quality Agreement has had an offshore water quality focus. There were two mentions of the word nearshore in the 1987 Protocol, firstly in Annex 3, Clause 3 (b) which talks of phosphorous load reductions in ‘various localized nearshore problem areas’ and in Annex 11, Clause 3(b) which speaks to baseline data collection for whole lake including ‘for nearshore areas (such as harbors and embayment, general shoreline and cladophora growth areas)”. However, there is increased recognition that nearshore areas need to be further included as part of an integrated approach to management. A consortium of over 200 Great Lakes Scientists agreed that the nearshore is critical as a buffer for stresses to the Great Lakes (Bails et al, 2005). Further, the IJC issued a call for the inclusion of the nearshore, focusing in on it in the 15th Biennial report (IJC, 2011) and in the 2009 workgroup report on the Nearshore Framework (IJC, 2009).

Heeding these calls, for the first time Annex 2, the Lakewide Management Annex of the Protocol, issues a call for an Integrated Nearshore Framework (Nearshore Framework). The word nearshore appears with a frequency of 16, a 400% increase from the 1987 Protocol. Clause 7, Annex 2 calls for the implementation of the Nearshore Framework through the Lakewide Management process of each lake. It calls for an assessment of the state of nearshore waters, identification of highly stressed nearshore areas, determination of stressors, identification of high ecological value nearshore areas, engagement of restoration and protection agencies, consideration of human health and the environment, consideration of shoreline hardening, non-point source runoff and monitoring at a frequency determined by the Parties. It also calls for regular assessment and revision “as appropriate”. The definition of “the Waters of the Great Lakes” specifies the waters of all the five Great Lakes, the river systems and now includes “all open and nearshore waters” (Canada and US, 2012).

4.5.9 Review and Amendment

The Protocol retains the need for review following the IJC's third Assessment of Progress Report. However, the timeframe is longer as it is following the third triennial report, not biennial as in the 1987 Protocol. This longer time frame can be seen as a strength that it will allow for a more comprehensive review, and allow for a more forward looking agreement that incorporates longer future time frames. Article 5, Clause 4 that speaks to the review also stipulates that the Parties will determine the scope and nature of the review but will take into account the views of the Indigenous people, public, municipalities, Sate and provincial governments.

4.5.10 Public Participation

The Protocol does allow for a strong role of the public in Great Lakes Activities, with four instances of public input in the language as contrasted to none in the 1987 Protocol. The Parties are urged to seek public input in the implementation of the Agreement under Article 4. Additionally, Article 5 stipulates a formal requirement for both the Parties and the IJC to convene a Great Lakes Public Forum within one year of entry of force of the Protocol and triennially thereafter and to have representation from the broader public in the Great Lakes Executive Committee. This is a step forward as it allows both the Commission and the Parties to solicit and discuss public input at a common forum. One of the roles of the IJC under Article 7 is to incorporate public input on the Progress report of the Parties in the triennial reports, lengthening the period from the biennial stipulation in the previous agreement. This facilitates the involvement of the public in the assessment of programs and other measures of the Agreement.

The Protocol does not stipulate the extent of the engagement. It is hoped that the public will be able to participate in all stages of the review process, including the renegotiation that was characteristic of the 1987 Protocol and missing in the renegotiation of the 2012 Protocol. Both Parties can utilize innovative mechanisms like the Stakeholder Advisory Panel the assisted the Canadian mediators during the negotiations of the 2012 Protocol. It is recommended that the webinars, teleconferences and social media be used by the IJC and the Parties to engage those who cannot attend meetings and also to engage youth in Great Lakes events.

4.6 Weaknesses of the Great Lakes Water Quality Protocol 2012

4.6.1 Ambiguous language of the Agreement

There is ambiguous language in many parts of the Protocol. In Annex 5, Discharge from Vessels, Clause 6 (b) on ballast water speaks to undertaking scientific and economic analysis on risks, ballast water management systems and technologies and approaches “when appropriate”. There is no indication of what constitutes the appropriate time for such analyses. There were 21 uses of the term “as appropriate” with no indication of what constitutes relevance. The Protocol includes stipulations to incorporate public opinion and advice “as appropriate”, adopt virtual elimination “as appropriate”, use the philosophy of zero discharge “as appropriate”, develop lake ecosystem objectives for temperature, pH….”as appropriate”, develop substance objectives…..”as appropriate”. These are only some examples of the 21 instances of the use of the term “as appropriate” This leaves the question of who will determine what appropriate action is and how the public will be consulted in such determinations.

4.6.2 Lack of clarification of what’s feasible for Aquatic Invasive Program

The purpose of Annex 6, the annex on aquatic invasive species speaks to the contribution of the general and specific objectives through the establishment of a binational strategy for the prevention, control or reduction and eradication, “where feasible” of existing AIS in the Great Lakes Basin. There is no clarification of the determinants of what is feasible in this case. This Annex also stipulates the development and implementation of introductions of AIS by using ‘risk’ assessments to inform a binational prevention based approach. It also goes on to say that new species can pose a ‘risk’. There is no clarification of what constitutes risk.

4.6.3 Lack of Gap Analysis for all annexes

The Protocol issues a call for gap analysis in Annex 7, Habitat and Species and Annex 8, Groundwater. For Habitat and Species, the requirement is to assess gaps for programs in habitat and species as a first stage of the development of a binational framework for prioritizing activities. In the annex on groundwater, a gap analysis is required for information and science needs. One wonders why the gap analysis is only reserved for these two Annexes and not applied more broadly to other annexes including chemicals of mutual concern, science and Aquatic Invasive Species. These gap analyses should be followed by a detailed implementation plan.

4.6.4 Inconsistent referencing on Impact on Human Health

While the Protocol focuses on human health, it is not consistently carried through to all the Annexes. There is no specific mention of impact on human health in Annex 1, Areas of Concern even though some of the Beneficial Use Impairments (BUIs) have a potential direct impact on human health. BUIs such as restrictions on fish and wildlife consumption, tainting of fish and wildlife flavor, eutrophication or undesirable algae, restrictions on drinking water consumption and beach closings have a direct human health impact. Additionally, Annexes 6 through 10 has no direct mention of the impact on human health. This is a concern as it can lead to a lack of focus on this issue in the implementation of these Annexes.

4.6.5 Separate Treatment of Groundwater

While the scope of the Protocol has been broadened to include nearshore waters, the definition of waters of the Great Lakes does not include a mention of the groundwater. In Article 1, Definitions, "Waters of the Great Lakes" is defined as the waters of the lakes and the connecting river systems and open and nearshore waters. However, Annex 8 on groundwater recognizes "the interconnection between groundwater and the Waters of the Great Lakes.." in Clause C. This separate treatment of groundwater throughout the Protocol can lead to the exclusion of groundwater in implementation actions and can also lead to increased costs and confusion through replicating of actions for components of the ecosystem that are interconnected. This separation of ground and surface water can also be a deterrent for participation from the Indigenous Community of Tribal and First Nations, Metis who view the environment in a holistic and interconnected manner.

4.6.6 No Annex on Contaminated sediment and dredging

The Annex on Contaminated Sediments, Annex 14 and the Annex on Dredging, Annex 7 of the 1987 Protocol was dropped in the 2012 Protocol. The word ‘sediment’ occurred 38 times in the 1987 Protocol while its frequency decreased to 7 in the 2012 version.

Contaminants in sediment continue to be of concern as they can be a source of toxic chemicals that can perpetuate up the food chain. Since the introduction of Remedial Action Plans in the 1987 Protocol, 28 years of effort has gone into work on contaminated sediment as they impair beneficial uses in all of the Areas of concern. While there were significant declines between 1970 and 1990s in PCBs, DDT, lead and mercury in sediment, it is unclear if that trend continued as the emphasis was shifted to chemicals of emerging concern such as brominated flame retardants and perfluoralkylated substances, due to their potential to harm the health and environment (IJC, 2013).

The USEPA has recently published a list of over 80 contaminated sediment sites in the Great Lakes, with only 27 being completely remediated (USEDPA, 2013). The lack of profile of contaminated sediment in the 2012 Protocol is a weakness of the Protocol.

4.6.7 No Clear Definition of Nearshore

While the inclusion of the nearshore areas of the Great Lakes is strength of the Protocol, the lack of a clear definition of what constitutes nearshore waters can be detrimental to successful planning and development of the nearshore waters as there may be varying understanding of the geographic bounds of the nearshore. Near shore areas have been defined by the IJC (2011) as extending 16 km in both land and water directions. This definition is neither hydrological nor ecologically defensible as it appears to be based on convenience and approximation. Edsall and Charlton (1997) uses hydrology to define nearshore waters as beginning at the shoreline or lakeward edge of the coastal wetland and extending offshore to the deepest lakebed depth contour where the thermocline typically intersects with the lakebed in the late summer or early fall. According to their definition, for Lake Superior nearshore waters are between shoreline and 9-m depth contour, while in the other four lakes, the nearshore waters are between shoreline and 27-m depth contour. Nearshore has also been defined as areas encompassed by water depths generally less than 15 m (Mackey, 2009a). Mackey (2009b) further defined nearshore areas to include higher energy coastal margin areas and lower energy open water areas. The concept of coastal zone can be used in the definition nearshore areas. An advantage of this would be the ability to learn and benchmark from other Coastal Zone Management programs in North America and around the world.

Successful implementation of Annex 2 requires that a definition of the nearshore be clarified and adopted. It also needs a clarification of what the near shore framework is for; a framework for monitoring, science, governance, other?

4.6.8 Confusing Overlaps on nearshore areas in the Annexes

Annex 2 on Lakewide Management devotes clause 7 to the development of an integrated nearshore framework. This clause specifies what should be considered under this framework. However, this list seemed incomplete as the nearshore is also addressed in Annex 4, Nutrients, under the setting of substance objectives. Clause C (2) in this Nutrients Annex talks about developing substance objectives and load reduction targets for phosphorous for the nearshore waters of the Great Lakes. This separate referencing of the nearshore could lead to disjointed efforts and confusion of different sub-committees roles during the implementation process. Similarly Annex 8, Groundwater, acknowledges the connection of groundwater to the waters of the Great Lakes (which includes nearshore waters). Again, this separation can lead to implementation challenges.

4.6.9 Lack of clarity on dispute resolution within the committees of GLEC

The Great Lakes Executive Committee (GLEC) is established in Article 5 which states that the Parties will serve as co-chairs and invite wide representation from the Indigenous population, Federal Governments, State and Provincial Governments, Municipalities, watershed agencies and other public agencies. While all these stakeholders have a seat at the table, it is clear from Clause 2 (d) under this Article that the US and Canada hold decision making power in their hands; this clause states that the Parties shall establish priorities ‘in consultation’ with the GLEC. This can be interpreted as the Parties in the form of the two co-chairs will make the final decision on GLEC matters, despite the viewpoint of the majority members. This can prove detrimental to the restoration process and act as a demotivation to GLEC members to participate in the future.

4.6.10 Discrepancy between Principles and Annex

The Protocol incorporates a number of principles and approaches in Article 2, Clause 4. This section speaks to accountability in reporting, anti-degradation, coordination, the precautionary principle and polluter pays. While it is good that these measures are included, there is often not a follow through on how they will be incorporated in the programs described in the Annex. For example, clause 4(h) on "polluter pay" is visionary in incorporating this principle of the Rio Declaration on Environment and Development where "the polluter should, in principle, bear the cost of the pollution". However, there is no carrying through of this principle in the Annexes. For example, Annex 3 Clause 4 on Chemicals of mutual concern states that "the Public can contribute to achieving reductions of the environmental impact of chemicals of mutual concern by using safer and less harmful chemicals and adopting technologies that reduce or eliminate the uses and releases of chemicals of mutual concern" (US and Canada, 2012, pp27). In using the word 'can' this gives manufacturers and industry the option of contributing to the reduction of harmful impacts of chemicals, whereas the incorporation of the 'polluter' pays holds them accountable through monetary measures.

4.6.11 No Annex on Indigenous Engagement

For the very first time, the Protocol contains specific references for the involvement of the Indigenous population including First Nations, Tribal Organizations and Metis. One can argue that since this indigenous population are the first people of North America, that in any reference to them, they should precede other groups such as the government. This is not the case in the Protocol. Since there is no history of Indigenous engagement in the Protocol, there should have been an Annex on developing an engagement protocol for the first nations. Water ethics demands that Indigenous engagement is approached in a manner that is respectful of their culture and empowers them at the negotiating table. The Indigenous culture and spirituality depends on healthy water and ecosystem while the ecosystem health depends on their spiritual practices, in a mutual symbiotic relationship (Groenfeldt, 2013). The Indigenous culture relating to water presents several water challenges; indigenous cultural views about water are often misunderstood and ignored, indigenous communities are rarely given meaningful opportunities to participate in policy and planning, customary access and rights are seldom recognized nationally, water bodies that are critical to cultural well-being are polluted (Groenfeldt, 2013). These challenges are all applicable to the Great Lakes Region. An Annex on Indigenous engagement would help in developing an engagement strategy that would recognize the Indigenous Rights to Water. These rights were formally recognized globally in the 2007 UN Declaration of the Rights of Indigenous Peoples (DRIP (UN, 2008). An Annex on Indigenous engagement would have been in keeping with the vision of DRIP.

4.7 Opportunities for the Great Lakes Water Quality Protocol 2012

4.7.1 Right to Water

On July 28, 2010 the United Nations General Assembly formally recognized the human right to safe and clean drinking water and sanitation as "essential for the full enjoyment of the right to life" (UN Human Rights, 2013). The UN Human Rights Council adopted a second resolution two months later affirming that water and sanitation are human rights which is derived from the right to an adequate standard of living. The UN Human Rights Council further declared that the human right to water and sanitation is "inextricably related to the right to the highest attainable standard of physical and mental health as well as the right to life and human dignity" (UN Human Rights, 2013). As members of the United Nations, both US and Canada are obligated to prepare an action plan for the realization of the right to water. This action plan must outline how they will meet the three obligations inherent in a human right; the obligation to respect, the obligation to protect and the obligation to fulfill. The obligation to protect presents an opportunity for the Great Lakes. Under this obligation, both US and Canada are obligated to prevent third parties from interfering with the right to water and sanitation, through actions such as preventing pollution and extraction of water by the private sector. The Great Lakes water quality agreement can harness this right in the protection of the waters of the Great Lakes, which is a source of drinking water to so many North Americans.

4.7.2 Legal Mechanisms to Incorporate the Protocol

Both the United States and Canada have existing legal mechanisms that enshrine parts of the Protocol in cooperative Agreements and law. For example, Canada has relied on the Canadian-Ontario Agreement as a mechanism for cooperation between the Province of Ontario and the federal government for Great Lakes Restoration. According to the Ontario Ministry of Environment Website (2013), the Province of Ontario is working on the proposed Great Lakes Protection Act which has the potential to provide tools for setting broad direction for ecological restoration as well as accommodating targeted action in priority degraded areas. Similarly the *US has recognized the Great Lakes Water Quality Agreement in the Clean Water Act, the Beaches Act, the Great Lakes Restoration Initiative (GLRI) and several Executive Orders of its Presidents. These are visionary precedents that can aid in the implementation of the Protocol.*

4.7.3 North American Free Trade Agreement Environmental Committee

The North American Free Trade Agreement (NAFTA) came into force on January 1, 1994 and was accompanied in the same year by the North American Agreement on Environmental Cooperation (NAAEC), which was designed to facilitate cooperation on environmental protection by the three countries. A Commission for Environmental Cooperation (CEC) was established as an intergovernmental organization to facilitate this cooperation on environmental matters, to ensure implementation of environmental legislation and for dispute resolution. The CEC receives financial support from all three countries and comprises of cabinet level representation from each country on a governing Council. (CEC, 2013).

The CEC presents an opportunity for the Great Lakes Water Quality Agreement as it is an established organization working on matters that will have an impact on the Great Lakes Region. For example, in the area of chemicals management, the CEC has a Sound Management of Chemicals (SMOC) initiative which is a collaborator initiative for the comprehensive life cycle management of a range of chemicals of mutual concern. The CEC has already identified chemicals of mutual concern such as pesticide, DDT, lindane, mercury, dioxins, furans and flame retardants such as polybrominated diphenyl ethers (PBDEs). A partnership between the CEC and the GLEC can inform the implementation of the Annexes and prevent the fragmentation and duplication of efforts in protecting the waters of the Great Lakes.

4.7.4 The Canada-European Union (EU) Comprehensive Economic and Trade Agreement (CETA)

The Canada-European Union (EU) Comprehensive Economic and Trade Agreement (CETA) was agreed in principle on October 13, 2013 (CETA, 2013). This is a comprehensive trade agreement between Canada and the EU that has the potential to boost trade and investment between the two regions that share some of the worlds shared water basins. As such, CETA can be seen as an opportunity to benchmark from the regulatory and technological practices through partnerships centered around regulatory cooperation for freshwater protection, shared experiences under the EU Water Framework directive and the Protocol, learn from the implementation of adaptive management in transboundary basins such as the Danube and foster technological innovation through centers such as Ontario Water Innovation Centre. The desire to harness the market potential in the EU may for Canadian producers to adopt cleaner, more environmentally sustainable practices such as no or reduced tillage on farms.

4.7.5 New Partnerships

Since the original Agreement, groups have coalesced around common interests around Great Lakes restoration. Some of these groups contain experts and activists who have dedicated their lives to Great Lakes work. There are two new partnerships that afford the opportunity to engage these experts and also allow the capacity building of a newer generation of Great Lakes researchers and advocates. They are the Great Lakes Futures Project and the Great Lakes Policy Research Network. According the Great Lakes Futures Project Website (2013), it is an inaugural project of the Trans border University Network (TRUN) for water stewardship that assessed past and potential future states of the Great-Lakes St. Lawrence River Basin that aims to inform policy through visioning alternative futures. The Futures project also aimed to train future Great Lakes leaders through their involvement in the research. The Great Lakes Policy Research Network, a collaborative of researchers, practitioners, and graduate students in Canada and the US documents on their website (2013) their goal as improving policy outcomes through the engagement of government, non-governmental, private sector, community organizations in the creation of new knowledge through transboundary research projects. This represents a ready pool of resources that can be harnessed in the implementation of the Protocol.

4.7.6 Funding Sources

There are various funding sources that can be harnessed for the restoration of the Great Lakes. The Great Lakes Restoration Initiative is one example of this. This was the election campaigning promise of President Obama that came to fruition in 2010. Similarly, Canada has a Great Lakes Sustainability Fund (GLSF) that began in 2000 as part of the Great Lakes Program's Great Lakes Basin 2020 Action Plan. According to the Environment Canada website, the GLSF will continue until March 2015. It should be noted that the GLSF is limited to the delisting of the Areas of Concern (AOC). Ontario has also launched the Great Lakes Guardian Community Fund with the aim of engaging communities in protecting their corner of the Great Lakes.

4.7.7 Engaged Community Groups

There are many community based organizations that are engaged in Great Lakes efforts and also many existing that are not yet part of the restoration efforts. Some Indigenous Organizations are not yet part of the restoration efforts. Organizations such as Chiefs of Ontario and Provincial Territorial Organizations can be engaged in restoration efforts. The Watershed Organizations in the United States and the Conservation Authorities in Canada already has stewardship programs with communities and can be called upon to lead the community engagement efforts.

4.7.8 Experienced Great Lakes Experts and staff

There is an experienced pool of Great Lakes Experts and staff still working on Great Lakes issues. The Great Lakes Policy Research Network has compiled list of policy experts as part of the project. There is also an expert directory on the International Association of Great Lakes Research (IAGLR) website (2014). These persons represent a ready pool of experienced, committed individuals who are available to work on the implementation of the Protocol. The US Environmental Protection Agency and Environment Canada are staffed with personnel with over a decade of Great Lakes expertise. These persons will be engaged in the implementation of the Protocol as part of the Great Lakes Executive Committee (GLEC).

4.8 Threats to the Great Lakes Water Quality Protocol 2012

4.8.1 The Canada-European Union (EU) Comprehensive Economic and Trade Agreement (CETA)

The Canada-European Union (EU) comprehensive Economic and Trade Agreement (CETA) can also be a threat to the Great Lakes if it is used only for profit maximization Some of the key partnership sectors include agriculture and agrifood, manufacturing, food, fish and seafood and chemicals and plastics. According to Canada's CETA website (2013), an average of $2.5 billon was earned by agricultural exports during 2010-2012, with average tariffs of 13.9 percent. When CETA is entered into force there is likely to be increased production of crops that no longer carry a tariff; (CETA, 2013).

This increased production of agricultural products will likely have a negative environmental impact on the waters of the Great Lakes. According to the EU-Sustainability Impact Assessment Report (EU-SIA Report) (EU, 2011), under the full removal of tariffs scenario, the concomitant changes in demand will affect land and water usage and quality, waste creation, biodiversity and air pollution. This raises the question of how well positioned are relevant annexes in the protocol, such as nutrients, chemicals of emerging concern, habitat and species positioned to counteract these potential threats.

4.8.2 Lack of Resources for Implementation

In Article 4, clause 3, on implementation, the parties committed themselves to the appropriation of funds for implementation and for the IJC to carry out its activities. Further, Article 4 Clause 5 further expounds on this for US and Canada by qualifying their obligations as being subjected to the "appropriation of funds in accordance with their respective constitutional procedures". As was seen in the past, the lack of funding was one of the key weaknesses in the ability to implement restoration work.

While there are funding initiatives in both Canada and the United States, these have been steadily declining. In Canada, funding was allocated from 1989-2012 under the Great Lakes Action Plan, a federal funding commitment to implement the Federal Great Lakes Program and to honor commitments under the Great Lakes Water Quality Agreement. This funding commitment of $8 million dollars over five years, with annual allocation of $50M ceased in 2012. The Canadian Ontario Agreement (COA) also expired in 2012, so there has been no new commitment of funds as there has not been a new COA. On the US side, President Obama's Great Lakes Restoration Initiative (GLRI) funding commenced in 2010 with an initial total commitment of $2.2 billion for the five years (Sheikh, 2013). However, on July 23, 2013 a bill was approved by the US House of Representatives subcommittee that cut funding for 2014 by 80%, down from a proposed $285 million to $60 million (Michigan Radio Newsroom, 2013).

This represents a growing funding gap for what is required for restoration of the Great Lakes.

4.8.3 Fragmented Nongovernmental Organizations - Closing of Great Lakes United

The growing sense of community of Great Lakes Non-Governmental Organizations is widely captured in the literature. This culminated in a bi-national citizen Organization, the Great Lakes United (GLU) formed thirty years ago and dissolved in 2013 due to lack of funds (Elder, 2013). The political influence of this bi-national force grew as the GLU was able to harness the public's opinion and represent their interest. The GLU conducted meetings with the public and reported their views in "Unfulfilled Promises: A citizen's Review of the International Great Lakes Water Quality Agreement", recording criticisms for the conflict of interest in Water Quality Board members and highlighting how the lack of funding impeded implementation (Botts and Muldoon, 2005). The closure of this bi-national group is a threat to the implementation of the Protocol.

4.8.4 Poor Governance

Much has been written on the poor governance in the Great Lakes (Botts and Muldoon, 2005; Manno and Krantzberg, 2008; Bails et al, 2005). Elements of this poor governance include fragmented institutions, poor accountability and transparency, lack of governance capacity including the resources for restoration of degraded areas and lack of public participation. This could prove one of the biggest stumbling blocks in the implementation of the Protocol.

4.9 SWOT Summary Table

A summary of the results found in the SWOT analysis is found in Table 4.4. As can be seen from Table 4.4, there are numerous strengths of the Great Lakes Water Quality Protocol 2012. However, weaknesses internal to the environment of the Agreement and threats in the external environment can impede the implementation process. By being cognizant of these threats, policy makers can harness the opportunities in the external environment to aid in the implementation of the Protocol.

Strengths (S)	Weaknesses (W)
• Visionary Purpose • Binationalism • Contemporary Focus • Broadened Scope • Indigenous Involvement • Relevant to Tar Sands • Clear Role of the IJC • Nearshore Focus • Review and Amendment • Public Participation through GLEC	• Ambiguous Language • Lack of clarification of what's feasible • Lack of gap analysis for all annexes • Inconsistent referencing of impact on human health • Separate treatment of Groundwater • No Annex on Contaminated sediment and dredging • No clear definition of the Nearshore • Confusing overlaps on nearshore areas in the Annexes • Lack of dispute resolution process for GLEC • Discrepancy between principles and annexes • No Annex on Indigenous engagement
Opportunities (O) • Right to water • Local Legal Mechanisms • NAFTA CEC • CETA • New Partnerships • Funding Sources • Engaged Community Groups • Experienced Great Lakes Experts and staff • Great Lakes Human Health Effects Program	Threats (T) • CETA • Lack of resources including political will • Fragmented NGOs – folding of GLU • Poor Governance

Table 4.4:Results of the SWOT analysis of the Great Lakes Water Quality Protocol 2012

4.10 Conclusion

Overall, the Protocol represents a renewed call and commitment to the restoration of the waters of the Great Lakes ecosystem. It retains the original purpose to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes while expanding to encompass new threats in both revised annexes and three completely new ones: Aquatic Invasive Species, Habitat and Species and Climate Change. This protocol has retained the spirit of binationalism of the original Agreement and has expanded to include participation of the public including the Indigenous Community including the First Nations, Metis and Tribal leaders, with accommodations for representation on the Great Lakes Executive Committee. The public is also allowed participation through the triennial Great Lakes Public Forum.

The SWOT analysis of the protocol reveals many strengths and weaknesses that are internal to the Protocol and Opportunities and Threats in the external environment. It is envisioned that this SWOT analysis will prove useful for implementation of the Protocol by inviting decision makers to consider important aspects of the internal and external aspects of the Protocol.

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Chapter 5

The Great Lakes Water Quality Protocol 2012: A Focus on the Effectiveness of the International Joint Commission

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Abstract:
The Great Lakes Water Quality Agreement Protocol 2012 (the Protocol) was signed on September 7, 2012 by Canada's Environment Minister Peter Kent and US EPA's administrator Lisa Jackson. Both Kent and Jackson endorsed the protocol, articulating that the changes signify a commitment by both the US and Canada to improving water quality in the region. While there is optimism that the Protocol will lead to a more resilient Great Lakes basin ecosystem, there is great uncertainty regarding specific solutions required to tackle the stressors to the nearshore areas. Some of the stressors impacting the nearshore areas and threatening the sustainability of the ecosystem include extensive colonization of zebra mussels in the lower lakes, invasion by other aquatic invasive species basin-wide, algal blooms in Lake Erie, toxic contaminants, and hydrologic modifications. Experts feel that this is a crisis in governance, as Great Lakes Institutions have had limited success in addressing essential policy needs. This paper aims to critically evaluate the effectiveness of the International Joint Commission, the transboundary bi-national institution that could be at the helm of governance to enable implementation of the protocol and the goal of sustainability of the Great Lakes aquatic ecosystem. The methodology employed for this critique is archival analysis.

Key Words: Great Lakes Water Quality Agreement, Protocol, International Joint Commission, Transboundary, Governance

5.1 Introduction

The signing of the Great Lakes Water Quality Agreement Protocol 2012 (The Protocol) on September 7, 2012 by Canada's Environment Minister Peter Kent and US EPA's Administrator Lisa Jackson can be seen as a reinvigorated promise for improving the quality of waters of the Great Lakes Basin Ecosystem and the biota it supports, including the 35 million of residents of the region. The Purpose to "restore and maintain the chemical, physical and biological integrity of the Waters of the Great Lakes" clearly articulates the integrated visionary scope of the Protocol (Canada and US 2012, 5). One of the keenly awaited provisions of the Protocol was restructuring the role and function of the International Joint Commission (IJC), the transboundary institution established by the Boundary Waters Treaty of 1909 and given the mandate to assess progress under the 1972 Great Lakes Water Quality Agreement, a permanent reference under the Boundary Waters Treaty.

In the early years of the Agreement the IJC was credited with the success of the Agreement such as leading the scientific research that resulted in the Parties reversing eutrophication in Lake Erie. However, changes to the Agreement in 1987 were thought to undermine the functioning of the IJC and resulted in lessened engagement and constrained reporting. As such, during the public engagement process for the review of the Agreement, many public groups called for the review of the function and scope of the IJC. This paper examines the provisions of the Protocol directed towards the IJC, to determine whether they can facilitate effectiveness of the IJC to aid in their role of mitigating and preventing stressors to the Great Lakes Basin ecosystem. This paper uses document and archival analysis to assess whether the Protocol contains provisions that meet the requirements for effectiveness of river basin organizations as documented in the literature.

5.2 The North American Great Lakes

The North American Great Lakes are the largest freshwater ecosystem in the world, accounting for 20% of the world's surface freshwater. These five lakes –Superior, Michigan, Huron, Erie and Ontario- have a total volume of 23,000 km^3 of water and cover an area of 244,000 km^2 (USEPA, 2013). According to the US EPA (2013) ten percent of the American population and thirty-one percent of the Canadian population live in the Great Lakes Basin. In addition to providing drinking water, the Great Lakes basin is a major industrial hub where 60% of North American steel and one fifth of all manufacturing goods are produced (Botts and Muldoon, 2005). However, the adverse effects of these activities including pollution from agriculture, urbanization and industry have continued to degrade the great lakes ecosystem.

This degradation of the Great Lakes ecosystem was documented in a report endorsed by over 200 Great Lakes Scientists in 2005. These scientists agreed that “the Great Lakes presently are exhibiting symptoms of extreme stress from a combination of sources that include toxic contaminants, invasive species, nutrient loading, shoreline and upland land use changes and hydrologic modifications” (Bails et al, 2005, p.1). These findings were reinforced in the IJC’s 16th Biennial report which provided further evidence of stressors to the Great Lakes: concentrations of chemicals of emerging concern such as polybrominated diphenyl ethers (PBDEs) have increased in fish since 1987, 34 nonnative species have become established in the Great Lakes through ballast water discharges from 1987, Diporeia spp. (small shrimplike invertebrate integral to the aquatic food web) has almost disappeared, there has been a resurgence of harmful algal bloom in Lake Erie and there is sign that climate change is affecting the Great Lakes evidenced by warming surface temperature and decreased ice cover (IJC, 2013). These stressors cannot be dealt with by a single command and control agency, and are evidence of the need for better governance mechanisms for the Great Lakes.

5.3 The International Joint Commission

The International Joint Commission (IJC) was established under the Boundary Waters Treaty of 1909. This treaty governs the use of boundary and transboundary waters between Canada and the United States. It establishes the International Joint Commission in Article VI and offers the provision of the Great Lakes Water Quality Agreement (1972, 1978, and 1987) as a permanent reference under the Treaty. This Agreement reaffirmed the obligation of Canada and the US to not pollute boundary waters under the Treaty and assigned the IJC the role of evaluating the Parties progress in meeting the purpose of the agreement, as well as assisting in the implementation of the Agreement.

Initially the IJC was lauded in its role of helping to foster a sense of community in the Great Lakes through its timely reporting, its public meetings and through engagement with stakeholders. One of the key roles of the IJC was the analysis of Great Lakes data provided by governments in order to report on progress of the Parties (US and Canada) in reaching the goals of the Agreement. However, after the 1987 Agreement the role of the IJC was changed, and some argue, diminished. The Parties did their own reporting and more took more responsibility for oversight of programs and policies. This diminished role of the IJC was evidenced by the lack of attention given to the

IJC reports by the Parties, the development of the Binational Executive Committee to evaluate progress and execute programs under the Agreement and to respond to emerging issues and also by the reduced funding to the Commission (Botts and Muldoon, 2005). This diminished role of the IJC has been linked to the lessening of community engagement by Great Lakes stakeholders (Botts and Muldoon, 2005). .

5.4 Evaluating the Effectivness of the International Joint Commission

The Great Lakes Water Quality Protocol 2012 included three new annexes to address aquatic invasive species, habitat and species, and climate change. These issues were raised during by the public and the agencies during the review of the Agreement (ARC 2006). Another issue that was raised was the role and effectiveness of the IJC. The Protocol contains provisions for the IJC under Article 7. However, there has been no assessment in the literature of whether these provisions can enable an effective IJC. As such, this task is attempted here using the framework for assessing River Basin Organizations in the literature (Schmeier, 2013)

According to Schmeier (2013), there are ten variables of institutional design of River Basin Organizations (RBOs) (or Lake Basin Organizations) that have an impact on lake governance effectiveness. These variables are: membership structure, functional scope, legal bases of RBOs, organizational structure, financing, decision making mechanisms, data and information management, monitoring, dispute resolution and external actor involvement (Table 5.1). The provisions in the Protocol for the functioning of the IJC will be evaluated using these variables to assess the potential effectiveness of the IJC under the framework of the Protocol.

Variable	#	*Hypothesis*
Membership Structure	I	The IJC will be more effective if it includes both the US and Canada equally in the governing process.
Functional Scope	ii	The IJC will be more effective if the problems addressed in the Protocol are included in the Scope of responsibilities of the IJC.
Legal Bases	iii	IJC will be more effective if it relies on principles of equitable and sustained use of the waters of the Great Lakes, not to cause harm and prior notification in the event of an undertaking. It will also be more effective it is equipped with a well-developed degree of legalization and institutionalization.
Organizational Structure	iv	IJC will be more effective if the organizational set up is sufficiently differentiated (with many parts) and if they have a secretariat in place to fulfill a well-defined set of administrative and executive activities.
Financing	v	The IJC will be more effective if it is provided with sufficient financial resources to undertake its responsibilities and to be innovative in its undertakings.
Decision Making Mechanisms	vi	The IJC will be more effective if internal decisions can be taken on the basis of majority principles and become increasingly binding by the Parties.
Data and Information Management	vii	The IJC will be more effective if data and information can be exchanged within and outside of the organization in a formalized and centralized manner.
Monitoring	viii	The IJC will be more effective if there are provisions to monitor the US and Canada's (the Parties) behaviour and ensure compliance with the institutions' rules.
Dispute resolution	ix	The IJC will be more effective if dispute resolution mechanisms are clearly defined, binding and institutionalized.
External Actor Involvement	x	The IJC will be more effective if all stakeholders in the lakes basin have the possibility to contribute, if epistemic community actors are enabled to share knowledge and if their activities are well coordinated with other regional institutions in the basin.

Table 5.1: The relationship between variable and hypothesis for effectiveness of the IJC

5.4.1 Membership Structure

The Protocol does not modify the existing membership structure of the IJC. Since it is a reference under the Boundary Waters Treaty of 1909, in Article 7 the Protocol links the IJC to the Treaty by using the words "pursuant to the Boundary Water Treaty" (US and Canada 2012). As such, the membership of the IJC remains as described in Article VII of the Boundary Waters Treaty. This stipulates that the IJC comprises of six commissioners, three from the US and three from Canada (Figure 1). What is particularly interesting as shown in Figure 5.1, is that notwithstanding that the population and antropogenic stressors are much greater in the US than in Canada, the equality at the head of the institution remain fundamental to parity in decision making. This structure has worked well in the past in preventing disputes over water quality and also water quantity as stipulated under the Boundary Waters Treaty of 1909. As such, the Protocol does facilitate an effective membership structure by not asking for any modifications to what exists.

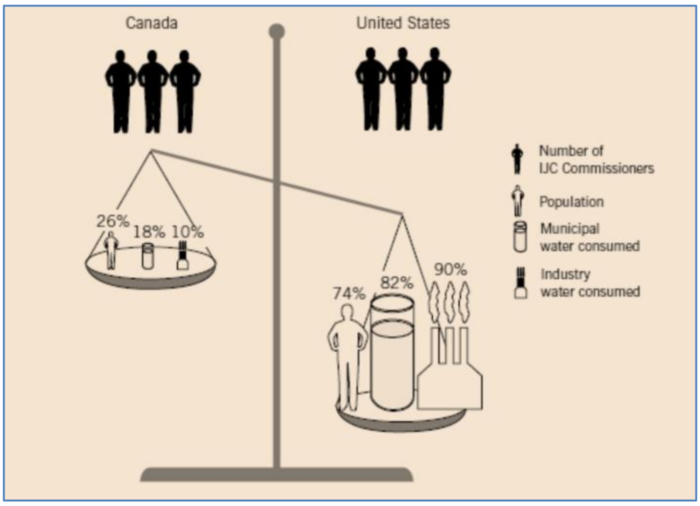

Figure 5.1 : The Membership structure of the IJC

Source: Commissioner of Environment and Sustainable Development, 2001

5.4.2 Functional Scope

The functional scope of the IJC is also outlined under Article 7 of the Protocol. The scope includes analyzing and disseminating data relating to the general and lake ecosystem objectives and also to the pollution of waters of the Great Lakes. This covers the entire range of stressors to the Great Lakes and thus is broad in scope. Clause C under Article 7 further expounds on the duties of the IJC including giving advice and recommendations to the Parties on social, economic and environmental aspects of current and emerging issues related to the quality of the waters of the Great Lakes and also matters covered under the Annex of the Agreement. As such, hypothesis ii in Table 5.1 is supported; we conclude that the IJC's functional scope under the Protocol is sufficiently broad to ensure effective oversight of Great Lakes water quality matters within its mandate and activities.

5.4.3 Legal Bases of the IJC

It should be noted that the Protocol is not a treaty. The reason for this is that it is a lengthy process to get it recognized as an Agreement in the US, also a Treaty implies that it has a legal foundation as a treaty is negotiated and signed by the President through the State Department and must be ratified by the senate (Duke University 2014). Some feel that not coding the Agreement into a treaty signifies a lack of political commitment and will. However, there are principles of transboundary water law that are embedded in the Protocol which can be useful for the IJC in assessing progress of the Parties. Further, cooperation in the basin under the agreement has proceeded without the legal instrument of a treaty.

In Article 2, Principles and approaches, international principles in line with Rio Declaration on Environment and Development such as 'polluter pays' and 'precautionary principles' are stated as guiding measures to achieve the purpose of the Protocol. Also, Article 6 on notification captures the key principle of prior notification, stating that each Party should notify the other if there is an imminent threat (or incident) of pollution that could be of concern. Further, the IJC can potentially use the legal power vested in it by virtue of the Boundary Waters Treaty for the resolution of any conflict pertaining to water quality. However, history has shown that this has never been used. With reference to hypothesis iii in Table 1, the IJC does possess a legal personality and a high level of institutionalization (conferred to it under the Boundary Waters Treaty) that can aid in effectively fulfilling its oversight mandate in the Protocol.

5.4.4 Organizational Structure

The Organizational structure of the IJC underwent changes in the 1987 Agreement and these have again been addressed in the Protocol. The Organizational structure of the IJC under the Protocol is shown in Figure 5.2.

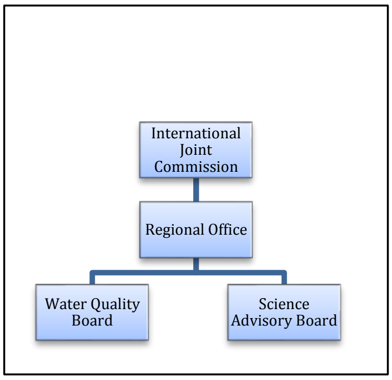

Figure 5.2: IJC Organization Structure under the Protocol

The IJC has a very compact organizational structure under the Protocol. It consists of the high level decision making Commission, the technical advisory Boards and the administrative Regional office (in liaison with the Ottawa and Washington Section offices). Under the Protocol, the Water Quality Board (WQB) is given the mandate as the principal policy advisor to the IJC and has equal representation from each country, inclusive of the Indigenous population, state and provincial governments, watershed agencies, local public agencies, jurisdictions and the public. The Science Advisory Board is given the mandate of providing advice on research and science to the Commission and to the WQB. This board has representation from managers of Great Lakes research programs and experts on water quality and includes representation from the Parties, state and provincial governments, academia, industry and others.

The IJC regional office is the administrative arm of the IJC that is located in Windsor, Ontario and managed by a Director whose position alternates between a Canadian and US citizen. According to the Protocol, the Regional office's role is the provision of administrative support and technical assistance to the WQB and SAB and their sub-organizations and also to provide public notice and outreach for the IJC and Boards activities, including hearings, and providing any other assistance as required by the IJC. Overall, the organizational structure of the IJC, in principle, can be said to be conducive to its effectiveness as the Boards facilitate its oversight function while the Regional office serves to aid its operational effectiveness.

5.4.5 Financing

The provisions for financing the IJC have not changed much from the 1987 Agreement to the Protocol. Both versions of the Agreement speak to the submission of the budget by the Commission and that each Party shall pay one half of the approved annual budget of the Great Lakes Regional Office. Both also commit the Parties to the appropriation of funds required by the International Joint Commission in the executing of its functions. This is not a guarantee that adequate funding will be provided under the Protocol as the Commissioner of Environment and Sustainable Development found that the provision of funds for the IJC has been slow and uncertain (2001). Further, it has been found that the reduction of resources to the IJC since the 1990s has led to a loss of reporting role of the IJC (Botts and Muldoon 2005). This confirms hypothesis v, that the IJC was more effective when there was more financing. There is nothing in the Protocol that guarantees commitment of funds to the IJC to carry out its mandate under the Protocol.

5.4.6 Decision Making Mechanisms

Decisions by the IJC are taken on a consensual majority basis with one vote per Commissioner. This is stipulated in the Treaty which states in Article X that "the majority of the said Commission shall have power to render a decision" (IJC 2013). The Treaty also stipulates that if the Commission is at a stalemate or unable to make a decision, then they shall make a joint report to the respective Governments. In the history of the Agreement, there have been very few instances of the inability of the Commission to make a decision. Dissenting positions from a single Commissioner, for example, are rare but not without occurrence. For example, Commissioner Pollock chose not to sign the IJC's advice to the Parties on recommendations of the International Upper Great Lakes Board because "it places insufficient emphasis on climate change and the need for governments to pursue and fund adaptive management strategies in the Great Lakes Basin" (IJC, 2013). Further, the Protocol facilitates the decision making process by stipulating in Article 2 the reliance on science based management where implementation of management decisions, policies and programs are based on best available science. According to Botts and Muldoon (2005), this common fact finding facilitates the decision making process as it de-politicizes the problem, creating unity around a fact finding mission.

Much like the 1987 Agreement, there is no mechanism in the Protocol to ensure that the decisions of the IJC are binding to Parties. In the past, the Parties (federal governments) have not followed up on many of the recommendations of the IJC under the Water Quality Agreement. For example, in the US response to the 11^{th} Biennial Report, the US stated that "it is very difficult to set reliable schedules for remediation" in a repeated recommendation by the IJC to set priorities and schedule for contaminated sediment remediation (IJC, 2013). Further, the parties have taken much time with giving a response as shown in Figure 5.3. As such, according to hypothesis vi in Table 5.1, that while the decision making by consensus aids the effectiveness of the IJC, it is compromised by the lack of responsiveness or enforceability by way of policy or program reform by the Parties.

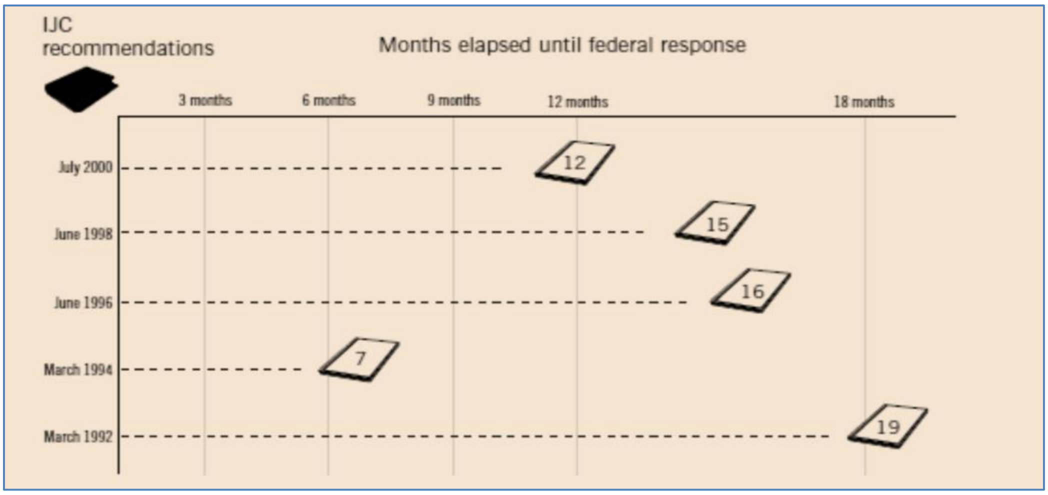

Figure 5.3: Delays in the Parties response to the IJC's recommendations

Source: Commissioner of Environment and Sustainable Development, 2001

5.4.5 Data and Information Management

There are many provisions for data and information sharing and management in the Protocol. The IJC has a responsibility for the dissemination of information to the public triennially in the Great Lakes public forum as stipulated in Article 5. Under Article 7, the IJC is mandated with the analyzing and sharing of data and information obtained from the Parties, the Indigenous community, government agencies, municipal agencies and the public. The IJC is also mandated to provide data and information in its triennial report to the Parties. However, for it to execute this function effectively, the IJC needs to have data provided by the Parties as called for in Article 7, clause 2, which states that the Parties shall provide data or information as requested by the IJC subject to national security considerations, information laws, and privacy laws, regulations and policies. While these provisions were included in the 1987 Agreement they did not result in the timely provision of information to the Commission by the Parties as shown in Figure 5.4.

October 1996	The Commission met with representatives of Canada and Ontario and asked how budget cuts would affect their ability to meet their obligations under the Great Lakes Water Quality Agreement. No response was provided.
March 1997	The Commission sent the two governments a letter repeating its request.
October 1997	At a semi-annual meeting with the Commission, a federal official said the information would be sent later that fall. It was not.
June 1998	In its 9th biennial report, the Commission reminded the federal and provincial governments that it had not received the information it wanted.
August 1999	The federal and provincial governments informed the Commission by letter that they were still committed to rehabilitate, protect and conserve the Great Lakes basin ecosystem. The letter also said that while they would not meet some targets in the Canada-Ontario Agreement on schedule, they would meet the majority and would make significant progress toward others.

Figure 5.4: Delays in the Parties providing information to the IJC

Source: Commissioner of Environment and Sustainable Development, 2001

The Parties need to provide more timely information to the IJC for it to be effective in its governance of Great Lakes water quality, in keeping with hypothesis vii in Table 1.

5.4.6 Monitoring

The Protocol gives the IJC responsibility for both environmental and compliance monitoring under Article 7, which has the potential to make a significant contribution to the effective governance of the sustainability of the waters of the Great Lakes. With regards to environmental monitoring, the Protocol gives the IJC the authority to independently verify the data and information supplied by the Parties for an assessment of their progress to meeting the objectives. The IJC does not do any independent ecological monitoring; rather it uses third party results with their own independent analysis and interpretation, supported by the Boards. With regards to compliance monitoring, the Protocol gives the IJC the mandate to monitor results in order to assess the progress of the Parties in achieving the General and Specific Objectives of the Agreement. This is to be done through triennial reports that evaluate the progress of the Parties, and made available to the public and the Parties.

The function of monitoring of progress of the Parties is made easier for the IJC by Annex 10, clause D. This clause mandates the Parties to establish and maintain comprehensive science based ecosystem indicators to assess its own progress in achieving the objectives of the Protocol, and to assess the state of the Great Lakes and anticipate emerging threats. Depending on what they are measuring and reporting, these indicators could make it easier for the IJC to evaluate the Parties performance related to the Protocol. However, there are no mechanisms to ensure that this compliance to the provision of information is adhered to. As such, in accordance with hypothesis viii, the IJC's effectiveness can be undermined if the Parties do not comply with the provision of information to facilitate monitoring of progress, or if the indicator metrics and methods of reporting are not clearly related to meeting the purpose of the Agreement.

5.4.7 Dispute Resolution

The dispute resolution process within the IJC is facilitated by consensual decision making and science based decisions. As such, there has not been a history of conflicts within the Commission. However, there has been a record of conflict with the IJC and the Parties that led to the pulling away of the Parties from the IJC processes (Botts and Muldoon 2005). There is no provision in the Protocol for dealing with conflicts resulting from untimely submission of information by the Parties to the IJC. This can undermine the effectiveness of operation of the IJC.

5.4.8 External Actor Involvement

The IJC does not operate in a vacuum but considers input from the public. Throughout the history of the Agreement the IJC has involved the public through biennial meetings, public hearings and attendance at board meetings and events. The Protocol contains provisions for the inclusion of a wider cross section of the public, for the first time mandating the inclusion of the Indigenous community. The Protocol requires that the Parties and the IJC convene a Great Lakes Public Forum within one year of entry into force and triennially after. This forum shall allow the IJC to receive public input on the progress report of the Parties, other issues that concern the public, in addition to allowing the Parties to receive public input on the state of the Lakes. Over the years the IJC has used mechanisms such as press releases, websites, webinars and public meetings for engagement of the public. The IJC has also involved academia in the Boards and through the use of scholarly research reports. The IJC has a history of engagement with binational organizations such as the Great Lakes Fishery Commission and the then (now dismantled) Great Lakes United. In accordance with hypothesis x, the provisions in the Protocol allow the IJC to engage the public in Great Lakes matters and hence improve its effectiveness towards achieving sustainability of the Great Lakes

Basin ecosystem.

5.5 Conclusion

The Great Lakes Water Quality Protocol 2012 contains many provisions that enable effective governance by the International Joint Commission. The membership structure of the IJC is very conducive to its effectiveness, as there are three members from each country and each member acts on his own expertise rather than on national interests. Further, the Protocol enables the IJC to advise the Parties by ensuring its scope covers all the issues that face the Great Lakes today and includes room to tackle emerging issues. For it to achieve its mandate in the oversight of the Agreement, the IJC is given specific responsibilities under Annex 7 of the Protocol. This review has found that although the Protocol is not a legal document, there are sufficient international water law principles in the Protocol to enable the effectiveness of the IJC. Such principles include ‘the polluter pays’, the precautionary principle and the concept of equitable sharing.

The IJC’s organizational structure under the Protocol is sufficiently differentiated to enable its effectiveness. It has both the Water Quality Board and the Science Advisory Board for the provision of policy and scientific/technical advice while it has a Regional Office for additional research and administrative support. The Protocol enables the IJC to engage external stakeholders in meeting the requirements of the Protocol. However, the effectiveness of the IJC could be hindered by a lack of adequate funding and conflict arising from the untimely provision of information of data and information by the Parties to the IJC and the inability or unwillingness of the Parties to implement the recommendations of the IJC. There is no mechanism to enforce IJC recommendations. As such, while the Protocol contains adequate provisions to facilitate the effective functioning of the IJC, failure by the governments of Canada and United States to follow through on those provisions could limit the effectiveness of the IJC and prove damaging to the sustainability of the waters of the Great Lakes ecosystem.

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Chapter 6

The Toledo Drinking Water Advisory: Suggested Application of the Water Safety Planning Approach

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Abstract:

On 2 August 2014 the city of Toledo, in Ohio USA issued a "do not drink" water advisory and declared a state of emergency. This was as a result of elevated levels of the toxin microcystin in the final treated water, a dangerous toxin produced by the algae cyanobacteria. The Toledo water crisis is a key focusing event that can advance dialogue on eutrophication governance in the context of public health. This paper examines the Toledo water ban with the aim of determining whether this crisis could have been averted. Further, we explore how this event can be used to stimulate action on eutrophication governance, to motivate action to protect water at its source. We use the World Health Organization's Water Safety Planning Methodology to show that the crisis could have been averted with some simple risk management actions. We also show that a water safety planning approach could lead to well developed operational and maintenance planning resulting in a higher probability of safe drinking water.

Keywords: drinking water advisory; Toledo water; water safety planning; Great Lakes; eutrophication; cyanobacteria

6.1 Introduction

On 2 August 2014, the city of Toledo, Ohio, in the United States of America issued a "do not drink" water advisory. This put the city in the local, regional and international media spotlight, with headlines reading "Water crisis grips hundreds of thousands in Toledo area, state of emergency declared" [1], and "400,000 in Toledo, Ohio, water scare await test results" (CNN) [2]. A state of emergency was declared by Ohio Governor John Kasich in Toledo amidst national and local efforts to test the water. Efforts were also made to secure potable water for residents, with the governor calling on the National Guard to aid in the delivery of safe water to residents [3]. While the water ban in Ohio's fourth largest city did not result in any fatalities and was lifted after three days, could this crisis have been avoided entirely? This paper aims to show how the World Health Organization's (WHO) water safety planning approach could lead to a well-developed operational and maintenance planning system resulting in a highly reliable safe drinking water system with a greater probability of safe drinking water more of the time. This paper describes the Toledo water crisis as an opportunity to frame the conversation on eutrophication governance in the context of the protection of public health to spur immediate action. Historically, extreme events have resulted in the development of new policy. For example, the Cuyahoga River catching fire, organic contaminants in the Love Canal and Hurricane Sandy all have shifted the way Americans view environmental issues and have shaped their responses. Perhaps the Toledo case is an example of an event that could be a catalyst in progress toward a better water management strategy, linking the health of the lakes with land-based activities and human health. In the end it is the re-framing of the problem and evidence based research that can lead to development of policy, as in the case of policy and law on pesticide use on lawns in Canada [4].

Further, urban water management issues are best described as wicked problems, with high levels of complexity, uncertainty and multi-actor involvement. The governance literature [5,6] advances a new approach to public problem solving that places emphasis on the centrality of collaborative approaches that allow for multi-actor involvement, where government is one actor among many. An important consideration is the means by which regulatory authorities fulfill their mandates in such structures. Vabo and Røiseland [7] address the challenges faced by public leaders arising from new governance arrangements (networks) where government is just one of many stakeholders, thus rendering hierarchical approaches problematic. Engle *et al.* [8] also point towards fundamental water governance issues associated with networked forms of governance, that is, the limitations of hierarchical institutional arrangements and decision-making in an environment of uncertainty. This paper describes a governance regime that could contribute to the prevention of such incidents in the future.

6.2 Background

The city of Toledo was founded in 1833 and has a history of innovation in the glass industry, leading to its nickname as "The Glass Capital of the World" [9]. The city is located at the western end of Lake Erie and on the northern border of Ohio, as shown in Figure 6.1.

The city lies along the banks of the Maumee River, which was the first source of water for the city's 30,000 residents in 1870. In the first year of operation, water was pumped (pump capacity was 30,000 gallons) untreated to the first customers (twelve) through 85 miles of pipeline [11]. As the population of the city grew, water quality in the Maumee deteriorated. Initially, pollution was the result of untreated residential sewage discharges to the river, leading to epidemics of diseases such as typhoid. While the initial water system was driven by the goal for residents to have a convenient source of water supply and to have water more readily available for fire safety, the increase in pollution and associated epidemics led to an increasing call by residents for treated water. According to the City of Toledo [11], this resulted in the commissioning of Brookford Filtration Plant (with a capacity of 20 million gallons per day) on 2 February 1910. From that time forward, Maumee River water has been filtered and treated before being pumped to residents.

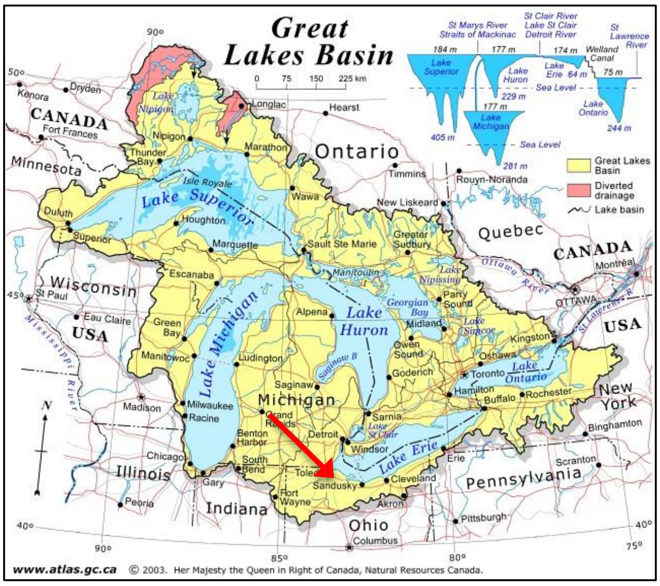


Figure 6.1. Map showing the city of Toledo, Ohio, USA [10]

In 1941, the growing population and increasing pollution of the Maumee River led to relocation of the city's drinking water source to Lake Erie when the Collins Water Treatment plant began operation with a capacity of 80 million gallons per day. During the 1950s and 1980s changes were made to the water treatment plant to increase the volumetric capacity, with 146.8 million gallons pumped in 1988. The first processing change was made in 1997, with a sludge dewatering facility being brought online [11]. This allowed the lime sludge to be recycled into other products. The treatment plant has made other changes such as the installation of a backup power facility that began construction in 2004 and the installation of a potassium permanganate feed system facility in 2009 to control the zebra mussels that were obstructing the water intake and damaging the water treatment lines. According to the City of

Toledo [11], some of the improvements made at the plant between 2011 and 2013 included updating pumps to variable speed drive, installation of a solar panel field to provide one million kilowatt hours of energy per year (2011), replacement of the flocculator drive systems (2012), roof and impeller replacements, rebuilding of the motor, drive and pump for the Heatherdowns Pump Station pump and the installation of a gas chromatograph/mass spectrometer for detection of compounds that cause taste and odor problems (2013).

6.2.1. The Toledo "Do Not Drink" Water Advisory

On 1 August 2014 at 6:30 p.m., the city of Toledo notified the Ohio EPA that the testing results for microcystin were above the drinking water advisory threshold (1 ppb), a finding that was later confirmed with a second set of samples [12]. Additional samples at 11:00 p.m. again confirmed this result in the final treated water. According to the Ohio EPA [12], a sudden spike in algal blooms in Lake Erie, combined with an unusual amount of extracellular toxin in Lake Erie, overwhelmed the treatment plant and the operators were unable to adjust their treatment regime proactively. Ohio EPA [12] advised the City at 12:00 a.m. to issue a "Do not drink" advisory, and such an advisory was issued to half a million water customers at 2:00 a.m. on 2 August 2014. On the same day, the Ohio Emergency Operations Center was activated at 5:00 a.m. and at 10:00 a.m. Governor Kasich declared a state of emergency for Wood and Lucas Counties and then extended the announcement to Fulton County.

During this time, sample protocols were being examined by the US EPA and partners to determine whether they were resulting in representative results. There was collaboration amongst agencies on sample collection, testing and interpretation of results. On 3 August, at 4:00 p.m., federal, state and City of Toledo water quality experts arrived at consensus on protocols for sample collection, and handling and testing, and additional samples were analyzed. On 4 August 2014 at 9:35 a.m., after water analysis showed that the water was safe to drink, the Mayor announced the lifting of the "do not drink" water advisory. During this time, there was extensive coverage of the event in local, regional and international media including the Toledo Blade, Bedford Now, Great Lakes Echo, CNN, BBC News, USA today and the New York Times. This interest was captured in a Google trends report, which recorded 100 searches for "Toledo Water Crisis" in August 2014. Interest waned over time, with Google searches dropping to 5 in September 2014.

6.2.2 Current US Water Legislation

The US Safe Drinking Water Act (SDWA) requires periodic testing of drinking water for contamination, and response to detected risks [13]. Still, an estimated 25% of the US water treatment systems violated the SDWA in 2011

[14]. Of these total violations, about 25% were of health-based standards [14], including violations related to microbial waterborne illnesses, which are estimated to affect 19.5 million Americans annually [15]. These waterborne illnesses can be the result of both regulated and non-regulated contaminants. For example, cyanotoxins from algal blooms in the Great Lakes recently caused the shutdown of a local drinking water treatment plant. However, cyanotoxins, an unregulated contaminant group harmful to human health, are currently on the Contaminant Candidate List to be considered for regulation in the next five years. Testing for this group in Toledo and elsewhere is therefore voluntary at present, but has nevertheless led to boil water advisories [16]. This means that until cyanotoxin testing becomes a regulatory requirement, some drinking water systems may not test for these compounds and therefore not take precautions against them [13].

6.3 Water Safety Planning: Literature Review

6.3.1 Background

The Water Safety Plan (WSP) approach has been developed and recommended by the World Health Organization (WHO) to ensure the safety of drinking water supplies. WSP is a methodology to assess, prioritize and manage risks to the water supply from catchment to consumer [17]. It is a combination of more traditional multiple-barrier risk management approach and the hazard analysis critical control point (HACCP) approach [18]. The main focus of WSP is on safe drinking water supply but it also has health-based targets to evaluate the quality of the water supplied and the condition of the water supply system. WSP includes a system assessment approach that determines if the water supply system, from source to tap, delivers a water quality to the consumer that also meets health-based targets ([19], p. 127). System assessment evaluates whether the suite of control measures in a given location are sufficient for this purpose, based on an analysis of local hazards, hazardous events and the efficacy of local control measures [19].

WSP has been a successful approach to maintain drinking water safety and is now used in many countries; it is also a regulatory requirement in several countries [17]. Some countries that have implemented WSP include: Iceland (legislated in 1995: [17]); Bangladesh, Belgium [20], Switzerland [21], the Netherlands [22], Argentina, Bolivia, Brazil, Guyana, Honduras, Jamaica, St. Lucia, Uruguay, Ecuador, Peru, Portugal [23] and Nigeria [24]. Implementation of WSP in the European Union was promoted by the International Water Association and supported by the WHO [25–27].

The motivation behind introduction of WSP and the methodology of implementation differs from country to country. For example, in Iceland, Slovenia and Switzerland, drinking water comes under food legislation and risk assessment is mandatory. In Flanders (Belgium), a few incidents highlighted the need for a framework that would address emerging issues (such as emerging pollutants) and this need became a key driver for implementation of WSP [28]. In some countries, WSP has been implemented as recommended by the WHO, while in other places there have been linkages to risk assessment and management [28]. A similar concept is sanitation safety planning (covering wastewater and sanitation), which is based on WSP and was also developed by the WHO [29].

6.3.2 Case Studies Where WSP Has Been Implemented

The following case studies show that implementing WSPs improves water quality and reduces the incidence of microbiological contamination.

6.3.2.1 Germany

In Germany, the WSP [30] concept was adopted in a modified version termed "Technical Risk Management" (TRM), where in addition to health-based targets additional targets such as quality, quantity, pressure and continuity are also identified (mainly to satisfy German drinking water standards and the expectations of consumers) [31]. This is an interesting case because unlike other countries, which depend only on one source of water supply, Germany has applied the TRM concept at water treatment plants that draw water from both surface and groundwater sources. Periodic evaluation of the existing raw water data has been helpful in understanding the variability and impacts of various land-use activities in the catchment areas. GIS-based hazard source maps are used to monitor hazardous sites with the potential to affect drinking water sources. While, it would be helpful if certain agricultural practices (especially use of fertilizers, pesticides, *etc.*) could be modified within a given catchment, such changes have proved to be more difficult in practice because such measures involve policy and are often beyond the control of water suppliers [31].

A study from a German hospital has shown a clear linkage between WSP implementation and positive health outcomes, specifically a reduction in hospital-acquired infections and neonatal sepsis ([32,33]). In 2004, very high concentrations of microorganisms occurred in a newly opened part of the hospital, resulting in the Department of Health (DHC) declaring unacceptable water testing results three months before the opening. A taskforce on water safety was formed and initiated a program to implement WSP in the hospital. To evaluate the efficacy of the WSP the microbiological results were recorded from May 2004 to April 2006. Results revealed a decrease in the density of microorganisms following implementation of the program.

6.3.3.2. Iceland

In Iceland most of the drinking water supply is from groundwater and is not generally disinfected. However, it is the responsibility of Local Competent

Authority (LCA) to protect drinking water. The Icelandic Drinking Water Regulation (IDWR) legally requires protection of sources of drinking water, which makes it obligatory for the LCA to define protection around drinking water intakes ([17], p. 7783). Implementing WSP has resulted in increased compliance with the IDWR and improved water quality, and has also resulted in a culture which regards drinking water as a public health issue [17]. The results from Iceland show an overall significant reduction in diarrheal incidences after the implementation of WSP.

6.3.3 Systems Assessment

Assessment of surface water drinking water systems in industrialized countries tends to involve site-specific monitoring of pathogens in source water. For example, the US drinking water regulation LT2 ESWTR under the Safe Drinking Water Act [34] requires pathogen monitoring in source water as the basis for system assessment. In this case, the health-based targets are taken as treatment performance objectives. A system assessment under this regulation looks at the pathogens present in the water source and evaluates treatment processes to see if they can remove the pathogens at source. The regulation specifies some important considerations for evaluation of both factors. For example, sample size, frequency, location, method, processing method and data analysis are important for monitoring pathogens in source water, while turbidity monitoring, measurement location, measurement frequency, accuracy at low turbidity levels, calibration and maintenance of the monitors and data analysis are important for monitoring the treatment process ([19], p. 130). It is also important to take into account rainfall events or snowmelt events when pathogens or turbidity in water might peak ([19], p. 131).

In the case of surface water drinking supply systems, data on pathogen occurrence in source waters and efficacy of water treatment processes is sometimes not available. In response, some water utilities have developed predefined health targets to set water quality targets and have used published data on pathogen occurrences to identified preferred treatment methods. Results of this type of system assessment have also been used to prioritize investment in specific treatment optimization or upgrades to meet the health-based treatment performance targets ([19], p. 128).

Decisions about the level of investment in treatment systems or drinking water supply systems should be based on local conditions. For example, in Kampala (Uganda), 72% of people use piped water supply from Lake Victoria (treated via coagulated, rapid sand filtration and chlorination) and of this only about 20% of people have household connections. The remaining population gets water from protected springs. Data has shown a large number of incidences of pathogens and associated diseases in Kampala, with treatment failure the main cause of the disease burden. In this case, studies have suggested that the most cost effective investment would be in improving access to piped water supply at homes. Similarly, a study in Bangladesh found that risks of microbial contamination and incidence of diarrheal disease were reduced when water supply infrastructure was improved and safer water sources were chosen [33,35].

WSP has been modified and implemented for small systems as well. For example, New Zealand has a public health risk management plan and Australia has an electronic tool to support development and implementation of WSP for small systems. Small-scale community-based WSP pilot projects were also tested in Bangladesh, with positive results. Newer versions of WSP have emerged since these pilot studies to reflect lessons learnt during the pilot stage. However, it has been observed in Bangladesh and other places that while there is an improvement in water quality and overall reduction in microbial contamination following implementation of WSP, it is difficult to achieve complete removal of indicator bacteria such as Thermo Tolerant Coliform Bacteria [35–37]. Robust monitoring tools and sustained surveillance are important to the success of these kinds of initiatives to remove Thermo Tolerant Bacteria [35].

6.3.4 Challenges/Issues with Implementation of WSP

Although WSP is widely regarded as one of the most effective frameworks to ensure safe drinking water delivery, there are some problems with the way WSPs are developed, implemented and evaluated. The first problem is in the way WSP is written. At times (for example in the case of Pacific Island countries), the focus is on writing the document with no emphasis on monitoring and evaluation. In some cases, the plan is also weak in terms of the effectiveness of control measures [33]. It would therefore be desirable to establish standard procedures to ensure consistency in development of WSPs, especially with respect to detailed system description, risk assessment and prioritization, improved schedule, monitoring plans and evaluation. Another problem is the lack of benchmarks, indicators or performance measurements against which the effectiveness of a WSP can be evaluated. As discussed by Davison and Deere [38], key public health and operational targets should be used to measure the effectiveness of WSPs; however, most jurisdictions lack measurable performance indicators associated with WSP. To rectify this, it would be important to identify the Key Performance Indicators (KPIs) to track WSP progress. The next challenge is then to evaluate these KPIs, which should include systematic verification and validation measures. It is essential to recognize that the evaluation of water supply and the evaluation of WSP are two different things, and a different set of performance indicators is needed for each. WSP targets thus need to be set at two levels: macro-targets (measuring health outcomes and overall performance improvement because of WSP implementation) and micro-targets (measuring improvements in the performance of individual systems and processes from implementing WSP) [33]. Other challenges include: limited staff to develop and implement WSPs; lack of financial aid; lack of supporting policy and regulatory environment; and lack of training and guidance materials (especially in local languages) [28].

6.3.5 Conclusion of the literature review

Most of the conventional methods for testing drinking water quality focus on end-point testing to make sure that the drinking water meets the required biological and chemical standards. WSP, however, is more comprehensive and addresses the whole water system from source to the consumer to ensure prevention of contamination at each stage [17,30]. The WSP methodology has built-in structures for improved maintenance policies and procedures, systematic repairs of pipes, a cleaning plan (e.g., regular flushing of fire hydrants and cleaning of reservoir tanks), and regular improvements in the systems (e.g., backflow prevention) ([17], p. 7782).

Implementation of WSPs in Portugal has also shown that independent auditing is valuable for successful operation of WSPs at a national level. All the major stakeholders, such as drinking water suppliers, environmental protection authorities, authorities responsible for maintaining water quality, research and educational institutions, *etc.*, should be engaged in the process from the very beginning. Furthermore, as one author has noted, “A strategic approach for WSP implementation at a national scale will enable legislators and policy makers to better apply a step-by-step phased process for effective risk assessment and risk management in water supply systems, and what this implies for the achievement of sound mechanisms in protecting public health.” ([39], p. 115).

Experiences of pathogen related illnesses via drinking water in Australia also led to implementation of WSP approach in that country. It was concluded that the communities cannot just rely on monitoring of end of the pipe water quality, because by then it is usually too late—by the time results come out of the tests consumers have already consumed this water. Implementation of preventive risk-management approach such as WSP is more reliable from the perspective of public health [40]. We recommend this approach for our case study, Toledo.

6.4. Applying the Water Safety Plan to the Toledo Case to Avoid Future Water Crisis

Based on the discussion in Section 3 on the success of WSP in reducing the incidence of microbiological contamination, the authors recommend that WSP should be applied to Toledo to avoid future crises. The WHO guidelines for drinking water quality [41] list three main sections of the WSP as follows:

(1) System assessment: This involves documenting the components of the entire water system from source to the consumer. This will aid in the determination of the ability of the system to meet set health based standards and the identification of points that are vulnerable to

potential contamination. This leads to identification of corrective actions to mitigate these risks.

(2) Operational Control Measures: This section enhances risk management through developing of operational control measures and concomitant monitoring procedures to assess effectiveness.

(3) Management and Communication Plans: This is the documentation of all sections of the water safety plan, including system assessment, operational monitoring and verification procedures. This would also include actions to be taken to optimize routine operations and also emergency procedures.

These three parts are elaborated in 11 modules, each of which will be applied to the case study of the Toledo “do not drink” water advisory in the manner of a gap analysis.

6.4.1. Assembling the Team

The first step in the water safety planning process is the establishment of an expert team to develop the water safety plan, implement it and assess and make changes in an adaptive manner. Due to the nature of these roles, it is imperative that these persons have combined expertise in the water system from catchment to consumer, and would include expertise such as environmental protectors, regulatory agencies, health specialists, utility managers, process treatment specialists, laboratory personnel, financing agents, administrative personnel, private sector representatives and non-governmental organizations. In the case of the Toledo water crisis, there is already an established working relationship between the Ohio Environmental Protection Agency, the Ohio Department of Natural Resources and the Ohio Department of Health formed during the development of the State of Ohio Harmful Algal Bloom Response Strategy [42]. However, this team does not have the expertise in drinking water abstraction, treatment and distribution. As such, it could be expanded to include professionals from the Collins Water Treatment Plant, from the City of Toledo, from private sector organizations (possible polluters and innovators) and from local non-governmental organizations with expertise in pollution mitigation and with close contact with stakeholders.

This group should also have the political authority to facilitate implementation of the recommendations emanating from the water safety planning process. To this end, it is recommended that senior officials from the relevant agencies be a part of the Water Safety Plan steering committee. In an event such as the Toledo “do not drink” water crisis, there would have been an established communication structure in place and trust amongst these individuals, leading to a more rapid action. However, with the implementation of the WSP approach, microcystin levels would not have been elevated to the extent that they were, as the contamination would have been mitigated through risk management. The engagement of senior officials in the process would facilitate tasks that require senior decision making, such as the development and implementation of standards for cyanotoxins in drinking water, developing regulatory measures and providing necessary resources for these actions. Key actions that this team would take include the appointment of a team leader, identifying the skills and personnel needed to be on the team, deciding on the scope of the water safety plan and the time frame for development, developing terms of reference for the team (norms, *etc.*), developing stakeholder engagement strategies and finally, the development and implementation of the water safety plan. For the Toledo water safety planning team, one key challenge would include organizing the workload of the team to fit in with the existing organizational structures and roles. This challenge can be mitigated by recognizing the importance of the process and incorporating the roles into daily workloads.

6.4.2. Describe the Water Supply System

This step involves a thorough mapping of the water supply system from source to the consumer. It usually consists of a detailed flow diagram that is validated through on-site checking and should be an almost exact representation of the system to allow the identification of vulnerable points in the system. It should provide information on where the system is vulnerable to hazardous events, types of hazardous events and control measures. For the Toledo case, the water supply system description would describe the water quality standard (or lack of it), the source water of Lake Erie and an alternative source in case of the pollution incident (or point out that there is no viable alternative source for the treatment plant), potential changes in water quality due to algal blooms in Lake Erie, details of land use in the catchment area such as farming practices, details of weather conditions and their impact on land use activities, the point in Lake Erie from which water is abstracted, details on the storage of water, details on the treatment plant processes including the chemicals that are used and the capability/limitation of the treatment system and the vulnerability of the system, the details of the distribution system, including storage in the network and tankers, identification of the end users of the Collins Water Treatment plant, availability of trained staff and how well existing procedures are documented. During the Toledo water crisis, there was a lack of agreed upon standards for testing of the water for cyanotoxins, there was no back-up plan for alternative water sources for the treatment plant and treatment plant vulnerability and control measures were not thoroughly thought through and documented. It should be relatively easy to document the treatment process of the Collins water treatment plant as the plant is fully automated and has an existing flow diagram. Documenting the distribution system, however, might prove a challenge due to the age and extent of the system.

6.4.3. Identify Hazards and Hazardous Events and Assess the Risks

This process involves the identification of the potential biological, physical and chemical hazards in each step of the flow diagram that can impact the safety of the drinking water supply; it identifies all hazards or events that can result in the water supply being or becoming contaminated, compromised or interrupted. For the Toledo case study, this can take the form of a quantitative or semi-quantitative approach. A quantitative approach could involve investigation of the likelihood/frequency and the severity/consequence of contaminated, compromised, or interrupted supplies. A qualitative approach might be based on the expert judgment of the water safety plan steering committee. For Toledo, this step would identify hazardous events such as agricultural contaminant loads, heavy precipitation leading to hazards such as microbial contamination, phosphorus enrichment of the water, and algal blooms. The most important consideration is the impact on public health, but other factors such as continuity, aesthetics, adequacy of supplies and utility reputation should be considered. Another hazardous event would be the capacity of the treatment plant (lack of capacity due to age) leading to inadequate treatment for toxins such as microcystin. One of the most critical threats to the Toledo system is institutional, including lack of operator training (as a trained operator would know that source water quality needs to be monitored to optimize the treatment process), a lack of system accountability to ensure routine monitoring of the source water quality, and a lack of standard operating procedures for source water monitoring.

6.4.4. Determine and Validate Control Measures, Reassess and Prioritize the Risks

This step occurs concurrently with the previous step of identifying hazardous events, hazards and identifies risks. The Water Safety Plan team would document existing and potential control measures aimed at reducing or mitigating the identified risks. The validation steps should also be documented. Validation of control measures is the process of obtaining evidence on their performance. Operational monitoring would show that a validated control continues to function. For the Toledo Case study, this step would involve the prioritization of risks in terms of their impact on the likelihood of the system to supply safe water. In the case of Toledo, the hazardous event could be the presence of the cyanotoxin hazard from contaminated source water. One control measure could be protection of the catchment through implementation of agricultural best management practices. The critical limit to trigger action would be any non-permitted development or activity in catchment.

One of the challenges to the Toledo case study would be uncertainty in estimating the effectiveness and value of some catchment and treatment controls. For example, there would be difficulty with measuring and enforcing the permitted land use in the Lake Erie watershed due to the vastness of the watershed and the large number of farmers in the watershed. There would also be difficulty in having confidence in the effectiveness of the control measures. For example, there is still a great deal of uncertainty as to the operational effectiveness of best management practices, even if they were used as a control measure for agriculture. One of the likely findings of the WSP team in the Toledo case would be that standards and protocols are not always carried out as indicated or might be inadequate. The State of Ohio Harmful Algal bloom response strategy for freshwater [42] had a documented sampling strategy, yet during the Toledo water crisis there was disagreement amongst the agencies on the sampling protocol [12]. The review of current systems operations that are incorporated in the WSP process would be useful in understanding the effectiveness of practices and control measures.

6.4.5. Develop, Implement and Maintain an Improvement/Upgrade Plan

The Toledo water crisis demonstrates that control measures are not working to assure water safety. This step calls for an improvement plan, with the aim of reducing risks and improving control measures. Since the Collins water treatment plant is dated to 1940, the plant may be in need of an upgrade to deal with surprises such as spikes in microcystin in the source water. There is a time lag between the action to treat a contaminant at the plant and the impacts of that action in finished water. This plant is also sole-source dependent, so an upgrade plan for this might include investigation of alternative sources of water or backup storage. An improvement plan would also include standards for cyanotoxins in water and a standard testing protocol with all the key partners. This plan would also indicate who is accountable for what action and set out expectations about timelines and cost sharing.

6.4.6. Define Monitoring of the Control Measures

This step calls for the multidisciplinary WSP team to define and validate the monitoring of control measures, including the corrective actions to be taken when targets are not met. A corrective action in response to the lack of monitoring of source water quality would have been introduction of a monitoring program in the Collins water treatment plant. This would have allowed proactive treatment through the plant and would have significantly reduced the likelihood of microcystin contaminated finished water. This step allows for a corrective action for each control if monitoring shows that the critical limit is being exceeded and thus could compromise final water safety. This step would also reiterate the need for standards for cyanotoxins in drinking water.

6.4.7. Verify the Effectiveness of the WSP

This step involves auditing the WSP to ensure that it is working effectively. For the Toledo case study, a third party auditor such as a representative from the Ministry of Health or the Environmental Protection Agency would have been able to easily check the plan against the actual operations. An audit can also verify that customers are satisfied with the water supplied to them.

6.4.8. Prepare Management Procedures

This step requires documentation of management procedures under normal operating conditions and under incident conditions. This would ensure that practices are based on best available knowledge and that there is consistency in operation regardless of the person attending to the plant. Standard operating procedures (SOPs) can be documented for the monitoring of treatment plant operations, for the operator hand-over of shift protocol, for dealing with an incident, for equipment operation, for dealing with heavy pollution in raw water and for reporting and recording of information. Since the EPA found the testing protocol “questionable”, [12], it can be inferred that there was also no robust management procedure for monitoring source water quality to optimize the treatment process.

6.4.9. Develop Supporting Programs

Supporting programs ensure that there is commitment to the water safety plan and build capacity to execute the water safety plan. Supporting programs for the Toledo case study that would have mitigated the risk of contaminated finished water would include the required training of plant operators, research on treatment plant optimization and processes to remove microcystin. Training could also have resulted in a standardized protocol sample collection and analysis of water samples. There could also be awareness training so that all personnel understand the impacts of their actions on drinking water safety. Supporting programs for Toledo could include stakeholder workshops to educate farmers on the impact of their practices and discussions on how best management practices can improve water quality while ensuring farmers’ productivity.

6.4.10. Plan and Carry Out Periodic Review of the Water Safety Plan

This stage of the WSP process ensures the team keeps in regular contact and regular communication to review the progress of the WSP and discusses new hazardous events and risks. It also facilitates capacity building initiatives, secures funding and facilitates smooth transitions through staff changes for continuity of the WSP. Having this step in the Toledo case would have facilitated smoother communication and more rapid and coordinated responses during the Toledo "do not drink" water advisory.

6.4.11. Revise the Water Safety Plan Following an Incident

This step is designed to invoke changes following the "do not drink" water advisory in Toledo. It would have led to revision of the WSP once standards were developed and agreed upon for cyanotoxins in water and would have also led to the development of SOPs for the monitoring of source water and for response to elevated levels of contaminants in source water.

6.5 Discussion

Drinking water can be contaminated by both microbial and chemical pollutants and thus impact human health [40]. Public health authorities generally require testing and monitoring of drinking water quality at the point of distribution, but this rarely prevents outbreaks [38]. This can be attributed to the fact that by the time something is detected at the source, customers have already consumed contaminated water. Water monitoring programs also lack predictive values to real world situations thus the results need to be interpreted with caution [43]. Most traditional water surveillance systems are retrospective and reactive. A robust and proactive water quality monitoring system is needed to provide early warning of contamination outbreaks, including a preventive risk-management approach [40]. WSP responds to this need. As shown in the examples above in the German hospital case study and in Australia, implementation of WSP has reduced the risk of contamination incidences. We recommend such an approach for Toledo as well. The 11 elements or modules recommended above mirror the approach recommended in Australia, triggered by microbiological contamination in Sydney in 1998 [40]. It moves away from reliance on point-of-distribution testing of water quality and instead emphasizes early identification and correction of issues, reducing the likelihood of contamination and water consumption advisories. The framework also requires an incident and emergency response protocol and a communication plan for consumers. WSP emphasizes the protection of source water, implying the need for government to take proactive steps to link land-use (especially non-point sources of pollution) to water quality impairment.

In the Toledo case, state, provincial and federal governments in the Great Lakes should develop and implement policies and plans to prevent the pollution Great Lakes waters as a drinking water source. This would include nutrient pollution leading to eutrophication. Although it is admittedly more difficult to manage non-point source pollution than point sources, risk management approaches adopted under WSP could help governments become more proactive in their response to drinking water impairment.

The discussion now follows two strands: how does WSP compare with federal drinking water legislation? And how would reframing the issue of eutrophication and adoption of WSP help reduce waterborne outbreaks?

6.5.1 Comparison of WSP with Federal Drinking Water Legislation

As shown by Baum *et al.* [13], WSP will add value to federal drinking water legislation, such as the US Safe Drinking Water Act (SDWA). The comparison done by Baum *et al.* [13] clearly shows that the focus of the U.S. regulations is on setting national standards for maximum contaminant levels, best treatment processes, and best available technologies for contaminant reduction, by which each utility determines the safety of their water through the detection of pathogens and toxins in treated water. The problem with this process is that by the time these contaminant levels have been detected, contaminated water may have already been distributed and customers exposed to risks caused by the contaminant, as has been seen in the case of Toledo. However, implementation of WSPs provides an additional focus on prevention of contamination, so that water is not supplied before it is tested. The difference in focus between US drinking water regulations and WSPs can be seen in three main steps or areas: internal risk assessment and prioritization; management procedures and plans; and team procedures and training. Based on 28 drinking water related outbreaks between 2009–2010, five factors have been identified as leading contributors to outbreaks: back flow from cross-connection, corrosion and aging of pipes or storage tanks, distribution monitoring and maintenance failures, lack of treatment and disinfection, and source water contamination [13]. All of these factors would have been eliminated by the adoption of a WSP approach. As recommended by Baum *et al.* [13], one of the changes that the US SDWA needs is a more tailor-made, local approach such as is provided through WSP. This means that instead of attempting to control the risks (and regulating them) at the national level (regardless of their differences in size, location or water source), specific issues and risks should be regulated locally. Just as in the case of WSP, local identification and regulation of risks and issues gives a sense of ownership. It also improves understanding of local risks and aid prioritization of risks for each water system. Issues such as backflow and contamination from cross-connections are preventable using the WSP approach. For example, step 3 of the WSP includes the identification of hazards such as cross-connection. In this step, control measures would be identified, developed and monitored. Although the SDWA requires operators to know the system risks, it does not require specific systems risk analysis or prioritization of risks. Similarly, infrastructure updates (aging and corrosion of pipes), distribution maintenance (low pressure or failure to flush the system) and monitoring are not fully regulated under current US legislation but will require better procedures and monitoring under WSPs. WSPs would also require SOPs to cover "response actions, operational monitoring, responsibilities of the water system, communication protocols and strategies, emergency situation responsibilities, and review and revision of plans" ([13], p. 7). While SDWA requires certified water operators it does not require such detailed SOPs, the review or update of the system, or revision of existing practices [13].

WSP requires staff to have a thorough understanding of the entire water supply system, from the source to the point water reaches the consumers. This increases the responsibility of individual employees to understand the treatment and distribution system and associated procedures. WSP also adds training, research, development, and preventive maintenance in addition to daily operations for individuals. This stands in contrast to the SDWA, which requires recertification but do not require the other supporting programs [13].

It must be recognized that the regulatory-based, reactive approach to water quality risk management has substantially reduced waterborne disease risk over the last several decades. On the other hand, management of system-specific risks via a preventive approach (WSP) could reduce the risk of waterborne diseases even further. An incentive-based system that encourages specific water systems to identify and control their specific risks could promote a preventive approach to reduce waterborne outbreaks and related diseases. Implementation and adoption of WSPs could be an important mechanism to reduce future water-borne diseases. However, given the current focus on regulatory controls in the US, and the time and resources needed for WSP, it may be more realistic to expect adoption of WSPs if they are required under the law [13].

6.5.2. Reframing Eutrophication Governance through the Lens of Public Health Using WSP

Many North American cities along the Great Lakes shoreline depend on water from the lakes, and eutrophication of the water leads to contamination of drinking water and a potential health crisis, as demonstrated in the Toledo case study. Reconsidering governance through the lens of a WSP approach would reframe the eutrophication issue by showing it is not just an environmental issue, but one that also affects our health and as such, needs focused attention and priority. It also places more responsibility on agencies like the US Environment Protection Agency and Environment Canada/Health Canada to develop better standards for toxins in the Great Lakes. Further, proactive source water protection will require government to work more with land-based activities, especially urban and agricultural systems.

One of the sources of eutrophication in the Great Lakes is manure from farmlands. Agricultural operations have intensified across the region over the past several decades, with concomitant increases in fertilizer and manure input. However, there are few regulatory controls to deal with this issue, unlike the point source controls on nutrients (such as the phosphorus ban in detergents) in the 1960s and 1970s. The US federal Clean Water Act regulates large Confined Animal Feeding Operations, but not drainage from the vast area of cropland across the Great Lakes basin that is believed to be a major source of current nutrient loadings into the Great Lakes [44]. As discussed by Pralle [4], issue redefinition and venue shopping are key strategies for enacting agenda and policy change. Issue redefinition not only involves change in the image of an issue but also the bases for considering these issues. For the purposes of this paper and case study, it would mean that the problem of eutrophication needs to be reframed with a lens of human health (and risks defined under a WSP framework) by showing that the health of source water (in this case, from Lake Erie) directly impacts human health. It can be argued that farming is linked to the breadbasket and food security of the region, which is as difficult to regulate as the non-point source pollution. Some steps have nevertheless been taken in partnership with farmers to resolve this issue. This includes simple steps such as engaging farmers on the linkages between source water and human health, but also the development of innovative methods to use in agriculture. For example, Fox P Trade, a Great Lakes Commission (GLC)-led project with funding from the US Department of Agriculture's Natural Resources Conservation Service (NRCS), is adopting and applying water quality trading principles to help alleviate high nutrient levels in the lower Fox River (Wisconsin) watershed. Another NRCS-funded partnership with the GLC is creating demonstration farms in the Fox River watershed, places where innovative agriculture practices can be tested, monitored and showcased [44].

In addition to developing and implementing innovative agricultural practices to deal with eutrophication, some proactive policy initiatives are also needed. As recommended by the International Joint Commission (IJC)'s Lake Erie Ecosystem Priority (LEEP) [45] report, the policies can be grouped under four main categories:

(1) Setting phosphorus reduction targets for Lake Erie;
(2) Reducing phosphorus loading into Lake Erie from agricultural sources and septic systems;
(3) Reducing phosphorus loading into Lake Erie from urban sources; and
(4) Strengthening monitoring and research in the Lake Erie basin.

As pointed out by the IJC report ([45], p. 9):

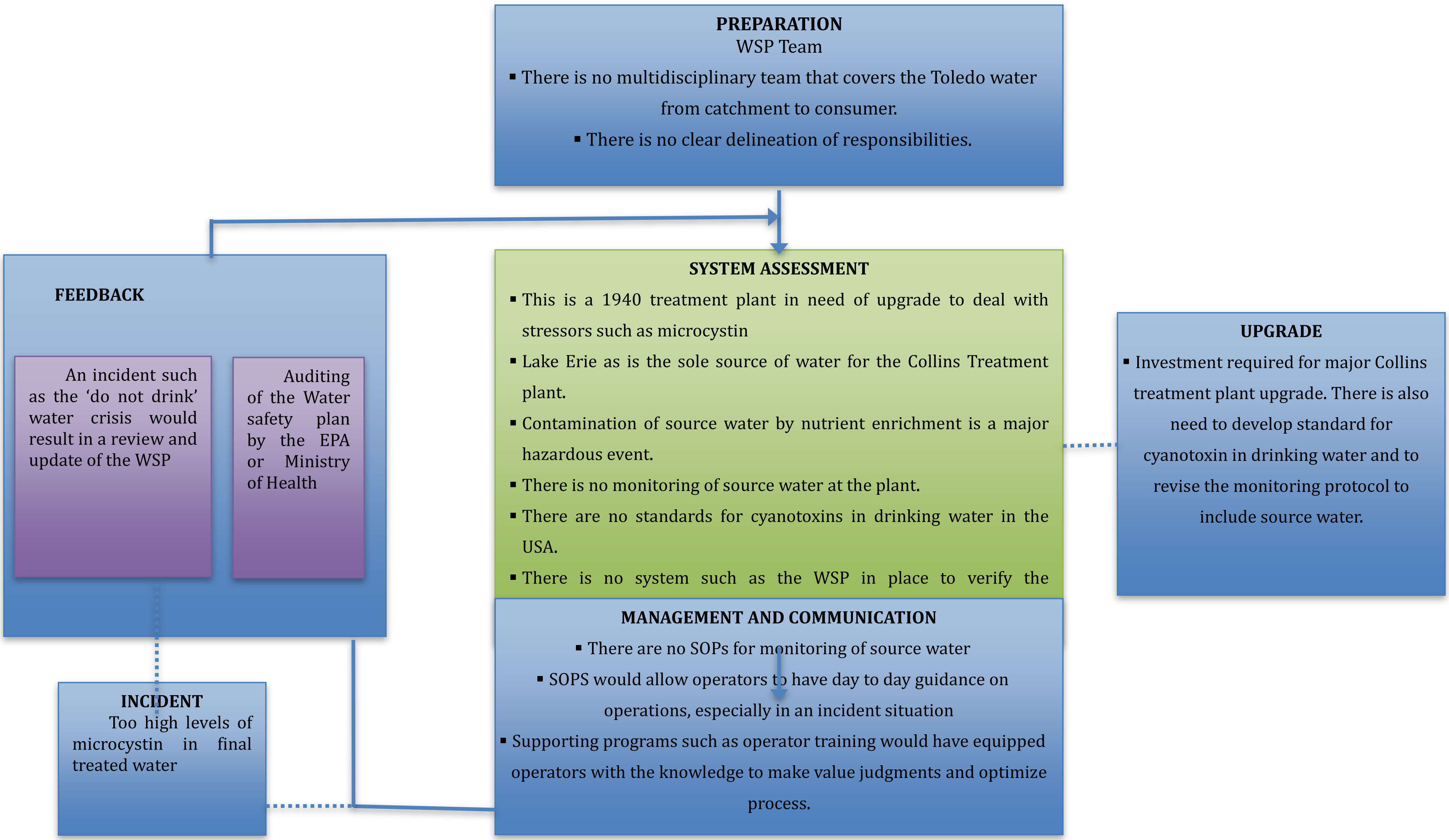
…the IJC recommends that governments throughout the watershed refocus agri-environmental management programs to explicitly address DRP [dissolved reactive phosphorus]. This includes an emphasis on best management practices (BMPs) most likely to reduce DRP, such as improving the rate, timing, location and form of phosphorus applied to fields, and reducing *runoff* from those fields. Such nutrient management initiatives should focus on reducing the load delivered during the spring period and on priority sub-watersheds that are delivering the most phosphorus to the lake. The IJC also recommends that governments increase the scale and intensity of BMP programs that have been shown to reduce nutrient runoff, while strengthening and increasing the use of regulatory mechanisms including linking crop insurance with conservation performance. And to address a concern raised repeatedly by the public regarding the health of Lake Erie, the Commission recommends that Ontario, Michigan, New York, Ohio, Pennsylvania and Indiana ban the application of manure, biosolids and commercial fertilizer containing phosphorus on frozen ground or ground covered by snow.

6.5.3. Using the WSP Approach to Achieve Water Governance Goals

The Water Safety Planning process is designed to be a multi-stakeholder collaborative process to effectively identify risks and management plans to mitigate those risks from catchment to consumer. The expert team required for this process includes a diversity of stakeholders such as experts in environmental protection, from regulatory agencies, health specialists, utility mangers, laboratory personnel, private sector representatives and non-governmental organizations. This multi-stakeholder collaboration characteristic of the Water safety planning process makes it compatible with other water governance models. For example, Integrated Water Resources Management (IWRM) provides a governance platform that allows for multiple-actor decision-making processes at watershed scales. Adaptive management (AM) paradigms enable decision-making in the face of uncertainty where policy is shaped through continuous feedback loops that create "systemic experimentation and learning". AM thus has an inherently self-organizing ability [8]. Schoeman *et al.* [46] adds a third governance arrangement, Ecosystem-based Approach (EBA), which provides adaptation to climate change while attempting to minimize the risk. To realize the outcomes of IWRM, a WSP framework is important as it facilitates multi-stakeholder collaboration to protect the water from source to consumer. To help attain proposed phosphorus targets, a governance model as proposed by the IJC [45] envisions the USEPA working with the governments of Michigan, Ohio and Indiana to develop a tri-state phosphorus total maximum daily load (TMDL) targets for the western Lake Erie Basin. Since Ontario does not have this mechanism, collaborative decision making under the Great Lakes Water Quality Agreement urges their involvement in target setting. The measures would take into account all significant sources of phosphorus loadings and allocate specific reductions of phosphorus according to relative contributions from point and non-point sources. Clearly, an issue of this magnitude goes beyond the responsibility of one jurisdiction for response. All of this can be linked to WSP framework in identifying risks and hazards to the water system and how to improve and monitor it.

We conclude that by utilizing the water safety planning approach, the city of Toledo could have significantly reduced the risks to the provision of safe water to residents and could have averted the crisis on 2 August 2014. The Waters Safety plan (WSP) approach would have resulted in the monitoring of the source water, which would have identified the elevated levels of microcystin in the source water and lead to operational adjustments to assure the final drinking water quality. These steps would have been detailed as part of the standard operating procedures (SOP) included in the “Management and Communication” step of the WSP (Figure 6.2). The systematic application of the WSP process to the city of Toledo reveals significant gaps, including the lack of a multi-stakeholder team representing key personnel along the entire process from source water to consumer. Other findings of this assessment are shown in Figure 2. The WSP approach is relevant to municipalities throughout the Great Lakes and beyond. This approach can also inform other areas with similar water quality impairment problems, such as Pelee Island [47] and the Carroll water treatment system in Ohio, US [16] and Pelee Island in Windsor-Essex County, Canada [47]. In September 2013 the Carroll water treatment plant was shut down due to elevated levels of microcystin in the treated water (3.8 ppb) resulting from elevated levels of microcystin in the Lake Erie source water (50 ppb) [16]; a year later in September 2014 the Windsor-Essex County Medical Health Officer issued a water ban to residents of Pelee Island for one week due to elevated levels of microcystin in the water [47].

Figure 6.2: Results of the WSP assessment of the Toledo water crisis



6.6. Conclusions

The water safety planning (WSP) process can be a useful tool to assure the safety of drinking water supplies. This paper has shown that if this process had been used for the Collins Water Treatment system in Toledo, Ohio, it would have averted a water crisis situation by mitigating risks associated with hazardous events such as unmonitored source water, increased algal blooms, increased microcystin concentrations in source water, and lack of treatment capacity to remove contaminants. It would also have resulted in operator training that in turn would have encouraged independent thinking and improved the ability of the operator to suggest process and operational improvements, Identifying and evaluating risk at the local level (as compared to national standards) encourages local operational staff to take responsibility for prevention of waterborne disease outbreaks.

In addition, re-framing the problem of eutrophication in a new way to tell a new story with linkages to health might lead to more effective governance. If we shift the focus of the problem from solely protecting the environment to protecting our own health, and regulate from a public health standpoint (through WSP), we broaden and strengthen the framework for eutrophication governance.

The adaptive (co-) management literature contains four institutional prescriptions: collaboration in a polycentric governance system, public participation, an experimental approach to resource management, and management at the bioregional scale. These prescriptions largely resonate with the theoretical and empirical insights embedded in the (water) governance literature [48]. However, this literature also predicts various problems. In particular, this case study demonstrates the need to overcome complexities associated with participation and collaboration, and de-politicizing discussion on governance at the regional scale. The Systematic application of the steps of the water safety planning process requires a multi-stakeholder team representing key personnel along the entire process from source water to consumer. This methodological approach is relevant to the Great Lakes bioregion, and has implications for municipalities and other stakeholders and orders of government.

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Author Contributions

Savitri Jetoo conceptualized this research and is the main author of this paper. She assessed the Toledo water crisis from a WSP perspective and made all changes to reviewers' comments. Velma Grover contributed to the paper through the literature review and initial editing while Gail Krantzberg provided oversight of the research and edited the paper and made additions on Great Lakes governance. All authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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Chapter 7

Adaptive Capacity for eutrophication governance of the Laurentian Great Lakes

Savitri Jetoo and Gail Krantzberg

Abstract: The Great Lakes are the largest freshwater system in the world, holding 20% of the world's fresh water. Together, the watersheds of Lakes Superior, Michigan, Huron, Erie and Ontario are home to over 35million Americans and Canadians, a factor that leads to severe human related stress to the lakes' ecosystems. The eutrophication of Lake Erie is one manifestation of this anthropogenic stress. Nutrient enrichment in that lake arises from farming, sewage treatment plant discharges, airborne emissions and nutrient flows from paved surfaces. This paper examines the eutrophication of Lake Erie and shows that it is a "wicked problem" that can benefit from an adaptive governance approach. More specifically, it proposes a framework for assessing adaptive capacity and tests this framework through key informant interviews in a specific case study where adaptive capacity was displayed. The case study was eutrophication in Lake Erie, a system that went from severe eutrophication the 1960s to significant nutrient reduction and ecosystem restoration in the 1990s. Results of this analysis are used to identify gaps in adaptive capacity for current eutrophication governance of Lake Erie.

Key Words: Adaptive capacity, adaptive governance, eutrophication, Great Lakes, Lake Erie, nutrient enrichment.

7.1 Introduction

Eutrophication refers to the nutrient over-enrichment of water bodies and is one manifestation of anthropogenic adverse impact on the environment worldwide (Smith, 2003). The interactive world map on the World Resources Institute Website (World Resources Institute, 2015) vividly showcases examples of eutrophic water bodies worldwide, including Lake Erie in Canada and the United States, the Susquehanna River in the United States, Lake Winnipeg in Canada and the Bohai Sea in China. Lake Erie has been subject to severe eutrophication in the 20th century, with excessive nutrient loading in the 1960s and 1970s. Indeed, it was primarily eutrophication that prompted the US and Canada to sign the Great Lakes Water Quality Agreement (GLWQA) in 1972, with stipulated nutrient loading reduction targets for the lake. These phosphorus (P) loadings were from both point (sewage treatment plants, industrial discharges) and non-point sources (agriculture, urban runoff), but measures in the GLWQA focused on point source reduction through phosphorus control technologies and regulations for phosphorus in detergents and sewage treatment effluents (DePinto et al., 1986). Whilst these measures were successful and resulted in P load reductions and the concomitant return of Lake Erie's resiliency (DePinto et al., 1986; Botts and Muldoon, 2005; Scavia et al., 2014), increases in hypoxia, beach closings and algal biomass since the mid-1990s are indications that Lake Erie has become eutrophic again (Bridgeman and Penamon, 2010; Burns et al, 2005; Michalak et al., 2013; Scavia et al., 2014). The term re-eutrophication has been used to describe this phenomenon (Culver and Conroy, 2012; Scavia et al., 2014).

While the causes of eutrophication of Lake Erie in the 1960s and 1970s seemed simple and could be linearly traced to P loadings, the current eutrophication of Lake Erie is highly complex and compounded by interacting stressors such as aquatic invasive species and climate change (Pennuto et al., 2014). The eutrophication of Lake Erie now displays the symptoms of a "wicked problem", where all the information is not known and the solution is not clear cut and is highly complex (Xiang, 2013). As such, a new model of governance is needed for the restoration of Lake Erie, a governance model that moves from the old command and control paradigm that worked well in a highly certain world, to one that embraces uncertainty. One such governance model is adaptive governance, as it is the facilitator of adaptive capacity that allows better response in an uncertain environment.

This paper introduces the concept of adaptive capacity and shows its relevance to eutrophication of Lake Erie. A framework for assessing adaptive capacity is developed and conceptualized by formulating determinants of adaptive capacity from the literature. These determinants are then validated through semi-structured interviews in a baseline case of Lake Erie, which went from severe nutrient enrichment in the 1970s to significant P reductions in the early 1990s. This paper argues that an analysis of these determinants can show the gaps in building adaptive capacity and can prove valuable in the implementation of actions for nutrient management and hence in the implementation of Annex 4 (Nutrients) under the Great Lakes Water Quality Protocol 2012.

7.2 Eutrophication of Lake Erie – Baseline Case

The Laurentian Great Lakes are the largest freshwater body on earth and comprise Lake Superior, Lake Michigan, Lake Huron, Lake Ontario and Lake Erie. All the Great Lakes are subject to a host of anthropogenic stressors, as illustrated in the land use pattern shown in Figure 7.1. Lake Erie is the least forested of all the Great Lakes and has the most intensive farmlands and urban areas. According to Environment Canada and USEPA (1995), 63% of Lake Erie watershed is being farmed while 84% of its shoreline is for residential uses, 35% is used for agriculture and 22% for commercial uses.

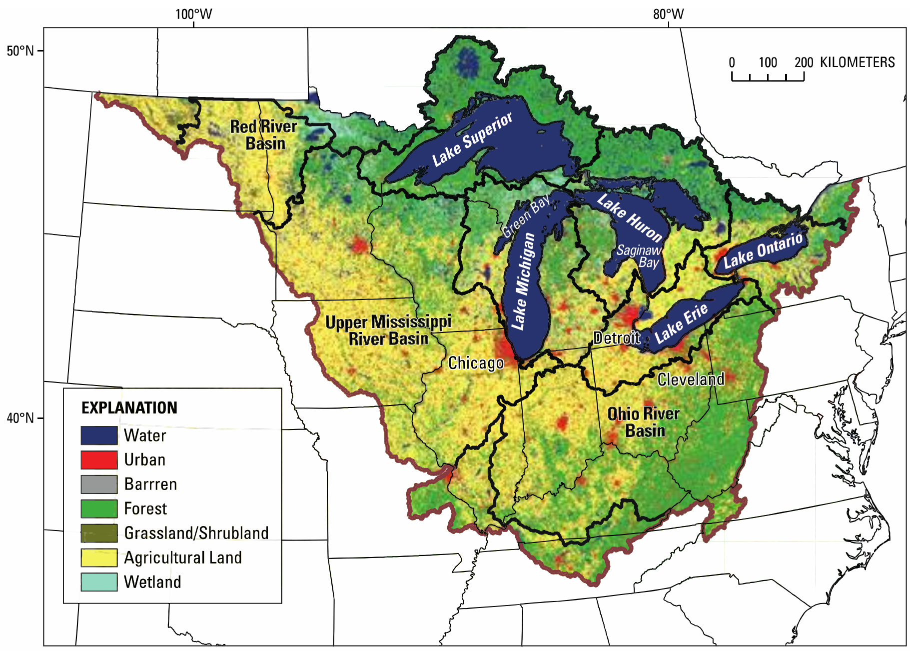

Figure 7.1: Great Lakes Land Use (Robertson and Saad, 2011)

This land use pattern means that, compared to the other Great Lakes, Lake

Erie is subjected to the greatest assault from anthropogenic impacts such as pesticides, sediment and nutrients. The impact of excessive nutrients is particularly felt, as Lake Erie is the smallest and shallowest of the Great Lakes. While Lake Erie has been subject to excessive nutrient loading from both nitrogen and phosphorus, scientists have found that phosphorus is the limiting nutrient in temperate lakes such as Lake Erie (Schindler, 2012; Scavia et al., 2014). During the 1960s and 1970s, phosphorus was heavily loaded into the lakes from sewage treatment plants, from detergents in washing liquids and from non-point sources, leading to the growth of algae which visibly contaminated the lakes and led to fish kills and taste and odor problems. The problem of eutrophication was one of the drivers that stimulated the governments of the United States (US) and Canada to sign an agreement to protect the quality of the waters of the Great Lakes, the Great Lakes Water Quality Agreement 1972 (Agreement), which has gone through several amendments leading up to the current 2012 protocol. The 1972 Agreement led to significant actions from the government directed at controlling point sources of pollution such as upgrading sewage treatment plants and regulating phosphorus in detergents. These actions led to the target Lake Erie phosphorus load of 11 000 metric tonnes per annum (MTA) being met, and resulted in eutrophication being reduced or eliminated (Michalak et al., 2013).

Notwithstanding these early improvements, it was evident by the harmful algal blooms (HAB) of 2011 that eutrophication has resurfaced since the 2000s and remains very much a current problem. Trends have shown that while point source P has decreased since the 1970s, non-point sources continue to be a problem (Figure 7.2). In the spring of 2011, heavy precipitation events, coupled with heavy loading of dissolved reactive phosphorus from agricultural runoff and warm temperatures, led to an extensive algal bloom of more than 5000km^2 (IJC, 2014). An analysis of this by a team of Great Lakes scientists found that HABs are linked to the uncertain weather pattern associated with climate change, and are caused as much by increased precipitation as by agricultural practices, weak lake circulation and dormancy of the lake (Michalak et al., 2013).

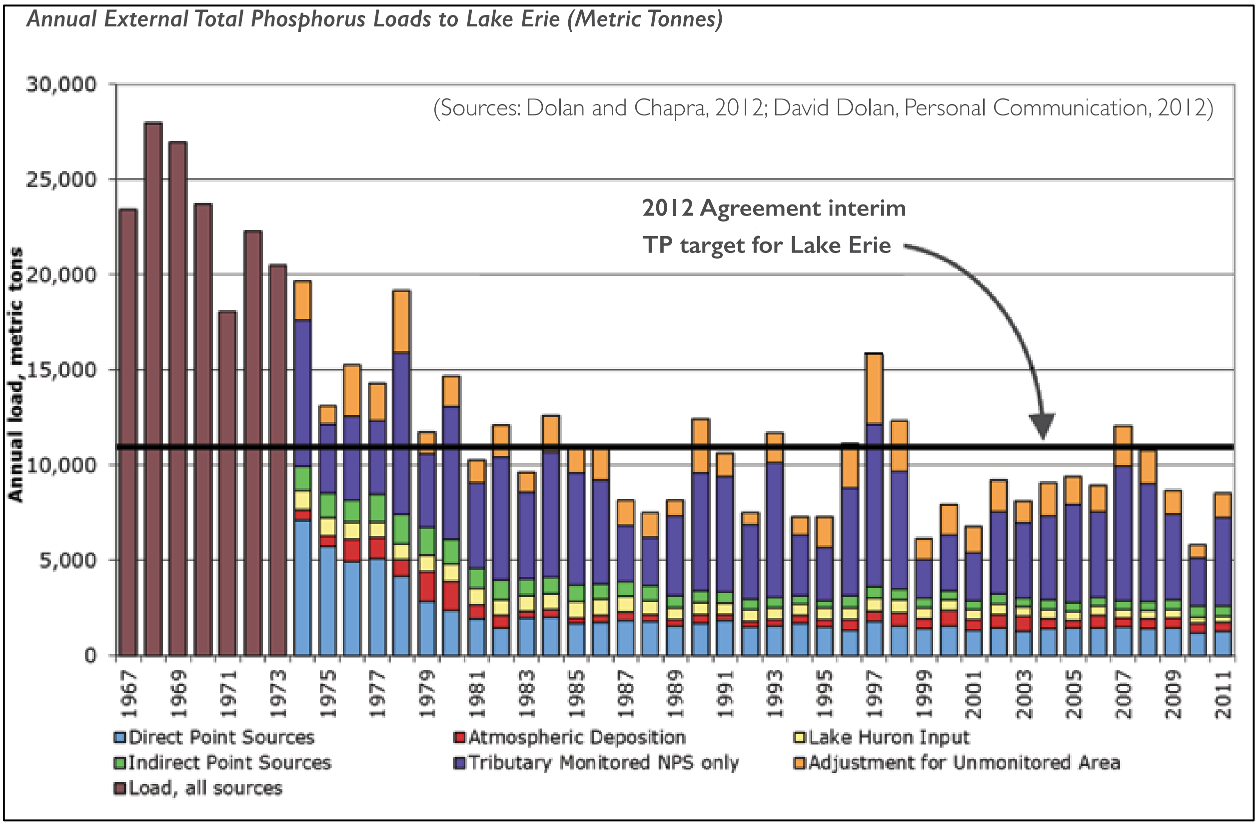

Figure 7.2 : Total external phosphorus load in metric tonnes to Lake Erie (IJC, 2014)

This confluence of long term farm nutrient practices and intense and frequent precipitation are characteristic of changing climate and conditions that would become very prevalent in our changing world. This uncertainty makes building adaptive governance very important and hence the study of the determinants of adaptive capacity crucial to this dialogue of eutrophication governance. The framework of adaptive governance is needed to reduce input of nutrients under the uncertain climate conditions to prevent harmful algal blooms.

As Figure 7.2 illustrates, the total phosphorus input into Lake Erie has decreased since the 1960s, so it seems counterintuitive that algal blooms have increased. However, total phosphorus is made up of particulate and dissolved reactive phosphorus (DRP), the second of which is biologically very available and readily taken up by plants and algae, and is the most likely to support algae blooms (Vanderploeg et al., 2009). Although total phosphorus has decreased, DRP from agricultural practices non-point sources has increased over the last 40 years (Figure 7.3), leading to increased algal bloom (Michalak et al., 2013).

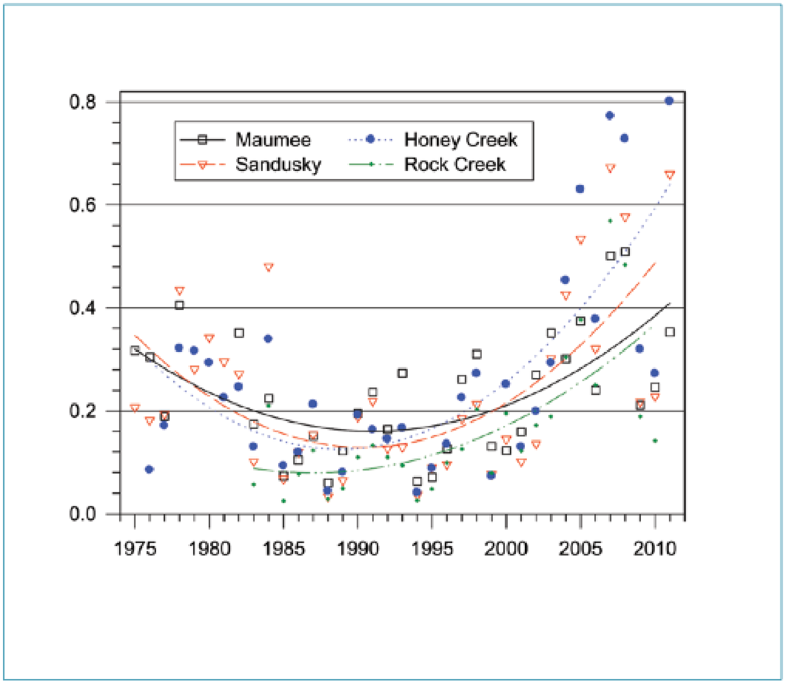

Figure 7.3: Dissolved reactive phosphorus loads into Lake Erie (IJC, 2014)

It might be expected that reduction in nutrient inputs would lead to proportional decrease in eutrophication, but this is not the case: evidence that eutrophication is indeed a wicked problem. Reductions in nutrient loading alone may not decrease eutrophication proportionally, because of the significant impact of meteorological factors, which are comparable to human induced nutrient loading in accounting for harmful algal bloom extent and oxygen depletion (Michalak et al., 2013). Solutions for the eutrophication of Lake Erie are therefore not obvious or straightforward, reinforcing the need for an adaptive, responsive governance regime.

7.3 Water Governance

What are some of the guidelines for governing the nearshore areas in this increasingly uncertain environment of eutrophication? Given the complex interactions of climate change, aquatic invasive species and nutrient loading, what factors can aid stakeholders in the reversals of eutrophication of lake Erie? These are questions of governance, more specifically water governance. Water governance can also be seen as one arm of environmental governance, which deals with natural resource governance and describes the collection of norms, rules and laws and organizations that determine the use and protection of natural resources (Lemos and Agrawal, 2006).

It is necessary to take a look at governance in general before diving into the governance of water. According to the Oxford online dictionary (2014), to govern is to "conduct the policy, actions, and affairs of (a state, organization, or people) with authority". This definition has a dictatorial tinge that is absent from the definition of governance in the Oxford online dictionary (2014), stated as "the action or manner of governing a state, organization, etc." This latter definition is reflective of the more inclusive nature of governance as compared to government, where the former includes stakeholders such as the private sector, non-governmental organizations and the public in the action of governing. There are organizations such as the World Bank that still conceptualize governance in a top down command and control paradigm, The World Bank defines governance as the "process by which authority is conferred on rulers, by which they make the rules, and by which those rules are enforced and modified" (World Bank, 2014). This is in stark contrast to the more participatory approach as defined by the Institute on Governance (Institute on Governance, 2014) as follows "Governance determines who has power, who makes decisions, how other players make their voices heard and how account is rendered". The inclusion of voices in the decision making process is a more recent practice, and represents a shift to the more inclusive and participatory rather than the more traditional controlling rule of government.

All these definitions of water governance illustrate that different disciplines conceptualize water governance in different ways based on their reality of water governance systems. There is one clear consensus emerging from the literature, however: traditional governance approaches characterized by the 'command and control' model and fragmented institutions and regulations can no longer maintain the resilience of complexly linked socio-ecological systems as such approaches seek to reduce uncertainty inherent in these systems rather than embrace it (Dietz et al., 2003, Gleick, 2003, Pahl-Wostl, 2009). Traditional models of governance treat each natural resource problem discretely, oblivious to the coincident or parallel effects of complex socio-ecological systems that are plagued by wicked problems, such as climate change or eutrophication of Lake Erie, with no clear or linear solution (Folke et al.,2005). For the governance of eutrophication in the Great Lakes, there are many federal and state, provincial agencies that operate as sectorial siloes, working independently of the local municipalities and stakeholders. The command and control paradigm is evident in the operations of these Great Lakes Institutions.

Disenchantment with traditional forms of water governance has led to the emergence of new paradigms for managing uncertainty in complex socio-ecological systems; models that are more inclusive and adaptive to change. Key terms emerging from this discourse include vulnerability, resilience, adaptive capacity and adaptive governance. These discourses are more suited to a complex problem like eutrophication of Lake Erie as they hold the promise of increased collaboration among local, regional and governmental actors. The local nature of the problem of eutrophication means that communities in the nearshore areas can play a significant role in generating workable solutions. These discourses propose loose networks of actors and institutions at many levels, sharing resources and information as an alternative to the top down command and control paradigm.

Authors such as Lemos and Agrawal (2006) consider these new governance models better as they facilitate integration and transmission of local, scientific and technological knowledge expeditiously and are operationalized in a flexible and redundant manner among multiple actors who work across scales to develop cooperation and synergy to solve common problems. These models are especially relevant to the problem of eutrophication in the nearshore areas of the Great Lakes as they promote social learning and compromise seeking, which are especially relevant for the multiplicity of actors at the local, regional and federal level with a stake in nearshore governance. According to Lemos and Agrawal (2006), these new governance models also recognize that the relationship between international regimes and non-state actors is crucial for economic and legal arrangements, factors that are particularly relevant for eutrophication governance of the Great Lakes. However, one of the limitations of these new models is that they may fail to limit the negative externalities associated with implementation deficits (Lemos and Agrawal, 2006), an issue that is especially relevant to the eutrophication in the nearshore areas of the Great Lakes. While the Great Lakes Water Quality Protocol 2012 contains an entire Annex (4) devoted to nutrients, Lake Erie's ever-changing ecosystem has responded poorly to the linear implementation focus of the past Agreement, which may indeed have exacerbated the problems.

7.3.1 Changing Governance Lens – Social Ecological Systems

Water governance can simply be seen as the chain that links humans and water bodies. Humans make decisions to govern water bodies, decisions that impact the water body, decision makers, and other stakeholders. Berkes and Folkes (1998) have coined the term Social Ecological Systems (SES) to formally link the processes between humans and the environment and the feedback systems between them. As conceptualized by these authors, SES assumes that resource management is necessary, not just in a practical sense to target a maximum sustained yield, but also to target the social institutions that influence the resource. They argue that the management of an ecosystem requires equal emphasis on the resource and the social institutions impacting the resource. This concept of SES is a useful framing of the complex interactions between the human systems that impact the water body and the water body itself in a complete, unified whole, and is thus useful in advancing the dialogue on eutrophication governance.

The literature on SES governance homes in on the primacy of informal, self-organizing and non-institutional forms of governance that are driven by collaboration at various scales and that emerge to more closely match governance to the scale of the environmental problem at hand (Brunner et al, 2005; Scholz and Stiftel, 2005; Ostrom 2007; Ostrom 2009). One such informal collaboration in the Great Lakes was Great Lakes United, a group that emerged out of frustration with the apparent inability of governments to deal with problems of the Great Lakes. The emergence of Great Lakes United resulted in a gradual shifting of power from bureaucratic federal and state top down decision making to a sense of Great Lakes Community, where there were more locally driven networks of individuals and communities united around Great Lakes issues (Botts and Muldoon, 2005). This in a sense was the start of the transition to the more inclusive governance that is characteristic of adaptive governance.

7.4 Adaptive Governance

The term “adaptive governance” can be found in the business literature as early as 1997, in a paper on loyalty in the supply chain, looking at how buyers adaptively shift the weight from loyalty and profitability to an emphasis on loyalty in the network interacting with suppliers (Klos and Nooteboom, 1997). The term was coined in the aforementioned paper in 1997 but its use in the environmental context can be traced to a 2003 publication by Dietz, Ostrom and Stern. These authors made mention of the term once in the body of the work but went on distinguish its difference to adaptive management as adaptive governance

> “conveys the difficulty of control, the need to proceed in the face of substantial uncertainty and the importance of dealing with diversity and reconciling conflict among people and groups who differ in values, interests, perspectives, power and the kinds of information they bring to situations” (Dietz, Ostrom and Stern, 2003, p1911).

This original conceptualization of adaptive governance in the context of governing the commons (the environment) described a flexible, multi-scalar, adaptive system for governing human and natural systems (in effect SES) in a highly uncertain, changing environment where knowledge of the system can be wrong or incomplete (Dietz et al, 2003). Environmental application of the concept of adaptive governance can also be traced to two other schools of thought: literature on collaborations for environmental governance by political scientists (Brunner et al, 2005; Gunderson et al, 1995); and resiliency literature (Holling, 1973, Walker et al, 2004, Berkes et al, 2003. Folke et al, 2006). Scholars from political science have advocated for adaptive governance that integrates scientific and other types of knowledge into policies that advance open decision making structures, recognition of diverse viewpoints, the role of non traditional science, and community based efforts (Brunner et al, 2005; Gunderson et al, 1995). This local scale participation in adaptive governance was further advanced by literature on the conservation movement in the developed world, putting an emphasis on context and consensus building (Wondollect and Yaffee, 2000; Brunner et al, 2005). Similar views are expressed in the resiliency literature, in which there are many definitions of adaptive governance that address the paradigm shift from traditional government controlled static institutions with clear boundaries to the view of institutions as dynamic, flexible, pluralistic and adaptive to cope with the limits of predictability inherent in future climatic conditions (Berkes and Folke, 1998; Carpenter and Gunderson, 2001; Pahl-Wostl, 2007b).

It is clear across the literature that adaptive governance is seen as the facilitator of adaptive capacity. The corollary is that the adaptive capacity of institutions and communities can be increased through governance and policy approaches that are more flexible, participatory, experimental and designed for learning, because these approaches contribute to building social-ecological systems resiliency under uncertainty. Adaptive governance systems facilitate these participatory approaches as under this paradigm, “systems self organize as social networks with teams and actor groups that draw on various knowledge systems and experiences for the development of a common understanding and policies” (Folke et al, 2005). Though experimental and flexible, adaptive governance systems are not ad hoc but respond to and shape ecosystem dynamics and change in an informed manner that acknowledges our dependence on the biosphere (Westley et al., 2011).

Despite the many discussions and interpretations of adaptive governance in the literature, there is little empirical evidence of successful implementation. According to the Stockholm Resiliency Centre (2014), adaptive governance is still an “***evolving*** research framework for analyzing the social, institutional, economical and ecological foundations of multilevel governance modes that are successful in building resilience for vast challenges posed by global change, and coupled complex adaptive SES” (author emphasis added). Medema et al. (2008) have noted that adaptive governance is an emerging field with teething problems in implementation, in real world applicability and political pitfalls characteristic of adaptive theories. Some of the real or perceived pitfalls of adaptive approaches include the high cost of information gathering and monitoring, resistance from key players who fear increased transparency, political risk due to uncertainty of future benefits, difficulties in acquiring stable funding for experiments and the fear of failure (Lee, 1999).

Within the adaptive theories literature, "adaptive governance" and "adaptive capacity" are often used interchangeably, with no clear distinction between the two. In fact, the two terms are very closely connected, as adaptive governance can be seen as the means of building adaptive capacity. Much of the literature has focused on governance for adaptive capacity in the context of climate change (Pahl-Wostl et al., 2007; IPCC 2007; Huitema et al., 2009). One of the central goals of the current research is to demonstrate the applicability of adaptive governance to other stressors, in this case eutrophication. Eutrophication governance fits neatly in this research theme as eutrophication in the Great Lakes is compounded by climate change and invasive species and as such, it has many parallels with models for climate governance, with similar uncertainties and complexities. This paper also aims to answer two other important knowledge gaps: the most important factors in adaptive governance that can lead to more resilient real world outcomes; and the most effective ways of governing for adaptive capacity in addressing stressors on large-scale ecosystems such as the Great Lakes.

7.5 Adaptive Capacity

Water governance is inextricably linked to adaptive capacity, a key factor in the resiliency of ecosystems. According to Kashyap (2004), water governance is the ability to develop adaptive capacity, where adaptive capacity is defined as the "the ability or potential of a system to respond successfully to climate variability and change" (IPCC, 2007). There are four general factors that build adaptive capacity in social-ecological systems (Folke et al., 2002): i. learning to live with change and uncertainty; ii. nurturing diversity for resilience; iii. combining different types of knowledge for learning; and iv. creating opportunity for self-organization toward social-ecological sustainability. According to Dietz et al. (2003), governance that facilitates these principles would involve many mechanisms for coordination and multiple decision-making centers.

In addition to governance, the IPCC (2001), as reported in Yohe and Tol (2002) has an extensive list of system-, sector and location-, and governance-specific determinants of adaptive capacity, as follows:

1. The range of available technological options for adaptation,

2. The availability of resources and their distribution across the population,
3. The structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed,
4. The stock of human capital including education and personal security,
5. The stock of social capital including the definition of property rights,
6. The system's access to risk spreading processes,
7. The ability of decision-makers to manage information, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers, themselves, and
8. The public's perceived attribution of the source of stress and the significance of exposure to its local manifestations.

Of these determinants, the third, about the structure of critical institutions and decision making authority, has received widespread attention in the literature as being crucial for adaptive capacity. Authors such as Pahl-Wostl et al. (2007a) and Olsson et al. (2004a) argue that building this kind of adaptive capacity in institutions requires flexibility and approaches that embrace experimentation and learning by doing. One such approach is the concept of adaptive governance, which has arisen from the failure among current approaches and the increased vulnerability of SES (Olsson et al, 2006).

7.5.1 Adaptive Capacity for Eutrophication Governance

This work is the first to advance the concept of adaptive capacity for eutrophication governance. This concept is useful for eutrophication governance as it has the potential to shift the dialogue from 'firefighting' or preventing nutrient over-enrichment to looking at the factors necessary to build adaptive capacity for eutrophication governance of Lake Erie, in which the governance system has the ability to alter processes or act proactively to restore Lake Erie's resiliency. It is hypothesized here that adaptive capacity is uniquely positioned to move the Great Lakes ecosystem under the stressor of eutrophication from a state of vulnerability to a more resilient status. Eutrophication governance that leads to adaptive capacity must contribute to SES resilience through adaptive measures at different levels and scales.

It is argued here that the concept of adaptive capacity can be transferred to eutrophication for, like climate change, eutrophication in general, and the current eutrophication event of Lake Erie, have all the characteristics of a wicked problem. According to Xiang (2013), a wicked problem is a social system problem where information is conflicting, leading to an ill formulated problem and where vested parties disagree on norms and values and goals. Some of the characteristics of wicked problems include i. the problem and solutions are not clear cut; ii. the problem can be managed but not completely solved; and iii. there are conflicting values amongst stakeholder groups, which vary with time. Due to the compounding and complex interacting impacts of aquatic invasive species, climate change, nutrient loading and multiple level interactions of fragmented institutions, the eutrophication of Lake Erie is a wicked problem that needs novel governance solutions. Given Michalak et al.'s (2013) view that the impact of climate change on eutrophication, HABs and hypoxia is comparable to that of phosphorus loading in Lake Erie, governance systems for eutrophication must address not only phosphorus loadings but also the complexity of extreme weather events and a changing climate. Such a governance system must be flexible, able to deal with complex interacting stressors, and able to adjust to uncertainties and changes. This paper argues that one such approach is the building of adaptive capacity for eutrophication governance.

7.6 Attributes, Determinants and Indicators

A growing body of literature has focused on identifying and developing attributes, determinants and indicators of adaptive capacity. These terms have often tended to be used interchangeably without clear definition and as such, they are briefly examined here for clarity.

The Oxford Online dictionaries (2014) are used for definitions of all terms. **Attributes** are defined in the dictionary as the qualities or features that are characteristic of or an inherent part of something. As applied to adaptive governance, the attributes of adaptive governance would be the factors that are present when there is adaptive governance, as reported from empirical studies in the literature. The word **determinant** has a related meaning of "a factor that decisively affects the nature or outcome of something" (Oxford Dictionaries, 2014). In the case of good governance, determinants would be the institutional, financial and technical factors that affect the outcome of good governance. On the other hand, an indicator is **defined** as "a thing that indicates the state or level of something". Indicators for good governance refer to criteria, whether quantitatively or qualitatively determined, that indicate the presence of determinants of good governance. In the context of good governance, indicators would be tools that point to the presence of factors that comprise determinants of good governance.

7.6.1 Governing for adaptive capacity-enabling factors

Recognizing the difficulty of translating governance for adaptive capacity into real world applications, a number of studies have attempted to operationalize the concept through attributes, determinants, dimensions or factors for governing for adaptive capacity (Dietz et al, 2003; Huitema et al., 2009; Huntjens et al. 2011; Pahl-Wostl et al., 2012). The identification and nurturing of characteristics of SESs that will increase adaptive capacity and resilience of the system to uncertainty by transforming to a better state is of importance to decision makers (Engle and Lemos, 2010). Further, the governance determinants of adaptive capacity play an important role in defining the ability of SESs to prepare for and respond to stress (Yohe and Tol, 2002). The earliest determinants of adaptive capacity were associated with adapting to climate change. The associated literature is extensive, with many discussions on determinants for climate-induced stressors.

The broad determinants that contribute to adaptive capacity (IPCC, 2001) have paved the way for more discussion of a more detailed range of determinants in the literature (Yohe and Tol, 2002; Folke et al., 2005; Engle and Lemos, 2010; Engle et al., 2011; Pahl-Wostl et al., 2012). These determinants have varied depending on the thematic area of focus, with most being developed in the context of adaptation to climate change. There are no determinants for adaptive capacity in the literature as applied to stressors such as eutrophication. As such, much more empirical studies are needed in order to create a robust analytical framework to identify, measure and sustain the components of adaptive capacity. This will aid decision makers who are interested in identifying and nurturing system characteristics that will build resilience and adaptive capacity (Engle and Lemos, 2010).

While the past may not be a good predictor of the future in a highly uncertain environment, institutions can use experience from the past to inform responses to present and future challenges (Huntjens et al., 2011). The literature has identified such learning as being essential for coping with uncertainty and change (Folke et al., 2006; Pahl-Wostl, 2007a). This study builds on that thinking by studying the evolution of eutrophication and associated governance in Lake Erie from the 1960s to the 1990s.

7.7 Framework for Assessing Adaptive Capacity

Many determinants of adaptive governance are described in the literature. This study has grouped them according to those most relevant to the ***Great Lakes Water Quality Protocol 2012*** (the Protocol), as this can inform the implementation of actions as stipulated under the Protocol. This research proposes six categories of determinants of adaptive capacity that are based on a broad survey of the literature: **public participation, science, networks,**

leadership, flexibility and resources. These determinants were carefully chosen based on relevance to the Great Lakes Water Quality Protocol 2012 and on the results of key informant interviews (**see Section 6.9.2**). Key informant interviews were useful in 'weeding out' determinants that were important in the theory but had no practical importance to eutrophication governance as identified by the experts (e.g., equity). They also revealed determinants that the researcher had eliminated as not directly applicable to the Great Lakes Water Quality Protocol 2012. The initial determinants as extracted from the literature were evaluated for their relevance to the Great Lakes Water Quality Protocol 2012 and to situate them in the context of the stressor of eutrophication. This process resulted in the elimination and merging of some determinants, and eventually led to the identification of six final categories: public participation, science, networks, leadership, flexibility and resources.

Table 7.1 presents the determinants of adaptive capacity and their basis in the literature. This study validated those determinants in a set of key informant interviews on a past eutrophication event in Lake Erie, where (because the system was able to deal with the stressor of eutrophication, as demonstrated by a reduction of phosphorus loading and resurgence of key ecosystems) it is assumed that adaptive capacity was realized. This validation was then complemented with data from key informant interviews conducted with experts who were active players in the Lake Erie eutrophication event from 1970s to 1990s. Conceptually, this combination of inductive (bottom-up) and deductive (top-down) approach enabled context-specific but transferable analysis, approaches that will be useful in scaling up this research.

The question of whether specific determinants such as leadership and resources are prerequisites for enabling adaptive capacity or outcomes of the presence of adaptive capacity is answered here by defining adaptive capacity such that the determinants are process indicators, rather than outcomes. As such, adaptive capacity is defined as "the ability of a resource governance process to first alter processes and if required convert structured elements as a response to experienced or expected changes in the societal or natural environment" (Pahl-Wostl, 2009) and not as "the ability of a system to adjust to climate change, to moderate potential damages to take advantage of opportunities and or cope with consequences" (Engle and Lemos, 2010). Following from the former definition, in the context of eutrophication, adaptive capacity is defined as the ability of the water body to first alter processes in response to nutrient enrichment, and if required convert structured elements as a response to experienced or expected changes in the societal or natural environment due to *eutrophication* (following from Pahl-Wostl, 2009).

The six determinants selected for this study are discussed in more detail in Section 7.8.

Determinant	**Description**	**Relevant Literature**
Public Participation (D1) Representation	Adaptive capacity will be built when there is participation of diverse, interested stakeholders to allow access to new modes of knowledge and stakeholder buy in to deal with the highly complex and uncertain environment of eutrophication. One challenge is determining which of the public is included and excluded for efficiency in processes.	Berkes and Folke, 1998; Brunner et al., 2005; German et al., 2007; Hahn et al., 2006; Heathcote, 2009; Pahl-Wostl et al., 2007b; Pahl-Wostl, 2007c; Newig et al., 2005.Jolley, 2007; Day et al., 2003.
Science (D2)	Adaptive capacity will be built when sound science is used to guide decision making processes on eutrophication issues across multiple scales.	Scholz and Stiftel, 2005;Pahl-Wostl et al. 2007a;
Networks (D3)	Adaptive capacity will be built when different actors operate across multiple scales on the same issues in horizontal governance networks such as epistemic communities, transnational advocacy coalitions and global civil society.	Folke et al, 2005;O'Brien et al, 200; Smit et al, 1997; Betsill and Bulkeley, 2004; Adler and Haas, 1992; Keck and Sikkink, 1998; Smit and Wandel, 2006; Rosenau, 2000; Kofinas, 2009; O'Toole, 1997; Finger et al, 2006.
Leadership (D4) Experience Decision Making	Adaptive capacity will be built when there is a new kind of leader who can interact with stakeholders and facilitate public learning to overcome uncertainty, distrust and conflict in the highly uncertain environment of eutrophication. A leader with more experience would more ably deal with uncertain events in an effective and timely manner. Complex uncertain problems such as eutrophication require leaders to consider and balance their thinking with others and to engage in new approaches to decision making.	Bryant et al., 2008; Heathcote, 2009; Folke et al., 2005; Olsson et al., 2006. Engle and Lemos, 2010; UNECE, 2009. Musselwhite, 2009; IISD, 2006; Huntjens et al., 2011.
Flexibility (D5)	Adaptive capacity will be built when there are mechanisms for information feedback loops that are as a result of monitoring and are used to guide decisions and adjust programs. Sound science is used in this culture of learning.	Engle and Lemos, 2010; Gunderson, 1999; Tompkins and Adger, 2001; UNECE, 2009; Engle et al. 2011.
Resources (D6)	Adaptive capacity will be built when there is availability of skilled human resources for functions such as innovation and monitoring and financial resources for implementation of policy measures.	IPCC, 2001;Pelling and High, 2005; Adger, 2003;Yohe and Tol, 2002; Olsson et al, 2006; Engle and Lemos, 2010.

Table 7.1: Determinants of adaptive capacity

7.8 Determinants of Adaptive Capacity

The following sections describe each of the final determinants of adaptive capacity in more detail.

7.8.1 Public Participation

Building adaptive capacity requires the participation of a group of diverse stakeholders including representatives of both governmental and non-governmental organizations and representatives of key citizen groups who are affected by eutrophication and can impact the nutrient enrichment of the lakes due to their activities. Governance approaches that involve diverse roles of non-governmental actors are a major part of natural resources management (Berkes and Folke, 1998; Brunner et al., 2005; Hahn et al., 2006; Pahl-Wostl et al., 2007b). Public participation in watershed management can take diverse forms in three key areas: participation in problem definition; participation in planning; and participation in implementation (German et al., 2007). Public participation in the development and implementation of policies is crucial in new forms of governance to embrace change in the highly complex and uncertain environment of stressors such as climate change (Pahl-Wostl, 2007c) and eutrophication. Key stakeholders can retard progress by putting up resistance during the implementation process, so inviting their participation can aid in reducing uncertainties that can be introduced by their opposition to implementation (Newig et al., 2005). Environmental focusing events such as organic contamination at Love Canal and the Cuyahoga fires were valuable lessons for governments, making them realize that time and money can be saved when the public concerns are addressed in a timely manner (Heathcote, 2009). An added advantage of having broader participation is the contribution of different kinds of knowledge that can lead to better assessment of the problem and hence more innovative solutions (Berkes and Folke, 1998).

While inclusion of the public is desirable, an additional challenge lies in determining representation. Broader representation of the public leads to buy in and mutually beneficial trade offs but can also increase the time for deliberations and lead to an inefficient process if not managed. According to Jolley (2007), non-expert respondents may lack the proper knowledge when responding to questions of natural resource policies and problems. Science-based processes involving technical experts fail to access, recognize and integrate differing values, wisdom and perceptions of non-technical stakeholders (Day et al., 2003). There is agreement in the literature that the involvement of the public allows a wide variety of viewpoints, and the access to historical and traditional knowledge and risk perceptions that is absent from a gathering of technical experts (Day et al. 2003). Well-designed representation of diverse opinion will facilitate prompt response and lead to better solutions.

7.8.2 Science/Knowledge

A scientific understanding of eutrophication is a fundamental requirement of adaptive governance for Lake Erie. Solutions to the problem of eutrophication will only be successful if the nature of the problem is understood. Eutrophication governance intersects with disciplines such as agriculture, hydrology, transport and heat exchange processes, geology and a range of life sciences. Policy makers and politicians expect to be given one clear answer by science but, as is evidenced by the debate genetically modified organisms (GMOs), science doesn't always speak with a single voice. In the case of eutrophication, policymakers would prefer one single answer to causation but the scientific community knows that the phenomenon is an interaction of non-linear processes and that more time is needed to study the problem. As such, policy processes that are aligned with scientific processes and knowledge production would be more effective users of science.

According to Scholz and Stiftel (2005), there are three dimensions to the alignment of policy and science processes: i. specialists will have differing views on the human and natural systems and decision venues that clarify and contrast differences can lead to both productive synthesis and heightened conflicts; ii. Scientific knowledge can be advanced through policy processes that provide a forum for experts to review existing results and design research projects to fill gaps; iii. Policy decisions may take the form of scientific experiments where critical assumptions are tested by monitoring outcomes. All of these dimensions could add value to the adaptive governance landscape.

7.8.3 Networks

Adaptive capacity is built when there is evidence of institutional change through networking that embraces new paradigms and ways of thinking. There are three types of transnational networks in global environmental governance: epistemic communities, transnational advocacy coalitions and global civil society (Betsill and Bulkeley, 2004).

An epistemic community is a network of experts who share a common understanding of the scientific and political nature of the problem. It has four defining features: i. shared normative and principled beliefs, ii. shared causal beliefs, iii. shared notions of validity, and iv. common policy enterprise (Adler and Haas, 1992). The motivation for involvement in these networks is usually emotional and intellectual. Transnational advocacy networks (TANs) are more likely to emerge when channels between domestic groups and their governments do not resolve existing conflict, where activists believe that networking would further their cause and where international conferences create hubs for strengthening the networks (Keck and Sikkink, 1998). International examples include Greenpeace, Friends of the Earth and the World Wildlife Fund. The global civil society approach takes the discourse away from state-centred approaches to the multitude of actors and institutions that influence the ways in which global environmental issues are addressed across different scales, through spheres of authority (Rosenau, 2000:172). According to Rosenau (2000), governance occurs on a "global scale through both coordination of states and the activities of a vast array of rule systems that exercise authority in the pursuit of goals that function outside normal jurisdiction." Transparency International, Nature Conservancy and International Rivers are other examples of global civil society networks.

For any of these networks, the presence of a strong kinship serves to increase adaptive capacity through greater access to pooled resources, increasing human resources capacity, and buffering psychological stress (Smit and Wandel, 2006). Further, adaptive governance systems often self-organize as social networks with actor groups that draw on various knowledge systems and experiences to develop common understanding and policies (Folke et al. 2005). Adaptive co-management requires flexible social networks that trump bureaucracies in their quick response time for rapid changing and uncertain conditions (Folke et al. 2005). Engle and Lemos (2010) suggest that the greater the networking and connectivity between groups and stakeholders involved in the management process, the greater will be the adaptive capacity. Bridging organizations such as management councils, learning networks and associations are important central nodes for interactions across scales but challenges remain in fostering adaptive learning between these bridging organizations and larger society (Kofinas, 2009). According to the UNECE (2009), network connectivity does not necessarily mean that there is a willingness to cooperate, posing a challenge to the development of adaptive capacity.

Empirically, there are three areas of research on networks: i. determine what networks exist; ii. examine the historical and dynamic dimensions of network formation and development; and iii. explore the array of networks in a broadly comparative perspective (O'Toole, 1997, 48).

7.8.4 Leadership

The top down command and control paradigm of natural resources governance has been associated with a bureaucratic leadership model, where the leader issues centrally-directed commands with little input from others (Folke et al., 2005). In this paradigm, leadership is defined as "the process where one or more individuals succeeds in attempting to frame and define the reality of others", and where the leader has an obligation or perceived right to shape and define the reality of others (Smircich and Morgan, 1982, p 258). This definition points to the shortcomings of this model of leadership in a highly dynamic, complex and uncertain environment; a model in which one person sets the reality of others will not be able to respond rapidly to changes in the system and will not necessarily build trust, effective networks and a common vision. There are many ways in which people exert leadership, and it equally holds that persons in power do not always employ leadership. According to Heathcote (2009, p113), three main categories of leadership include:

a. Positional Leaders – These are persons in positions of leadership by virtue of their role in an organization. This role positions them higher in a bureaucratic structure and implies power over those at lower positions in the organization structure.
b. Reputational Leaders – These persons are viewed as key decision makers by community members. They could include public officials, persons of wealth, and respected persons in public and private organizations, but also persons in non-governmental organizations who are highly knowledgeable.
c. Decisional Leaders – These are persons who were key decision makers in community meetings. The distinguishing element between reputational and decisional leaders is that while reputational leaders have the ability to influence, decisional leaders also show interest to influence decisions through active participation in meetings.

Heathcote (2009) goes on to state that all three types of leaders are beneficial in most situations. However, it is clear that in a highly dynamic and uncertain environment, such as that associated with eutrophication, a new model of leadership that is interactive and dynamic is needed to facilitate adaptive capacity and outcomes such as learning, networking and information sharing. According to Folke et al. (2005), vision, trust and innovative flexible leadership can facilitate key functions for adaptive governance, functions such as building trust, managing conflict, making sense, linking actors, initiating partnerships, compiling and generating knowledge and mobilizing broad support for change. These functions are important as they serve to bridge the interests of stakeholders leading to better collaboration, faster conflict resolution, and hence the faster decision making that is necessary in an adaptive governance environment. The criteria of vision, leadership and trust can also be used to test for accountability, as an unaccountable system will not generate trust among its citizens (Olsson et al., 2006). Leadership and vision can also be seen as requirements for political will to foster adaptive responses to stressors such as eutrophication.

The experience of a leader can also be important in fostering adaptive capacity. According to Engle and Lemos (2010), more experience would translate into greater ability to deal with both everyday and extreme events in an effective and efficient manner. Decision making is another important consideration in leadership for building adaptive capacity. Complex and uncertain problems such as eutrophication require leaders to consider and balance their thinking with others and to engage in new approaches to decision making. In a survey of 40 000 managers, Musselwhite (2009) found that the appropriate degree of inclusion of actors into the decision making process can be determined by considering five factors: i. problem clarity (consideration of the nature and scope of the problem; ii. information (facts and knowledge needed to make the best decision); iii. level of commitment (degree of buy-in and support needed to implement the decision); iv. goal agreement (degree to which stakeholders have common or competing goals among themselves and with their organization); and v. time (degree of urgency surrounding the decision and the time and effort others must make to participate in the decision making process). Devolved decision making to the lowest level means that the system would presumably be better able to recognise and respond to unforeseen circumstances (IISD, 2006). However, it can be argued that decision making can be difficult with many stakeholders who are vested in the process making the decision and thus decentralization is not a clear cut solution to water governance. A centralized governance structure is needed in a large scale complex system as it will facilitate participatory processes, set standards, build capacity, resolve conflicts and assist in building of cooperation across scales and boundaries through the provision of information to the local levels (Huntjens et al., 2011).

7.8.5 Flexibility

The Oxford Online Dictionary defines flexibility as “the ability to be easily modified". When applied to institutions, flexibility refers to an ability to bend without breaking and to learn iteratively by incorporating efficiently and effectively lessons learnt through experience (Engle and Lemos, 2010). This links back to the concept of learning by doing and making adjustments that are integral parts of adaptive governance. Adaptive capacity therefore requires flexible management institutions that will support the implementation of structured actions designed to promote learning.

Flexible management systems that self adjust based on new information are important for building resilience (Tompkins and Adger, 2001). Engle and Lemos (2010) propose that adaptive capacity will also be greater when the legislation and institutions are more flexible. However, when it comes to legislation, there is a tradeoff between the certainty or predictability required in law and the flexibility necessary for adaptive governance (Engle et al. 2011). On the one hand, by its very properties law requires that all rules and regulations be applied consistently and fairly, with little room for adjustments to circumstances. However, it can be assumed that consistency in the application of legislation and regulations will enhance adaptive capacity provided that the laws reflect the principles of equity and ecological integrity.

7.8.6 Resources

The factors listed in the literature as determinants of adaptive capacity represent some form of resources or the use of resources: economic resources, technology, information and skills, infrastructure, institutions, social capital and collective action (Pelling and High, 2005; Adger, 2003;Yohe and Tol, 2002;IPCC, 2001). Financial resources are useful for many actions aimed at bolstering adaptive capacity such as remedial action, building capacity for monitoring and environmental feedback, enforcing laws, responding to other environmental change and responding to extremes and feedback (Olsson et al, 2006). According to Engle and Lemos (2010) financial and human capital are vital for the success of a governance structure and since education and wealth varies within and between locations (they use the example of river basins), the greater the resources the greater will be the adaptive capacity of these locations/basins. However, one should recognize that even though more resources can increase adaptive capacity, thoughtful allocation and utilization of resources is important for program efficiency and effectiveness.

7.9 Methodology

7.9.1 Assessment of Adaptive Capacity

The measurement of adaptive capacity can be challenging as it is latent in nature, which means it can only be measured only after it has been mobilized or realized (Engle and Lemos, 2010). As discussed in Section 6.8, this study identified a number of governance determinants of adaptive capacity from a comprehensive literature review, and validated them using key informant interviews. For the case of eutrophication, system responses to past eutrophication events, specifically the eutrophication of Lake Erie in the 1970s and the lake's subsequent return to resiliency in the 1990s, can help in identifying governance determinants that aided system response. This approach has been described in the climate adaptation literature but has not been applied to eutrophication.

This research assumes that adaptive capacity is present if the eutrophication event has been governed successfully, resulting in reduction of nutrient loading to the water body, as in the case of Lake Erie in the 1970s to 1990s. The governance determinants of adaptive capacity are used to explore adaptive capacity in the selected case of Lake Erie where there was a past eutrophication event. While it is recognized that the past may not be a good indicator of the future in a highly uncertain environment, the focus on these past eutrophication events can provide useful insight for the governance of future events. Decision makers should be able to assess and develop responses to future eutrophication events through better understanding of the determinants of adaptive capacity.

7.9.2 Key Informant Interviews

Interviews provided access to experts' knowledge of Lake Erie eutrophication in the 70s-90s to capture their understanding of the determinants of adaptive capacity. For the purposes of this research, an expert was considered to be someone who was knowledgeable about the water body under investigation as evidenced by their involvement in prior projects (such as involvement in eutrophication issues in Lake Erie) or by their position in an institution whose mandate included some aspect of eutrophication governance of the water body under consideration. Fifteen key informant interviews were conducted with Great Lakes experts who were involved in eutrophication governance of Lake Erie during the period of 1972 to 1990. These key informants were carefully selected based on their roles in eutrophication governance of Lake Erie. Some of the key informants were involved in the Pollution from Land-Based Activities Reference Group (PLUARG) while others were past staff members of the International Joint Commission (IJC) or past members of the IJC Advisory Boards. Interviews were conducted either in person or on the phone using a standardized questionnaire, from June 2014 to December 2014. Interviews were approximately 1-2 hours in duration.

The expert interviews allowed the researcher access to the knowledge of the key stakeholders who possessed the technical knowledge and who also manage the consequences of this knowledge in practical decisions on eutrophication governance. For all the interviews, snowball sampling was employed: during an interview, an expert was asked to identify and recommend another expert who could add another dimension or additional knowledge from a different perspective on the subject under investigation.

The interview process started with a literature review, where organizations relevant to Lake Erie eutrophication were identified. The next step was to list these organizations and decide what information was needed from each. These organizations were then researched using the Internet, scholarly literature, and other reports. Relevant personnel were identified through this process and in consultation with experts. The researcher then designed the study to determine what information was needed and the preferred mode of extracting this information from the expert. The interview was recorded using hand notes and then transcribed into Word and stored for coding. The transcribed information was then analyzed to inform this research.

7.10 Assessment of Adaptive Capacity in the Great Lakes-Validation of Determinants

The results of the key informant interviews were coded and analyzed in Nvivo 10 for Mac, a data analysis software package designed for use with qualitative research methods such as interviews. Figure 7.4 illustrates a word cloud of the words used most frequently by the key informants, and reveals the most common themes emerging from those interviews.

Figure 7.4: Key themes from key informant interviews

The most frequently used words include IJC, the public, information, science, people, farmers, agriculture and money. In the following sections, these themes will be discussed further as part of the results from each determinant of adaptive capacity.

7.11 Results: Assessment of Determinants of Adaptive Capacity

7.11.1 Public Participation

As might be expected with the multi-level, cross sectorial nature of the problem of eutrophication, multiple stakeholders contribute to the problem and therefore multiple stakeholders are needed to devise effective solutions. The public was engaged in Great Lakes issues throughout the early years of the Great Lakes Water Quality Agreement 1972 (the Agreement), by taking part in meetings, by advocating for issues to be resolved and by participating in implementation of solutions. This public involvement in Great Lakes issues evolved through the years, as there was no involvement of the public in the development of the original 1972 Agreement. The public did influence the governments to create the Agreement through their growing awareness and concern for the pollution of the lakes:

> *The local public was telling the local government to get this under control. It is not a municipal issue. Our fishing and recreational outings could be at stake at the table. The pressure from the public reinforced the need for action. The focus on Lake Erie is not just because government is calling for it; it is a highly visible issue and people are calling for it.* [GL2D1]

> *What happened was after World War II, there began to be more concern for water quality, as incidents occurred that were blamed on pollution in detergent. Newspaper stories on fish dying in streams and foamy water led to public outcry in the early 1960s………There was a considerable amount of concern after the Cuyahoga River caught fire and US funding seemed to go up considerably, aimed at Sewage Treatment Plant upgrades*. [GL5D1]

Through the 1970s, the International Joint Commission provided (and continues to provide) information to the public through public hearings, although prior to 1972 the commission's communications were confidential and "only made available to the public by permission of the governments" (IJC, 1965). There is record of public hearings in Toronto, ON and Cleveland OH in 1969 and in Erie, PA, London ON, Rochester, NY and Brockville ON in

1970 (IJC, 1970). There is evidence that public concerns were heard by the IJC, as it is documented in the report by the IJC (1970) that there was widespread alarm and increasing awareness by the public of the impact of industrial and municipal discharges and nutrient enrichment of the lakes. Some of the testimonials of the public as recorded by the IJC are as follows:

> *We have become alarmed at the dramatic and shocking changes, which are taking place with respect to the condition of this grand waterway. The Federal Government should increase its financial assistance to the States for waste treatment. We have heard a lot of words. When is the action going to start, because the longer we procrastinate the worse the problem become? Our community is dedicated to pollution abatement*. [IJC, 1970]

Although the voice of the public was heard by the IJC, the general public had no role in decision making. According to the key informants in the current research, although the public was informed, the public was not empowered in decision making:

> *In those days we informed the public rather than empowered them to have a voice in the decision making process. We provided information rather than facilitating empowerment of the public. The challenge was how to get people empowered.* [GL1D1]

> *There was a command and control environment so the general public was not involved.*
> *The key stakeholders were mostly scientists.* [GL2D1]

> *There wasn't that much of a public movement. I worked in different agencies so was very seldom involved in giving information to the public. There weren't many major stakeholder groups. People weren't organized at that level until the late 70s early 80s.* [GL1D1]

> *There was a major paradigm shift for each period of time. The mechanism through the 70s and middle 80s was that there was no public participation. In the early 80s we were discouraged from talking to colleagues. Later during the late 80s and the early 90s we had more experience of talking to the public. IJC biennial meetings became a forum for the public.* [GL3D1]

This concern for the environment led to the formation of groups that advocated for a cleaner lake. There were non-governmental organizations that were actively involved in advocacy and in pollution prevention. These groups became more active with the push to ban phosphorus in detergents. Some of the groups that were involved included the League of Women Voters, the Clean Water Alliance, and Great Lakes United:

> *There were formation of groups and there was a citizen environment lab called the Clean Water Group. While it grew out of grass roots, Great Lakes United started being a more forceful organization. Everybody didn't think of environment until concerns such as the Cuyahoga catching fire. The Detroit River became known as the most polluted river in North America*. [GL1D1]

> *The public was kept informed. The public got involved in the phosphorus free movement to ban phosphorus in detergents, in the educational campaign, and shared in the distribution of information. [GL2D1]*

> *The League of Women Voters was a long standing advocacy organization in the US that still exists. However, as women have become more active in working life, membership has declined. I became involved. I worked with the Illinois League of Women Voters leadership; we worked together and pushed for public participation in meetings on Lake Michigan and the Calumet enforcement conference*. [GL5D1]

> *The public at large obtained information through newspapers. Public attention in Chicago was drawn to the Chicago Tribune that carried a series of articles and was the first paper that signed a reporter as first environmental editor. In the 1960s they ran a series of articles on the pollution of Michigan, the terrible die off of alewife; that series focused on Lake Michigan but then the focus shifted to Lake Erie. Science showed the effects of pollution but the publicity generated was a large factor in informing the broader public and led to private citizen involvement which was tremendous.* [GL6D1]

The participation of the public evolved with the requirement in the 1972 Great Lakes Water Quality Agreement (and in the 1978 Amendment) under Article VIII, that the IJC and the Boards provide a public information service for the programs, including providing for public hearings. The reports of the boards were made public and further communicated through workshops. The workshop organized by the Research Advisory Board (RAB) was the fertile ground that led to the establishment of 17 public advisory panels for the Pollution from Land-Based Activities Reference Group (PLUARG) watershed study (Botts and Muldoon, 2005). These reports and meetings were recognised by the key informants of this study as being instrumental in the evolution of public involvement in Great Lakes matters and helped in creating a sense of community, even though the meetings were initially adversarial in nature:

> *IJC biennial meetings were a way to set up communication. The Science Advisory*

> *Board set up a table at the front of the room and had a microphone for open questions and answers; people commented with a great deal of anger. The IJC would not give an answer as they are political appointees. I remember going to an IJC public meeting in 1992, but a lot of it was grandstanding, protesting, marching around with public demonstrations of concern. That's complaining and was not a good environment for fostering good understanding and communication.*[GL3D1].

> *For the IJC work, we set up a public participation network which involved people at the local level in each geographic area. At these meetings, people would participate as they wanted. Many of the persons who came to meetings were active outside of meetings to talk with friends, to represent issues to other people, to lobby politicians at local, state and provincial levels. Under the 1972 GLWQA, the IJC was given the mandate for the Pollution from Land-based Activities Reference Group (PLUARG) which included non-point source pollution. PLUARG set up an extensive public information network to inform the public. This helped the public to become engaged on the issues. Engagement was on a couple of levels; persons presented their ideas, told others of the issue and got concerns expressed to politicians. It was a positive success; it engaged hundreds of people across the Great Lakes region…It was like a spider web, persons outside of the Great Lakes area hosted meetings.*[GL7D1]

> *There was a fair bit of public participation. I am aware of meetings with farmer groups and groups around problems such as erosion and sediment yield and phosphorus and around Best Management Practices (BMPs). There were many stakeholders associated with PLUARG including federal and provincial and university people. There were public meetings. One of the things that helped immensely was that there was a group of farmers called innovation farmers. These were landowners and they formed way before PLUARG. They were aware of poor land management and downstream issues. They committed to do something on land on their own. They were an increasingly important group of landowners when it came to meeting more bureaucrats and enrolling other farmers. That helped having an initial group of people. We valued them immensely as they had a lot of good ideas and good experience. That was an important point; PLUARG made use of it.* [GL11D1]

The key informants felt that the engagement of the public was one factor that positively contributed to the nutrient reduction and restoration of Lake Erie. In Canada, the process of transitioning to full engagement of the public was a slow one. According to one of the key informants, the Municipal Industrial Strategy for Abatement did not include NGOs or the public, something that was later seen as a major flaw in the process (GL7D1). However, this improved in Ontario through the 1993 Environmental Bill of

Rights, which gave the public rights to environmental information, while in the United States (US) it was law that information had to be shared with the public.

The evolution of public involvement that has occurred over the last several decades can be demonstrated by the time stakeholders spent to prepare for meetings and the mode of engagement of the public. For instance, public involvement in the Grand River Strategy was invited through a limited series of advertisements in the newspapers, where the public was invited to submit their resumes to apply for positions on advisory committees. The public was very interested as was evident by the numerous applications received, but there were only six to eight spots to be filled:

> *The Grand River is a major river in Lake Ontario that drains to Lake Erie, with 13 different municipalities so a lower tier of government is involved. Public involvement was through open meetings but was limited in committees to a series of advertisements in newspapers asking people to submit resumes. This was one of most progressive processes in 70s and 80s to involve the public in the significant issue of eutrophication in Lake Erie. It yielded a lot of applicants, although there were not a lot of spaces to fill, only about six or eight seats on a committee. The Grand River had quite a strong influence with strong technical working groups that had about 12 members at most. What worked well, was to have these small groups working together for a long time. It helped to build a sense of team and rapport, trust, things that were lacking in places like the IJC biennial meetings. Those committees worked as a team and developed technical recommendations that eventually led to the Grand River plan. It had a lot of impact on the final decision. [*GL3D1]

During the 1970s, the public spent little time to prepare for meetings as they were given limited information with which to prepare (GL3D1, personal communication). This has evolved considerably in recent years. For example, for phosphorus trading in Lake Simcoe Basin, the public interest groups spend at least 2 days to prepare for meetings because more information is made available to them, as there is the expectation that there will be more substantive input (GL3D1, personal communication). As the public were encouraged to become more involved, there was no exclusion at the IJC meetings as these were made open to the general public through provisions in the 1972 Great Lakes Water Quality Agreement. This even led to the engagement of private companies and spurred them to investigate alternatives to phosphates in detergents:

> *There were a series of local meetings and the information was compiled to provide a broader picture across the GL basin. There was a strong voice, no exclusion from process and there was an effort to try to engage people or organizations or*

companies that were responsible for the problem. For example, Proctor and Gamble were major laundry detergent manufacturers that we tried to bring into discussion so that they could understand how the problems were, how they were contributing to the problem and how they could develop alternatives. P&G worked to develop alternatives to P in detergents. There was no level of government excluded. If a particular state or provincial government was responsible, we brought them into the discussion. [GL7D1]

The evidence from the key informant interviews presented above shows that, from the 1970s to the 1990s, there were varying levels and diverse modes of participation of interested stakeholders in the nutrient enrichment of Lake Erie. Key informants felt that this involvement played an important role in reducing nutrient input and hence building adaptive capacity for eutrophication governance of Lake Erie. The self organization of stakeholders into advocacy groups such as the League of Women Voters and the Clean Water Group helped in the development of a common understanding of nutrient enrichment through the organization of conferences and the bringing together of diverse stakeholders to speak to the issue of eutrophication. These groups acted as bridging organizations that lowered the cost of collaboration. In some cases, enabling legislation and policy, such as the Great Lakes Water Quality Agreement, facilitated the sharing of information with the public. This helped in the provision of key information for dealing with the poorly understood problem of eutrophication. Adaptive capacity was demonstrated by social systems making use of available information to self organize and to drive policy that resulted in improvements to the Lake Erie ecosystems.

7.11.2 Science/Knowledge

During the eutrophication of Lake Erie in the 1970s, scientific information was used to determine the cause of the problem, including the effects of phosphorus and nitrogen on algal growth in Lakes.

In 1964 the governments of Canada and the US issued a reference to the IJC to help determine the cause. Funding to the experimental lakes area resulted in scientific breakthroughs. [GL1D2]

A series of whole lake experiments were conducted by Schindler and Lee (1974) in which lakes were fertilized with combinations of phosphate, nitrates, and/or carbon to determine the limiting factor for eutrophication. These experiments demonstrated that the control of phosphorus was important in controlling eutrophication at that time (Schindler and Lee, 1974). A key informant noted that another big influence on the science at that time was the publication 'Algal Bowl' by Jack Vallantyne (GL1D2).

This use of science in making decisions for the Great Lakes region is embedded in the Boundary Waters Treaty (1909) where Article IX states that the IJC examines each case so as to report on 'facts'. This principle was carried forward into the Great Lakes Water Quality Agreement (1978), where the terms of reference of the Science Advisory Board (SAB) stipulate that scientific information should be reviewed to determine its impact, adequacy and reliability and also to identify gaps. Scientific models were used to determine target loads. According to the key informants of this research, science was the driving force behind decisions, driving the focus on elimination of P in detergents and the regulations for sewage treatment plants:

> *The 1972 GLWQA set Canada and US nutrient discharge at 0.5mg/l using the Vollenweider Model… We set these target loads. Science and engineering had the lead. Part of the reason we removed phosphorus out of sewage treatment plant effluent was that we could do it; we did what we could do; only what we can manage through the technology that we have. The notion that we can address anything with technology came out of the 60s and 70s. We no longer believe that.* [GL1D2]

> *Lake Erie was hypereutrophic and nobody knew why. Stakeholders were mostly scientists. Once scientists revealed that phosphorus was the issue, the decision was made. A report was produced by the IJC with the help of good science. It was a highly visible issue with fish kills. What was NOT known was acceptable loading to Lake Erie and this was worked out through extensive modeling that was shared binationally. There was innovation in methods; the method used to determine that phosphorus was a limiting nutrient was innovative. Modeling revealed where there was a gap in information.* [GL2D2]

> *Science did drive decisions to a point. The phosphorus (P) model didn't come on until the 1970s. Changes were made in phosphorus content in detergents, but a lot of the decisions made were political…Is money better spent on upgrading sewage treatment plants or best management practices on agriculture? Models became important for answering questions like that.* [GL3D2]

There was little innovation in the integration of Traditional Ecological Knowledge into the decision making. As one key informant put it "scientists scoffed at the mere idea of traditional ecological knowledge" (GL3D2). However, there was innovation in analytical methods in 70s to 80s, for example in the way phosphorus was analyzed. PLUARG drove the innovation in field measurement and the innovation in the eutrophication model for specific high risk systems like the Grand River; there were species specific eutrophication models for *Cladophora*, *Myriophllyum* (Eurasian milfoil) and *Potamogeton* (pond weed). These were three species that have been problematic in that system, as they have different phosphorus uptake dynamics and therefore required a different plant growth model for each species.

According to those surveyed, the use of scientific information was essential for the reduction of nutrient enrichment in Lake Erie. The information was used to show that the actions of sewage plant upgrades and banning of phosphorus in detergents made a difference in Lake Erie:

> *Science was an important factor in driving decision-making and answered questions as to how much phosphorus is essential for plant life in water. When there is too much phosphorus it is a problem. Science tells us what reduction in phosphorus loading is necessary in order to restore Lake Erie to a desirable environmental quality. Science established the relationship in the amount of phosphorus and plant growth in lakes.* [GL7D2]

> *The phosphorus concentration was going down from the mid 70s to the mid 90s; this was the turnaround period. We used that information to show how the system was cleaning up…. There was a huge amount of support for monitoring and research. Huge amounts of money were spent on monitoring in Lake Erie and it was very coordinated. The USEPA was the primary funder for monitoring and players collaborated. Science did drive decisions and decision makers were waiting for scientists…Groups were using same sampling and analysis technique, incredibly well done. Sharing and transmitting information was well done*. [GL12D2]

There was consensus amongst the key informants that the necessary science was developed and that the use of science was integral to the reduction of nutrients in the lake. Governance during this period facilitated the scientific process that was used to identify phosphorus as the limiting nutrient for eutrophication, which in turn led to improved understanding of the system as a whole. Adaptive capacity was demonstrated here through the generation of knowledge that led to improved understanding of eutrophication, which prompted adjustments in legislation and policy that resulted in decreased nutrient loading to Lake Erie.

7.11.3 Networks

During the period from the 1960s leading up to the 2000s there were several factors that contributed to creating strong networks and hence a sense of community amongst Great Lakes stakeholders. Firstly, there were the newspaper stories that stimulated public interest to save a 'dying Lake Erie'. Pictures such as the Cuyahoga river catching fire united the general public to reverse the situation.

The network was strongest amongst the epistemic community and was facilitated by the Agreement and the participation of scientists in the advisory boards of the IJC. According to the key informants, it was the provision in the Agreement that the IJC conduct its work through various advisory boards such as the Science Advisory Board (SAB) (or the then Research Advisory Board) and that it shared information with the public that created that strong network and the sense of community:

> *The reference to the IJC gave the IJC the ability to assemble a task force, a reference group. This reference group was populated by province and state representatives from around Lake Erie. The strength was the epistemic community's passion and commitment that was driven by a motivation to reverse a crisis situation. This group was populated by persons with similar research interests, motivated for same reason and pushed by need for action to do better.* [GL2D3]

> *The network was facilitated through the IJC during the 70s and 80s through its boards. The WQB was mainly government people on both sides of border and both levels of government. The SAB was operating for many years with broader membership of economists, lawyers, university researchers and academics. They were leading edge scientists and they had a first class way of sharing information across the border.* [GL3D3]

> *There was a great deal of collaboration; there were two centres that were very much working together-USEPA and EC. We would literally meet in the middle of the lake in boats and exchange samples to be sure that with our different instruments we are getting the same results. We would take their samples (and vice versa) and use our instruments and measure and compare results.* [GL12D3]

> *The IJC reference group was in touch with us researchers and made it clear that we had to share information and do everything openly. We were delighted to be sharing back and forth our ideas. It was a well-managed research program. We got together and tossed ideas around and had lively discussions between researchers and provincial representatives collecting data with open sharing of data.* [GL11D3]

There was an overlap of persons participating in the SAB activities and participating in IJC organized events that helped to strengthen the networks and create that sense of community. This community existed across geographical lines, areas of professional expertise and diverse experiences. There was also the formation of the International Association of Great Lakes

Research (IAGLR) about 60 years ago. IAGLR hosted annual conferences that helped fostering of stronger networks. There was a sense of community amongst government staff, researchers, scientists and environmentalists as they exchanged information both formally at meetings and informally over lunch (Botts and Muldoon, 2005). This networking was also evidenced in the political sphere, for even the heads of government who couldn't 'stand each other' worked together for the signing of the 1972 Great Lakes Water Quality Agreement:

> *The political network led to the signing of the binational agreement between two national leaders who hated each other.* [GL2D3]

> *Trudeau and Nixon signed agreement in 1972. It was the Prime Minister and the President back in the 60s that set the stage. It was above the party politics and transcended it. It didn't matter whether it was conservative or liberal. Trudeau was liberal, Nixon was republican-they had political differences on other areas but on environment they came together. The issue was so great it was outside of politics.* [GL7D3]

The citizens' advocacy group Great Lakes United, an example of a Transnational Advocacy Network (TAN), was credited with strengthening that sense of community amongst Great Lakes stakeholders. Great Lakes United was a binational coalition of environmental advocacy groups that influenced policy through exchange of information with scientists and government agency staff (Botts and Muldoon, 2005). This also helped with funding as there was also networking amongst NGOs for funding and around common issues:

> *There was some collaboration amongst non-governmental groups (NGOs) on specific issues. It was a competitive system but they formed consortia of groups when funding was tight.* [GL3D3]

There was also the networking that was facilitated by the PLUARG process:

> *For the PLUARG process, the strength of committees was terrific.* [GL3D3]

> *During PLUARG the networking linked researchers and government and conservation authorities. It was facilitated by the IJC mandate in how rigidly they said we had to share information. One individual who came to twice yearly meetings, while his belligerent manner annoyed people, was instrumental in making the sharing of information work.* [GL11D3]

> *One of the things that helped immensely was that there was a group of farmers called Innovation Farmers. These were landowners and they formed way before PLUARG. They were aware of poor land management and downstream issues. They committed to do something on land on their own. They were an increasingly important group of landowners when it came to meeting more bureaucrats and enrolling other farmers. It really helped having an initial group of people. We valued them immensely as they had a lot of good ideas good experience. That was an important point, PLUARG made use of it.* [GL11D3]

The PLUARG structure was successful in bridging various scales in the governance structure and functioned as a network that provided the resources necessary to facilitate change. These networks also facilitated communication and integration of technical and advocacy information and facilitated processes that encouraged diversity, hence harnessing adaptive capacity for learning and flexible adjustment (Folke et al., 2005). There was also a networking of the Ministry of Agriculture with the farmers through the agricultural extension services that PLUARG made use of:

> *There were Ministry of Agriculture and Food officers in each county; these worked closely with farmers. They had training in water resources and were closely in touch with farmers. There was a phenomenal network with farmers, the agricultural extension services.* [GL11D3]

Some authors believe that the sense of community that was created by the Agreement processes was what drove the political will of the government to meet the obligations of the 1972 Agreement (see for example Botts and Muldoon, 2005). The key informants agreed that networking drove the sense of community that was instrumental in leading to nutrient reduction in Lake Erie. Adaptive capacity was displayed during this time through strengthened capacity of the networked actors, resulting in collective learning and mobilization of resources to jointly drive nutrient reduction programs. This collective experience provided the context for the modification and acceptance of policies for reduction of nutrient loads to Lake Erie. As the key informants indicated, this collective experience was driven through different networking groups including the epistemic networks of the scientists, transnational advocacy networks and non-governmental networks.

7.11.4 Leadership

There were many examples of leadership displayed during the 1960s through to the nutrient reduction of Lake Erie in the 1990s. Positional leadership was displayed at the highest level through political commitment, which was especially visible when Trudeau and Nixon signed the Great Lakes Water Quality Agreement 1972:

> *There was leadership by Trudeau and Nixon but no camaraderie. This existed more at lower than at high management level agreement. EPA and Environmental Canada drove and pushed it up to the leadership. Trudeau's quote at that time was that Lake Erie was "pathetic and disgusting". There was federal leadership as the ban on phosphates in detergents was from coast to coast*. [GL2D4]

> *Trudeau and Nixon signed the Agreement in 1972. It was PM and President back in 60s that set the stage. It was above the party politics, it transcended it. It didn't matter whether it was conservative or liberal.* [GL7D4]

> *Leadership was there in that government signed the GLWQA; the fact that government signed the agreement showed that it had their backing to move forward*. [GL9D4]

> *The governments of both the US and Canada were active. There was significant leadership by the USEPA and Environment Canada and a great deal of collaboration between the two. The Clean Water Act had just passed and the GLWQA was just passed and NOAA was just formed. Both USEPA and EC were formed in 1970 and so they had brand new organizational strategies to try to create a presence.* [GL12D4]

This leadership by the governments was crucial in creating the fertile ground for stakeholders to act, and is in keeping with Miller's (2003) view that the extent to which organizations and individuals take on leadership roles is a benchmark of adaptive governance. There was widespread consensus by all the key informants that the IJC played a crucial leadership role in facilitating all the processes that led to the nutrient reduction in Lake Erie:

> *In those days the IJC had a lot of clout. They moved to policy development rather than information development. Knowledge is power; at one point the IJC was a great source of public information. In the 70s, the IJC was the watchdog, it had teeth. The IJC produced reports and made recommendations to governments at a high level and listed priority things that needed to be done*. [GL1D4]

> *IJC did not have experience with eutrophication but had experience with bringing stakeholders together in an impartial way to resolve disputes.* [GL2D4]

> *IJC showed clear leadership*. [GL5D4]

> *IJC facilitated communication between the US Environmental Protection Agency (USEPA) and Environment Canada. The role that was given to the IJC showed that both governments were supportive of role of the IJC, it was built into the IJC.* [GL6D4]

There was also the recognition of bottom up leadership by the greater public and groups such as Great Lakes United (GLU):

> *GLU provided a network amongst local and regional environmental organizations… they provided the connection so different organizations and groups know what is going on.* [GL7D4]

> *There was bottom up leadership and the citizenry got engaged. There were conversations with politicians and representation of the publi*c. [GL8D4]

> *There was leadership by the private foundations which provided funding for advocacy work and initially funded the work of GLU.* [GL5D4]

This recognition of the leadership of the private foundations is important, as it points to non governmental players who were key to successful management of the issue. There was also clear emergence of reputational and decisional leaders. There were particular names and environmental organizations that were seen as key informants as pivotal to the nutrient reduction in Lake Erie:

> *GLU started being a more forceful organization.* [GL1D4]

> *There was leadership by the Lake Michigan Federation, the Sierra Club and the League of Women Voters. They were stimulated by the newspaper stories showing stories of fish dying in streams and foamy water. In the early 1960s the league of Women Voters was an advocacy organization in US that still exists*. [GL5D4]

> *The Sierra Club was an established leader in organizing an early meeting in Washington DC during Great Lakes week. Citizens went to Great Lakes week and were informed through workshops on current issues and recommendations would be discussed.* [GL5D4}

There was also recognition of leadership by industry in trying to find alternatives to phosphorus in detergents:

> *Proctor and Gamble were laundry detergent manufacturers that we tried to bring into*

> *discussion so that they could understand the problems and how they were contributing to the problem and how they could develop alternatives. P&G worked to develop alternatives to P in detergents.* [GL7D4]

While there was strong leadership, there were also conflicts: conflict in political ideology between Canada and the US and also scientific conflict as to whether P or N was the limiting nutrient. These conflicts were resolved through dialogue and the use of science in decision making:

> *There was scientific conflict but it was not a difficult conflict; workshops, think tank and experimentation were means of resolving this conflict. New information was used in the decision making process that that P was the nutrient that 'caused the death of Lake Erie'. Also it was a highly controversial move to ban P in detergents as opposed to controlled upgrading of sewage treatment plants. This move reduced loading to plants from a dominant source.* [GL2D4]

> *There was apparent conflict on sharing data. Threat of cutting money helped with that, during PLUARG. There was conflict amongst researchers about science; there must have been but we seemed to resolve them. People involved got on with it. The overall commitment was great; government came up with answers. What really was happening was started at the organization group level and led to consensus.*[GL11D4]

> *Banning of phosphorus in detergents was a conflict. Was it really important to the US to sign the GLWQA, if so they would agree on phosphorus? Why would the US want agreement with Canada, as it was of more benefit to Canada, and there was more expenditure for the US – 50/50 representation on table – when it comes to clean up Canada was an order of magnitude less contaminated. The US was 2 orders of magnitude higher.* [GL2D4]

On the characteristic of good leadership, one key informant indicated that the IJC started to investigate why some Remedial Action Plans (RAPs) made good progress while others did not. They found that number of factors including i. the right investment in the right technology was helpful ii. teams and relationship and iii. the personality of the leader fostered the previous two points (GL3D4).

Another informant indicated that commitment was a hallmark of good leadership and reiterated that the ability to bring the right persons to the table was crucial:

> *Good leadership was displayed by persons who were involved in the reference group of the IJC. They were incredibly committed to geting answers. There was a person at*

> *that time on the reference group who pulled together people with similar backgrounds to work on erosion; work on soil erosion in agriculture fields; work on hydraulic modeling. They put a team together and worked 25 years together. There were a few people in the reference group that provided important leadership. As it evolved, people with the organization there became leaders.* [GL11D4]

On the issue of experience of leaders, it was recognized that no one had experience on eutrophication but that the IJC had experience with bringing stakeholders together and that was vital to the nutrient reduction in Lake Erie. Leadership by the IJC was essential in building adaptive capacity as it brought actors together in networks and created opportunities for learning, for new interactions and for sharing of knowledge. These are factors that are essential for dealing with uncertainty and change, for nurturing adaptive responses to change, and thus for building adaptive capacity. As noted by the key informants, the IJC leadership was instrumental in driving change by setting the agendas, communicating the issues at stake, facilitating dialogue to resolve conflicts, building trust, initiating partnership amongst stakeholder groups, compiling and generating knowledge and mobilizing actors to support programs for the changes necessary to achieve nutrient reduction goals.

7.11.5 Flexibility

In the early days of implementation of the 1972 Agreement, flexibility was evident as experiments were done to determine the cause of nutrient pollution, steps were taken to test the hypothesis, management actions were adjusted, and monitoring tracked the recovery of the lake. The Agreement itself had built in flexibility under the review clause as it equipped the governments of the US and Canada to adapt to a changing environment. This flexibility inherent in the Agreement was pointed out during interviews:

> *How vital was the Great Lakes Water Quality Agreement? It provided the governance framework for bi-national cooperation in this shared water body. While it did not have treaty status in US, it formalized the cooperation between US and Canada. The term 'Up for review' was included in the Great Lakes Water Quality Agreement, so at any point of time if the loading limit is too high, governments can call for review.*[GL2D5]

Article IX committed the governments to a review of the Agreement after five years. This review resulted in a revised Agreement in 1978 in which Article XIII contains amendments agreed to by the Parties. The monitoring and research that informed science facilitated this review process, including the whole-lake experiments on the limiting nutrient was for algae growth, and the PLUARG watershed scale experiments. The flexibility of targets was one area to negotiate in the Agreement:

> *The process of negotiating between Canada and US for the Agreement was a series of negotiations through IJC boards. The negotiators were never certain of the moves, there was no certainty that the loading number will have what they want*.[GL3D5]

> *Science wasn't so sure about agriculture back then. PLUARG was more about soil loss. We did not consider non-point sources. We did not know how to measure the phosphorus loads.* [GL1D5]

> *What was NOT known was the acceptable loading to Lake Erie and this was worked out through extensive modeling that was shared bi-nationally.* [GL2D5]

Initially, there was also flexibility in how to achieve the targets, whether one wanted to focus on removal in sewage treatment plants or on combined sewer overflows:

> *With respect to targets, there was flexibility in how to achieve the targets. If the target is to have a maximum load of phosphorus in the lake, we set out to determine how to achieve it. There was flexibility in how to do it, whether it was removal of phosphorus at wastewater treatment plants, from runoff or from combined sewer overflows.*[GL12D5]

There was flexibility in working with the unknown load from agriculture. Since the science and joint fact-finding were still in their infancy, and there was much uncertainty about the contribution from individual sources, there was great flexibility in setting target loads.

> *There was learning on what farmers work with and trying on the land. There was learning done at that time, learning as regards to managing technology. We tried finding ways of encouraging people to find ways to reduce the loading. Researchers talked about targets.*[GL11D5]

While there was an adaptive element in how targets were being set and a systematic process of hypothesis setting, experimental work and testing of hypothesis, this was not recognised as adaptive management:

> *In those days we were not doing adaptive management as it was not a term or technique used in the Great Lakes region in 1978. The goal in those days was a single target – 11 000 metric tonnes per year – it wasn't modified. We set the target, but after lot of discussion; modeling helped us to come up with targets. We had confidence in the model. We set a target of 11 000 metric tonnes and the lake responded. We might have had adaptive management sooner if the effort had not worked, but because it worked we thought the problem was solved and the federal government stopped its investment in monitoring and research.*[GL12D5]

What is evident here is that while there was an element of flexibility in target setting and in working with the various scenarios in the model to set the target for phosphorus loading to the lake, once the target was set the governments were reluctant to modify it (GL12D5). This was especially true as improvement was seen in the lake's trophic status. The IJC (1978) Sixth Biennial report noted that Canada had met the loading target for phosphorus and that eutrophication was slowing down.

Flexibility was also apparent in a mixture of legal versus voluntary measures. For farming, which was unregulated, there was the recognition that voluntary measures were needed to work with farmers to reduce phosphorus loading:

> *Unless and until there is an economic cost associated with environmental damage, persons would not willingly implement measures. People come up with environmental models. A farmer working on his land, there is a huge advantage for him if he loses less due to runoff; a big runoff can be an economic driver to keep phosphorus (P) on land. There is no penalty for what goes downstream. Those in agriculture said measures had to be voluntary*. [GL12D5]

> *Best management practices (BMPs) were encouraged but not legislated. This is an important point for there were all kinds of things you want to do but can't do because they were voluntary*.[GL3D5]

However, there was widespread agreement that legal measures were vital to the reduction of point source loads. The banning of phosphorus in detergents and regulations for phosphorus in sewage treatment plant effluent were seen as key moves in the reduction of point source loading and success in restoring Lake Erie:

> *We were focused on point sources, we invested money in improving sewage treatment – we set allowable limits on concentration of phosphorus coming out of sewage treatment plants. It was very effective. Legal measures were most important. This would not have happened with voluntary measures.* [GL3D5]

> *Lots of enforcement was done by the states. Voluntary measures and education go a long way, but are not working. We need to add to them. The US Clean Water Act-law cracked down on pollution sources. Billions of dollars were spent to upgrade sewage treatment using tools available under the Clean Water Act. Canada used a mix of legal and voluntary measures. It took both voluntary and legal measures. Without the Clean Water Act, much wouldn't have been done*. [GL10D5]

This approach led to the building of adaptive capacity as regulations were implemented systematically binationally and in the interest of ecological stability:

> *Regulations were put down on both sides of border. The USEPA did a lot to tighten up sewage treatment plants and also province of Ontario. Federal leadership for the ban on P in detergents was from coast to coast*. [GL2D5]

Even though there was lobbying from industry to try and prevent banning of P in detergents, this regulation was consistently applied:

> It was a *highly controversial move to ban P in detergents as opposed to controlling the upgrading of sewage treatment plants. This move reduced loading to plants from a dominant source.* [GL2D5]

There was also flexibility for the states and province of Ontario to tighten the limits to suit their own needs.

> *The legal instrument was regulatory in nature. There was a new regulation on P discharges for maximum P concentration that can come from a sewage treatment plant but the province and state can tighten the limits.*[GL2D5]

One key informant noted that Ontario's Environmental Protection Act provided a mechanism to prevent the discharge of a contaminant into the natural environment but this requirement proved difficult to enforce. Lawyers argued that phosphorus is not a contaminant and that a pipe (such as a sewer outfall) that discharged phosphorus into the water should not considered a part of the natural environment. In their words:

> *The lawyers argued that phosphorus is not a contaminant and that a pipe that discharges sewage is not a part of the natural environment. The Ontario Water Resources Act was not helpful for detergents or farmers.* [GL3D5]

There was a consensus from those interviewed that the combination of voluntary and legal measures worked best but that legal measures were vital to the success of the programs. These key informant interviews revealed that adaptive capacity was demonstrated through continuous updating of understanding of all aspects of the nutrient enrichment challenge through allowance for flexibility in the 1972 Great Lakes Water Quality Agreement, through flexibility in adoption of nutrient reduction measures and through flexibility in the mix of legal and voluntary approaches that were used to achieve the nutrient loading target to Lake Erie. Adaptive capacity was demonstrated by the learning that was incorporated into the system to meet the goal of nutrient reduction. In this adaptive system, scientists were among the actors in learning and knowledge generation, a move away from the role of the detached specialist delivering information to management.

7.11.6 Resources

The climate change literature indicates that the availability of resources and its distribution across the population is one determinant of adaptive capacity (IPCC, 2001). In the current study, key informants reported that resource availability was crucial to the successful nutrient reduction of Lake Erie that occurred from the 1960s to the 1990s:

> *The Federal government was the source of the strongest finances. They funded the Canada Centre for Inland Waters (CCIW). It was a real achievement of being able to take on an issue. In 1982 we did it. Five billion dollars ($5B) was spent very quickly to control nutrients by the federal governments. [GL1D6]*
>
> *Resource availability was made through references. States and provinces shared resources for monitoring. Adequate resources at that time allowed for innovation in methods. In the 1960s, we did not have Ministry of Environment to put forward these information collection systems and so it was created. A lot of this went on without the ministry being in Ontario. There was shared funding between the federal government and Ontario. Government provided funding to do research. Both sides did research. Without it, there would have been significant information gaps.* [GL2D6]
>
> *There was a lot more money for monitoring in 1970 and 80s than in the 2000s. Government funded PLUARG with significant money in the 70s and 80s. Funding was vital to the success of the programs and it was readily available in those days.* [GL3D6]
>
> *Resources were essential to a successful outcome.* [GL5D6]

Back in the 1970s, government seemed to have a fair amount of financial resources to put to solving problems and it was easy to justify spending money by saying we can remove this much P if we build a wastewater treatment plant (WWTP). It was easy to justify money once you know you would achieve the removal of P. Technical resources were available; people knew how to build WWTPs. Government provided funds for scientists to conduct research and surveillance and monitoring. Resource allocation was extremely critical. Government committed money and this money was spent and treatment plants built. Resources were critical to the successful outcome. [GL7D6]

We had an active group of modellers collaborating on developing solutions. There was a huge amount of money for monitoring in Lake Erie that was very coordinated. The USEPA was the primary funder for monitoring. Players collaborated. Monitoring and research were funded by USEPA. [GL12D6]

For those on the Canadian side, it was recognized that funding for the Canada-Ontario Agreement on Great Lakes Water Quality (COA) was essential to the execution of programs for nutrient reduction during this period:

In 1971 there was the COA. Canada had to have agreement with Ontario for the protection of the Great Lakes. The COA had provisions for monitoring, surveillance etc. Ontario had to agree to fund part of it and in the mid 80s to late 80s there was a cost sharing agreement between Canada and Ontario for funding of measures in the COA. [GL2D6]

*Scientists were central to what was going on. The first COA in 1971 has dollar amounts on it that the federal government committed to give to Ontario to help municipalities to upgrade STPs. Today's COA will do certain things but there is no dollar transfer. This was critically important for Canada. [*GL4D6]

There was also recognition of the value of foundation support to creating an active advocacy community and helping to foster a sense of community amongst Great Lakes environmental groups:

Foundation support was crucial; The Joyce foundation had been created in mid 1975 and was based in Chicago. The Joyce foundation for years (15 years) was a major supporter of activity of organizations like Lake Michigan Federation – they provided funding that made it possible for citizens to go to Washington DC for annual Great Lakes meetings. [GL6D6]

There was also recognition that human skills, research, advocacy and science were critical to the process and that having adequate financial resources was essential to having those other resources. In addition to having the resources available, the allocation of the resources was 'specific and surgical,' targeted to the programs that would result in the most nutrient reduction (GL8D6), and thus contributed to the successful outcome.

It was also felt that the problem had to be recognized as real for resources to be allocated to the issue:

> *If you acknowledge a problem, government may direct money there. If you say there is no problem, government shuts down. In the 1970s flood at the Grand River, we said there is a problem and there was a ton of money allocated to the Grand River. It completely built up the system to do a better job. During PLUARG, agriculture took a different position. Farmers understood the issue. There was a lot of that information being talked about. A lot of things were done pre-PLUARG. A lot of landscape change. New information was fed to PLUARG. Not as in touch with the public at large. How do you present information is crucial.* [GL11D6]

It is clear from the informant interviews that having adequate resources, strategically allocated, was critical to the successful nutrient reduction of Lake Erie. The availability of resources led to enhanced adaptive capacity by facilitating networking and implementation actions such as monitoring. Funding was essential for the implementation of policy measures such as upgrade of sewage treatment plants, and to support research activities and associated experimentation. Adaptive capacity was facilitated through the distribution of resources to key areas such as networking, scientific research, public meetings and general policy implementation. Adaptive capacity was built through availability of funding for nutrient reduction measures and the willingness of the governments to allocate funding to these measures.

7.12 Discussion

This paper sets out to show that the issue of eutrophication is so complex that it can be considered a wicked problem and as such, needs an adaptive governance approach. The underlying theme is that adaptive capacity improves the ability of governance systems to influence positive responses in institutional components for building resiliency to stressors such as nutrient enrichment. The climate change literature has proposed a number of characteristics and determinants of adaptive capacity (Folke et al., 2005; IPCC, 2001; Engle 2010), including resources, knowledge, equity, leadership, and cooperation. However, this concept has not been extended to the field of eutrophication; this is where this paper makes its contribution. Further, this paper introduces a framework to characterize and foster determinants of adaptive capacity, in order to help decision makers in a meaningful set of choices to aid with the implementation of the Great Lakes Water Quality Protocol 2012 (the Protocol).

One of the questions this study asks is 'what are the determinants of adaptive capacity for eutrophication governance?' This question was answered first by seeking the determinants of adaptive capacity in the literature that were relevant to the Protocol in order to develop a framework for assessing the presence of adaptive capacity. Since adaptive capacity is latent in nature and thus is more readily measured once realized, this study sought to assess the presence of these determinants in a case where adaptive capacity in eutrophication was displayed: the case of Lake Erie, which went from severe eutrophication in the 1960s to a significant nutrient reduction in 1990s. A series of key informant interviews served to provide key data to validate these determinants. This study, far from providing all the answers to eutrophication governance, does however clearly point to a number of key findings.

The determinants of adaptive capacity as elucidated from the literature are crucial for fostering adaptive capacity and were present during the period of significant change for Lake Erie. There was significant public participation through IJC meetings, through demonstrations, and in other forums. Science was central to demonstrating that phosphorus was the limiting nutrient for eutrophication in Lake Erie. There were strong networks amongst the epistemic community, especially amongst the NGOs who created a sense of community that was critical to successful nutrient reduction. Learning was incorporated into the system as new information was produced and there was extensive monitoring and system feedback. There was clear leadership by the IJC, government organizations and key individuals and there were adequate resources that were vital to the success of all programs for effective nutrient reduction.

Having identified that these determinants are crucial to build adaptive capacity for eutrophication governance, a logical question is how present these determinants are now in the Lake Erie context, and what gaps can decision makers address. One key informant believes that the complexity of the situation today needs to be understood by the decision makers, that they need to understand the complexities of this wicked problem:

> *We are starting to understand the concept of multiple stressors. It used to be that if we control P we control eutrophication. It now has to do with invasive species, climate change and nutrients; now we have to transition away from the simple solution of the 1970s. We have to take a new approach. We know the approach of dealing with each issue separately; we need to get into multiple stressors, which is more complicated than we thought.* [GL1D7]

There is a definite gap in the resources available for the current eutrophication governance of Lake Erie. This was clearly expressed by several of the key informants:

> *We have a huge resource gap; we don't have the people and money to do this. When the economy tanks, environment spending crashes.* [GL2D8]

> *We had a lot more money for monitoring in the 1970 and 80s than in the 2000s.* [GL3D8]

> *Funding has been drastically cut. We used to get $1M per year in the 1970s but now less than $100 000 per year in 2014. Resources were incredibly important – I would also say they were better coordinated in those days than today.* [GL12D8]

> *There has been a cutback in the amount of funding government provides to support scientists, research and routine monitoring. Government has to scramble to start over again to return people to develop scientific capability.*[GL7D8]

This cutback in funding and lack of resources has important implications for eutrophication governance. The ability to do vital monitoring of ecosystem responses presents feedback loops that are essential for learning and building of adaptive capacity. Informants note that resources are simply not as available as they were during the 80s and 90s.

The interviews revealed that political leadership was paramount to the achievement of the objectives for building adaptive capacity for eutrophication governance. With strong political leadership there is more allocation of funding for environmental programs. It therefore becomes clear that the political framework within which eutrophication governance takes place needs to be adaptive to embrace large-scale and long-term changes and the increasing uncertainty of an issue like eutrophication. In the current context, key gaps that were identified for building adaptive capacity therefore included leadership, resources and flexibility.

This research does not intend to suggest that there exists a magic formula to ensure that key stakeholders govern to combat eutrophication. Simply put, what is required is the fostering of conditions that allow the determinants of adaptive capacity for eutrophication governance to be present. This means that the public should actively be allowed to participate through having a voice in decision making processes; that science and monitoring should be continued so that informed decisions are made and that feedback loops can be operationalized and adjusted to achieve sustainable nutrient reductions; and that there needs to be clear political and other leadership. In addition, it may be appropriate to empower the IJC to carry out is third party observer function, a role that was crucial to the successful nutrient reduction that occurred in Lake Erie in the 1990s. What is required is a different understanding of governance, one that emphasizes adaptability rather than command and control as this would not work in the highly complex, uncertain environment of eutrophication today.

7.13 Conclusion

This paper proposed and validated a number of determinants for adaptive capacity for eutrophication governance for the Great Lakes. The eutrophication of Lake Erie has all the markings of a wicked problem and as such, an adaptive governance approach is recommended. The framework was validated by application to the case of a severely eutrophic Great Lake that went from severe nutrient enrichment in the 1960s to significant nutrient reduction in the 1990s. The results demonstrate that all of the determinants of adaptive capacity – public participation, science, networks, leadership, flexibility and resources – were essential to the successful nutrient reduction of Lake Erie that occurred from the 1960s to the 1990s. This research informs the current eutrophication governance of Lake Erie by showing that there are significant gaps in funding, monitoring and leadership and that successful nutrient management as stipulated in Annex 4 of the Great Lakes Water Quality Agreement is more likely if these gaps are bridged.

7.14 References

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Chapter 8

Eutrophication governance in Chesapeake Bay and the Baltic Sea: A comparison of the determinants of adaptive capacity

Savitri Jetoo and Gail Krantzberg

Abstract: This paper compares the determinants of adaptive capacity of water governance regimes to respond to the stressor of nutrient enrichment in Chesapeake Bay of the United States and the Baltic Sea in Europe. Both regions are in a highly developed world context and both water bodies experience severe eutrophication, with nutrient sources from sewage treatment plant discharges, airborne transport and from agricultural activities. Chesapeake Bay and the Baltic Sea represent two multijurisdictional watersheds that are highly populated with significant anthropogenic stressors. While there are many similarities between these regions, there are also differences due to their different governance, geographic and political contexts. This research examines eutrophication governance in both systems with the aim of determining differences in the determinants of adaptive capacity. This comparison is based document analysis and on key informant interviews with experts involved in nutrient governance. As a result of this study, conclusions are drawn about adaptive capacity, based on six determinants: public participation, science, networks, leadership, flexibility and resources. The results of this research highlight gaps in determinants, and will therefore be useful for decision makers in tackling the issue of eutrophication.

Key Words: Eutrophication, governance, adaptive capacity, Chesapeake Bay, Baltic Sea, nutrient enrichment

8.1 Introduction

The Millennium ecosystem assessment (MEA) found that water pollution is increasingly impacting marine environments throughout the world. The MEA reported that the issue of nutrient enrichment is a particularly acute one and is increasing, due to population growth and our increasing cumulative impact on the environment through activities such as urbanization, farming, discharge of sewage treatment etc. (Howarth and Ramakrishna, 2005) Nutrient enrichment or eutrophication of water bodies is a rapidly increasing environmental crisis, with over 500 coastal areas impacted by eutrophication worldwide (WRI, 2015). The extent of global eutrophication is shown in Figure 8.1 (WRI, 2015):

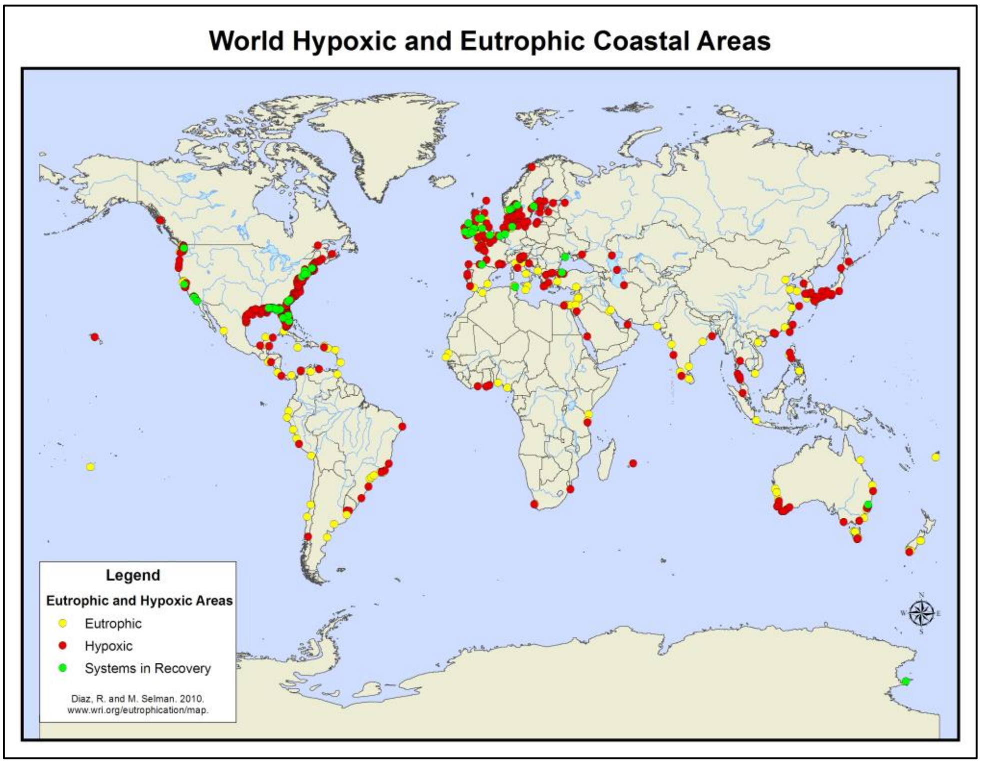

Figure 8.1-Eutrophication of Water Bodies worldwide (WRI, 2015)

Figure 1 also illustrates findings of coastal surveys in the United States and Europe, which found that 78% of the assessed (area that was studied) continental US and 65% of Europe's Atlantic coasts are under the effects of eutrophication (Bricker et al., 2007; OSPAR Commission, 2003). It is widely reported and accepted in the literature that the eutrophication of freshwater and marine ecosystems is a result of human activities (see for example Kemp et al., 2005; Mee, 2006; Diaz, 2007; HELCOM, 2009; Michalak et al., 2013). It is also clear that the problem will continue to increase as a result of increasing trends in population growth, increasing area of cultivated land, urbanization, sewage treatment disposal and energy use. These activities have almost doubled the flow of nutrients, nitrogen (N) and phosphorus (P) (Howarth and Ramakrishna, 2005), which causes eutrophication and other associated challenges such as growth of harmful algal blooms (HABs). The decomposition process of HABs consumes oxygen and results in hypoxia (oxygen depleted waters).

Harmful algal blooms (HABs) can be detrimental to human health through associated toxins that can enter drinking water (Jetoo et al., 2015) and through shellfish poisoning; they can also cause death of fish, other marine animals and shore birds (Anderson et al., 2002). Harmful algal blooms in Toledo, Ohio, resulted in the shut off of drinking water supply to over 500 000 persons in August 2014 (Jetoo et al., 2015). These algal blooms also lead to hypoxia, which has increased from 10 documented cases in 1960 to at least 169 in 2007 (Diaz et al., 2004). The largest documented dead zone in the world existed in the Black Sea where eutrophication and hypoxia were associated with stimulation of agriculture in the former Soviet Union; this dead zone caused the collapse of a number of fish species, from 26 commercially viable fish species in the 1960s to only five in the 1980s (Europe Now/Next, 2008). There are also well-documented hypoxic dead zones in Chesapeake Bay (Kemp et al., 2005) and the Baltic Sea (HELCOM, 2009).

The drivers of eutrophication are clear and are expected to increase with an increase in world population, from a current 7 billion to a projected 9.2 billion by 2050 (Bongaarts, 2009). If sources are not addressed, this population increase will result in increased nutrient enrichment of water bodies through increased production pressures on agriculture and industry and through increased urbanization and associated sewage effluent discharges to water. According to the MEA, sewage contributes to 12% of nitrogen input to rivers in the United States, 25% in Western Europe, 33% in China and 68% in the Republic of Korea (Howarth and Ramakrishna, 2005).

For both the Baltic Sea and Chesapeake Bay, the largest sources of nutrients are from agricultural operations, through nutrient from fertilizer runoff from fields, manure leaching from concentrated animal feeding operations (CAFOs) and aquaculture. According to the MEA, worldwide use of phosphorus increased more than 300% during the period 1960-1990, while the use of synthetic nitrogen fertilizer increased more than 700% (Howarth and Ramakrishna, 2005). The increase in farming operations is driven by changing dietary patterns with the FAO (2002) predicting that global meat consumption will increase by 54% from 2002 to 2030. For example, in China there was a 127% increase in meat production between 1990 and 2002, but less than 10% of livestock operations had installed pollution prevention measures (Ellis, 2007). Another significant source of nutrients in the agricultural sector is from aquaculture operations. On average, aquaculture operations that produce a ton of fish generate 42-66 kgs of nitrogen waste and 7.2 to 10.5 kg of phosphorus waste (Strain and Hargrave, 2005). Worldwide aquaculture production increased 600% from 1985 to 2005, from 8 million tonnes to 48.million tonnes (FAO, 2007). According to the FAO (2014), food fish supply (with an annual growth of 3.2%) has outpaced world population growth (annual growth of 1.6%), while world per capita fish consumption increased from an average of 9.9 kg to 19.2 kg from the 1960s to 2012.

The burning of fossil fuels contributes to significant emissions of nutrients into the aquatic environment, for instance through the release of nitrogen oxide which is transported to water through rain and snow. According to the MEA, combustion of fossil fuels contributes approximately one fifth (22 teragrams per year) of the global contribution of pollution attributable to synthetic nitrogen fertilizers (Howarth and Ramakrishna, 2005). In both Chesapeake Bay (EPA, 2014) and the Baltic Sea (HELCOM, 2005), atmospheric deposition is believed to contribute 25% of all nitrogen input (HELCOM, 2005). This contribution can be expected to increase over the coming decades: it is projected that per capita energy consumption will increase by 33% between 2010 and 2040 (from 87 MMbbl/day to 119 MMbbl/day) and the total worldwide energy consumption will increase by 36% during the same period (EIA, 2014).

While the scientific community is increasing its knowledge of the causes of eutrophication, there are also key complexities and uncertainties that are not yet understood by science. An example is the long-term consequences of nutrient fluxes for an aquatic ecosystem, and the effects of climate change and aquatic invasive species such as zebra mussels on those fluxes. For example, an extensive cyanobacteria algal bloom in Lake Erie in 2011 was found to be caused by a combination of nutrient management trends and extreme weather associated with climate change (Michalak et al., 2013). As result, the uncertainties associated with climate change have now become an important consideration in eutrophication governance. The extent to which the 2011 bloom is predictive of future conditions would depend on whether changes are made in agricultural practices and what climate conditions exist in the future. Additionally, in marine ecosystems where the residence time is long, such as Chesapeake Bay and the Baltic Sea, it is difficult to trace the reduction of non point sources of nutrients to ecosystem recovery, as the response time between action and result can take many years (Scavia et al., 2014). These conditions make eutrophication a “wicked problem”, one where the causes and solutions are not clear-cut (Xiang, 2013). As such, eutrophication requires a new, adaptive governance approach (Mee, 2005; HELCOM, 2010; Michalak et al., 2013). Jetoo and Krantzberg (2015) argue that because eutrophication is a wicked problem, the concept of adaptive capacity can be used for eutrophication governance and present a framework for assessing determinants of adaptive capacity for eutrophication governance. This paper uses that framework to assess the determinants of adaptive capacity for eutrophication governance in Chesapeake Bay and the Baltic Sea. The aim of the work is identify successful strategies and gaps, to inform governance of eutrophication of these water bodies.

8.2 The Case Studies: Chesapeake Bay and the Baltic Sea

The two case study areas, Chesapeake Bay (CB) of the United States and the Baltic Sea (BS) in northern Europe embody two large, multi-jurisdictional water bodies in a developed world context. The two systems face similar challenges of nutrient pollution from non point sources including agriculture, atmospheric deposition and nutrient pollution from point sources including discharges from sewage treatment plants (STP) and combined sewer overflows (CSOs). The following section introduces each water body in more detail.

8.2.1 Chesapeake Bay

Chesapeake Bay is the largest estuary in the United States, with a watershed that spans 64 000 square miles from the state of New York to the state of Virginia (see Figure 8.2), and includes the District of Columbia and the states of Delaware, Maryland, Pennsylvania and West Virginia (Chesapeake Bay Program, 2014). This watershed covers 11 684 miles of shoreline, 150 major rivers and streams. The main source of fresh water (50%) to the Bay is the Susquehanna River; other big rivers include the Potomac and James Rivers (Chesapeake Bay Program, 2014). According to the Chesapeake Bay Program, the depth of the Bay varies from 5 feet to 174 feet, with an average of 21 feet and the salinity varies from 0.5 parts per thousand where freshwater organisms can live to 36 parts per thousand near the mouth of the Bay. As is characteristic of a temperate estuary, the temperature varies from an average of 5^{o} C in winter to a summer average of 25.5^{o} C. Chesapeake Bay is one of the most productive estuaries in the world, with more than 3600 species of plants, fish and wildlife; its watershed is also home to 17 million people who live, drink the water, and enjoy recreational opportunities there (GAO, 2011).

However, like most estuaries in the world, the Chesapeake Bay ecosystem has deteriorated over time. According to the MEA, temperate estuaries (including Chesapeake Bay) experienced major damage before 1980 from nutrient overloading, toxic contaminants from industry, habitat loss from increasing development and population, alteration in flow regimes and proliferation of invasive species (Millennium Ecosystem Assessment, 2005). For most of the 20th century, public focus in Chesapeake Bay was directed at overharvesting of oysters and other fisheries, infectious waters, wetland loss, channel dredging and spoil disposal, and power plant effects (Davidson et al., 1997). It was not until the last quarter of the century, when marine eutrophication was beginning to emerge around the world (Nixon, 1995), that there was awareness that eutrophication had degraded the Bay ecosystem (Malone et al., 1996). Population growth and concomitant development are further stressors to the system. The population of the Chesapeake Bay watershed has doubled since 1950, and it is expected that the population will grow by an additional million persons every decade with a projected population of 20 million by 2030 (EPA, 2010). As with the Baltic Sea region, this increasing population results in more development, including paving of open spaces and increased sedimentation. Both of these factors are known to impair water quality. Urbanized areas tend to have a high proportion of impervious surface, so that polluted stormwater runoff is carried rapidly through storm sewers to receiving waters rather than infiltrating slowly into the land surface. Elevated sediment concentration in surface waters can affect the gill function of aquatic organisms, alter fish spawning habitat, and prevent light from penetrating to underwater grasses.

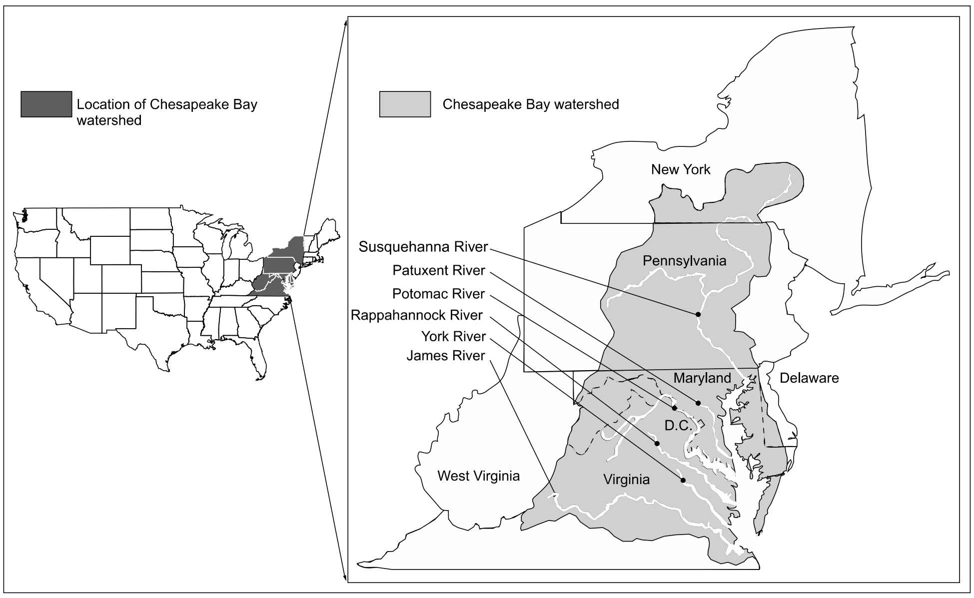

Figure 8.2 – The Chesapeake Bay Watershed (GAO, 2011)

8.2.1.1 Eutrophication of Chesapeake Bay

Chesapeake Bay is naturally susceptible to eutrophication given its large watershed to volume ratio, its seasonally stratified water mass and the isolation of its basins (Boesch et al., 2001). Paleo-ecological assessments of sediments from Chesapeake Bay reveal that the challenges of eutrophication and anoxia can be dated back to 250-300 years ago. Since the 1940s in particular, there have been rapid changes in key biomarkers such as pollen, diatoms, nutrient ratios etc. during the 1940s that are directly linked to cultural eutrophication (Cooper and Brush, 1993). There is a lot of focus on eutrophication of Chesapeake Bay in the literature (Cooper and Brush, 1993; Cornwell et al., 1996; Boesch et al., 2001; Hagy et al., 2004; Kemp et al., 2005; Cerco and Noel, 2007). According to the National Research Council (2011), agricultural operations contribute 38% of total nitrogen load to Chesapeake Bay, compared to 19% from municipal and industrial point sources. Similarly, agricultural operations contribute 45% of the total phosphorus load, compared to 21% from municipal and industrial point sources. Despite the growing population in the Chesapeake Bay region, there has been some progress in reducing nutrient inputs through a ban in phosphate detergents and sewage treatment plant upgrades (Figure 8.3). Figure 8.4 illustrates the levels of dissolved oxygen in 2005 in Chesapeake Bay during the summer of 2005 (US Global Climate Change Report, 2009); the report describes hypoxic water as waters with 1-3 mg/L dissolved oxygen while anoxic waters have less than 1 mg/L.

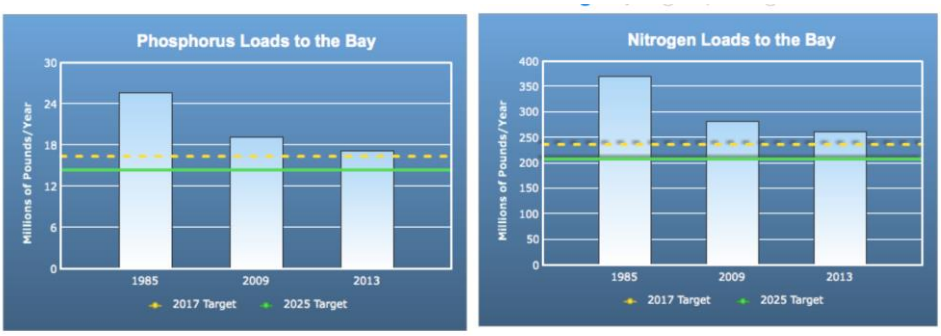

Figure 8.3 - Nutrient loading to Chesapeake Bay (Chesapeake Bay Program, 2015)

Cultural eutrophication of Chesapeake Bay has been detrimental to sustainability, causing economic, social and environmental problems including harmful algal blooms (Hagy et al., 2004, Kemp et al., 2005), hypoxia and anoxia in deep waters during summer (Hagy et al., 2004) and the consequent loss of submerged aquatic vegetation. These conditions have resulted in decreased recreational activities and alteration of the food web.

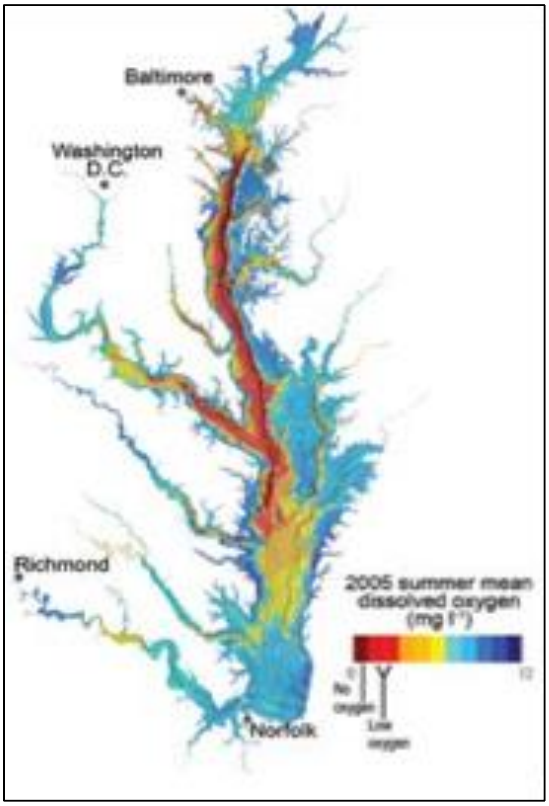

Figure 8.4 - Dead Zones in Chesapeake Bay (US Climate Change Report, 2009)

8.2.1.2 Eutrophication Governance of Chesapeake Bay

While the Chesapeake Bay ecosystem faces a welter of problems, it has also benefited from restoration actions originating as early as the 1930s. The Chesapeake Bay Program was established through a directive from Congress to the EPA to restore the Bay and to determine which units of government should have management responsibility and to determine a governance structure (Hennessey, 1994), and is therefore the principal governance framework for Chesapeake Bay. The governance of the Bay is highly decentralized, with authority given by the EPA to states for management actions. Some of the key efforts to restore Chesapeake Bay over the last 35 years are as follows (GAO, 2011); see Figure 8.5:

1. 1980 – The Chesapeake Bay Commission was formed by Maryland and Virginia (and later joined by Pennsylvania in 1985) to help the states to manage the Bay by serving as an advisory body to the state legislature and as a liaison to Congress (Chesapeake Bay Commission, 2014).
2. 1983 – The Chair of the Chesapeake Bay Commission, along with Maryland, Virginia, Pennsylvania, the District of Columbia and the EPA, signed the first Chesapeake Bay Agreement to formalize the Chesapeake Bay Program. The Agreement was a one-page document that established the Bay's liaison office in Maryland and recognized that a cooperative approach was needed to restore the Bay. The partners reaffirmed their commitment to restore the Bay in 1987 by

setting a target of 40% reduction in nitrogen and phosphorus loads. Under the 1992 Amendment, the partners further agreed to tackle nutrients at the source in the Bay Rivers (Chesapeake Bay Program, 2014).

3. 2000 – The signatories to the Chesapeake Bay Agreement signed a renewed agreement in 2000, outlining a vision and strategy to guide restoration until 2010. This “Chesapeake 2000” was the first version to put an emphasis on ecosystem based fisheries management and included 102 restoration goals. The headwater states, Delaware, New York and West Virginia, later committed to working cooperatively to achieve the goals of this agreement through a memorandum of understanding (Chesapeake Bay Program, 2014).
4. 2000 – Congress passed the Estuaries and Clean Waters Act, which directed the EPA to coordinate the Chesapeake Bay Program and assist with implementation of the Chesapeake 2000 Agreement. The Clean Waters Act also required that other federal agencies with facilities in the Bay watershed participate in the restoration efforts.
5. 2009 – Executive Order 13508 for the protection of Chesapeake Bay was signed by President Barack Obama on May 15, 2009. It recognized Chesapeake Bay as a national treasure and placed the federal government as the leader in restoration of the Bay and its watershed by establishing a Federal Leadership Committee to oversee the development and coordination of reporting, data management and restoration activities (Chesapeake Bay Executive Order, 2014).
6. 2010 – The Federal Strategy for Protecting and Restoring Chesapeake Bay Watershed was released as part of the requirement under the Executive Order. The strategy includes regulations to restore clean water, implementation of new conservation practices on 4 million acres of agricultural land, conservation of 2 million acres of undeveloped land and rebuilding the oyster fishery in 20 of the Bay’s tributaries. The strategy includes two-year milestones that will help in assessing progress toward reaching goals. Through the strategy, the EPA will implement a Chesapeake total maximum daily load (TMDL) – essentially a clean water blueprint; it will also expand regulations for storm water and animal feeding operations and increase funding for state regulatory programs. The US Department of Agriculture (USDA) will also work with farmers and forest owners by providing resources to prevent soil erosion and reduce loadings of phosphorus and nitrogen to the Bay. The strategy requires the USDA to develop a watershed scale environmental services market for trading water quality credits in return for the adoption of effective conservation practices (Chesapeake Bay Executive Order, 2014). The Chesapeake Bay states signed the

Chesapeake Bay Watershed Agreement in 2014 to recommit to Chesapeake Bay program partnership efforts.

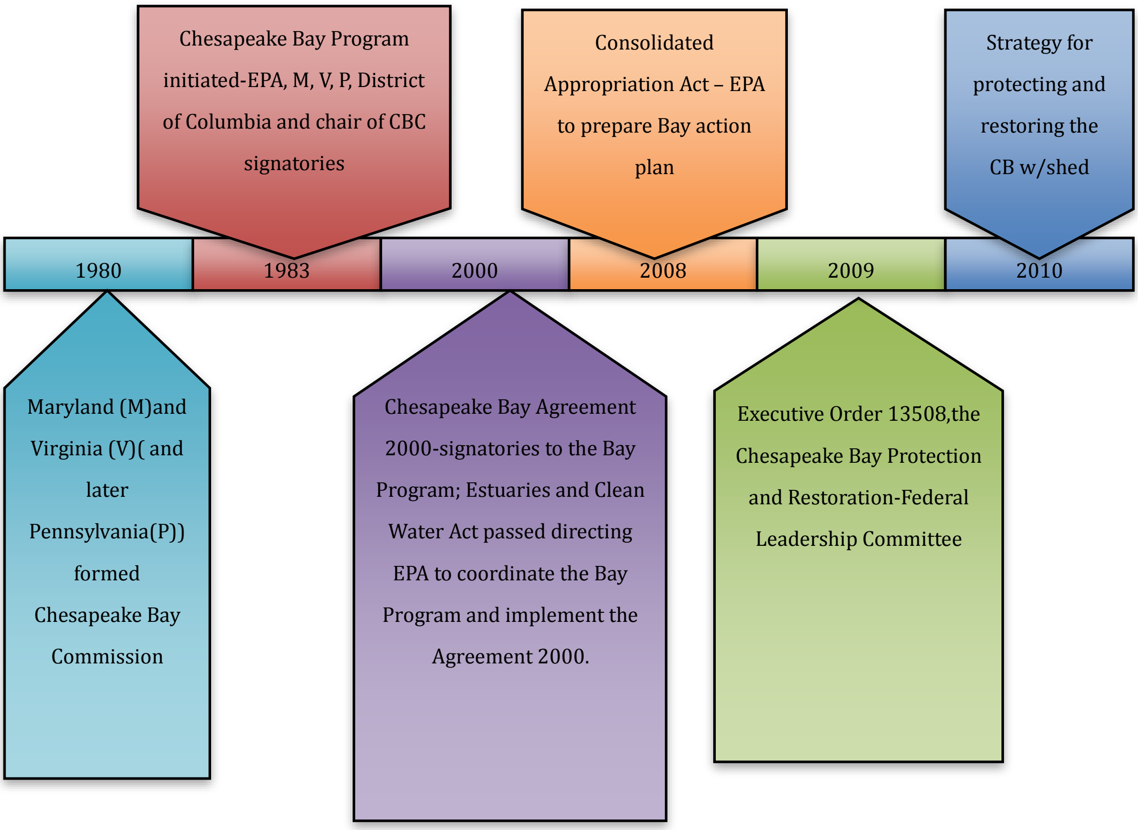

Figure 8.5- Key milestones in CB protection

The 1987 reaffirmation of the restoration of the Bay by the partners to reduce nitrogen (N) and phosphorus (P) by 40% by the year 2000 was made with incomplete information on the causes and effects of eutrophication (Pionke et al., 2000). In 2001, Boesch (2001) reported on findings from more recent research, monitoring, and modeling, including:

(i) the estuarine ecosystem had been substantially altered by increased loadings of N and P of approximately 7- and 18-fold, respectively from the 1950s to the 1980s;

(ii) hypoxia in the Bay has increased substantially since the 1950s;

(iii) eutrophication was the major cause of reductions in submerged vegetation, because of increased turbidity,and light attenuation at depth; and

(iv) reducing nutrient sources by 40% would improve water quality, but to a lesser degree than originally thought.

Despite these findings, it seems that the overall health of Chesapeake Bay improved between 2006 and 2013. The University of Maryland’s Centre for Environmental Science (2014) rated Chesapeake Bay’s health at 45% in 2013, an improvement over its rating of similar factors (water clarity, chlorophyll a, dissolved oxygen, presence of aquatic grasses, composition of the benthic community, total nitrogen, and total phosphorus) in 2006 of 39%. According to the Bay Barometer (Chesapeake Bay Program, 2014), during the period 2009-2013, political commitment and the support of the public have allowed for the reduction of 20 million pounds of N, 2 million pounds of P and 500 million pounds of sediment. However, these numbers represent a 7% reduction in nitrogen loads (27% of target), 11% reduction in phosphorus loads (43% of target) and a 6% reduction in sediment loads (37% of target). In their commentary on these findings, the Chesapeake Bay program recognized that nutrient reductions from non point sources such as urban streets, farm field and online septic systems have proved challenging to control.

8.2.2 The Baltic Sea

The Baltic Sea is the largest expanse of brackish water in the world and is a multinational water body, shared by Denmark, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland and Germany (Encyclopaedia Brittanica, 2015). It is the only inland sea that is entirely within Europe and is divided into several sub-regions (Figure 8.6): (1) the Baltic Proper (Arkona Basin, Bornholm Basin, western and eastern Gotland Basin, Gdansk Deep, Northern Baltic Proper), (2) the Gulf of Bothnia, comprising the Bothnian Sea and the Bothnian Bay, (3) the Gulf of Finland, (4) the Gulf of Riga, and (5) the Danish Straits, including the Belt Sea, and (6) the Kattegat area (HELCOM, 2009). The average depth of the Baltic Sea is 52m, the volume is 21,700 km3 and surface area is 415, 200km^2 (Encyclopedia Brittanica, 2015).

Figure 3.6 - The Baltic Sea Watershed (HELCOM, 2009)

The physical properties of the Baltic Sea, such as temperature, ice cover and salinity, vary with each sub-basin. According to HELCOM (2009) the salinity decreases from 20-25 practical salinity units (psu) in the Southern Kattegat, to

6-8 psu in Central Baltic proper to a low of below 1 in the northern and eastern tips of Bothnian Bay and Gulf of Finland. This makes the Baltic Sea system species-poor with few functional ecological groups (Bonsdorff and Pearson, 1999).

This transnational sea is home to 16 million persons on or near the coast and 85 million within the catchment area (HELCOM, 2009). The combination of a large catchment area and a large population means that anthropogenic stressors to the sea have a large impact. It is not predicted that the watershed population will increase significantly in the coming decades, but the pressure on coastal areas may still increase through migration and urbanization (UNEP, 2005). Nutrient loadings enter the Bothnian Bay from a well-developed agricultural sector and emissions from energy and transport, and have in turn resulted in eutrophication challenges in the Baltic Sea.

8.2.2.1 Eutrophication of the Baltic Sea

Eutrophication of the Baltic Sea can be dated back to the 1960s, when oxygen deficiency in the Baltic Proper was linked to the consequences of human activities (Jansson 1997; Elmgren, 2001). This human-induced nutrient enrichment of the Baltic Sea has been documented as one of top threats to its ecosystem (UNEP, 2005) and has been well researched and documented extensively in the literature (see for example Larsson et al., 1985; Jansson, 1997; Elmgren, 2001; Fonselius and Valderrama 2003; HELCOM, 2009; Savchuk et al. 2008). The consequences of this nutrient enrichment include increased algae blooms in summer (HELCOM, 2009) and more regions experiencing hypoxia (Figure 8.7), so that they are unable to sustain life and lead to 'dead zones' (Conley et al., 2009). According to Diaz and Rosenberg (2008) the Baltic Sea has the largest anthropogenic dead zone in the world. There have been reports of record hypoxic zones as large as 60 000 km^2, much above the long term average of 42 000km^2 (HELCOM, 2009) (Figure 8.7).

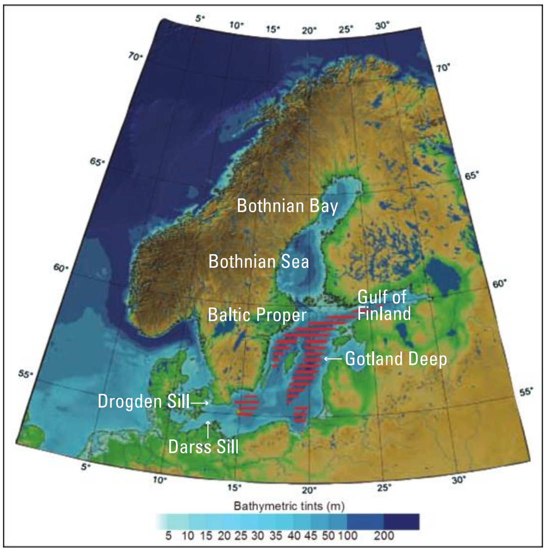

Figure 8.7 - Map of Baltic Sea showing hypoxic areas (red lines) (Conley et al., 2009)

During the 20th century, total phosphorus loads into the Baltic Sea increased eight fold while nitrogen loads increased four fold (Larsson et al., 1985), contributing to its extensive eutrophication (Figure 8.8). As Figure 8.8 shows, there are large variations in area-specific loadings of nutrients, leading to variations in eutrophication throughout the Baltic Sea. The main sources of nutrients are from agriculture, industries, aquaculture, municipal sewage discharges, river discharges and erosion, atmospheric deposition and nitrogen fixation (Wassmann and Olli, 2005). This combination of climatic conditions and changed trophic levels have caused concerns that the Baltic ecosystem is being pushed to its natural limits (Gustafsson et al.,2012)

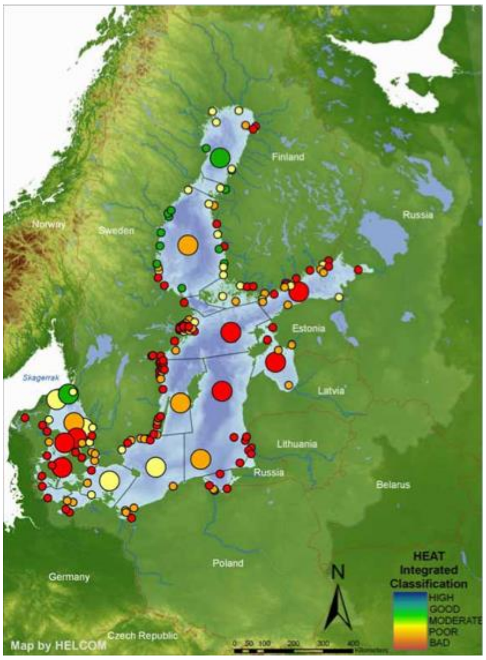

Figure 8.8-HELCOM eutrophication assessment tool (HELCOM, 2009)

8.2.2.2 Eutrophication Governance of the Baltic Sea

The governance of eutrophication of the Baltic Sea is highly complex because it is a common pool resource shared by nine littoral countries: Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland, Sweden and Denmark. All of these countries, with the exception of Russia, are part of the European Union and thus are contracting parties to several European Union Agreements relevant to the Baltic Sea. In 1991, the first EU regulations for the control of nutrient discharges into water bodies were adopted. These were the Urban Wastewater Treatment Directive (UWWTD) and the Nitrates Directive (ND) (Schumacher, 2011), which stipulate standards for sewage treatment and farming practices respectively. The EU provides guidance for airborne nutrients through the National Emission Ceilings Directive (NCED), which was adopted in 2001. There are also economic instruments for nutrient reduction, such as the Common Agricultural Policy (CAP) through which farmers are paid for best management practices that lead to prevention of nutrient releases into the waterways. The EU water framework directive was implemented in 2000, with the aim of attaining 'good ecological status' of European surface waters and groundwater by 2015. There is also the Marine Strategy Framework Directive for marine waters, which aims to achieve or maintain good ecological status in the marine environment by 2020. While the

EU has taken the lead on the development of policy for eutrophication for its member states, individual member states were given freedom to develop implementation plans taking into account each country's unique situation and perspectives. There are also international agreements for the prevention of eutrophication for the Baltic Sea such as the MARPOL 1973/1978 International Convention for Prevention of Pollution from Ships and the 1974/1992 Helsinki Convention (HELCOM). The governance framework for the Baltic Sea was established in 1974 with the signing of the macro-regional Helsinki Convention on the Protection of the Marine Environment (Rasanen and Laakkonen, 2008) and includes Russia in addition to EU member states. HELCOM has evolved into a manifold governance system through which programs such as the Baltic Sea Action Plan (BSAP), for Baltic Sea Protection are signed onto (in 2007) by members. All these HELCOM agreements are non-binding. This lack of binding supranational legislation for the protection of the Baltic Sea as a whole makes eutrophication governance challenging and very dependent on the cooperative efforts of the EU and a variety of international agreements.

The governance systems of the Baltic Sea Region can best be described as multi-level, with various bilateral, regional and international efforts aimed at protecting and improving the environment. One of the key challenges of this multilevel governance is the multitude of actors involved. In addition to the nine littoral countries, there are five additional countries in the watershed: Czech Republic, Slovak Republic, Ukraine, Belarus and Norway, which mean additional stakeholders in land and watershed management. There are also three policy levels: international (e.g., MARPOL), regional (e.g., HELCOM) and national, with governmental, non-governmental, industry and public interest groups involved, with each having a different interest and stake in eutrophication governance. The eutrophication governance of the Baltic Sea is made even more challenging as there is no legal mechanism that encompasses all the coastal and catchment area countries (Pihlajamäki and Tynkkynen, 2011).

Each of the countries on the Baltic Sea watershed and coast has tailored national water and marine policies for the Baltic Sea to suit their locality. This national level of Baltic Sea protection therefore reflects the capacity, funding and experience of each country's environmental administration (Schumacher, 2011), rather than the extent to which that country contributes nutrients to the waters. This makes eutrophication governance even more challenging. For example, Poland and Russia are the biggest sources of waterborne phosphorus and nitrogen (Figure 8.9), yet none of the EU policies include Russia and these countries are not given stricter guidelines or more ambitious targets than other nations.

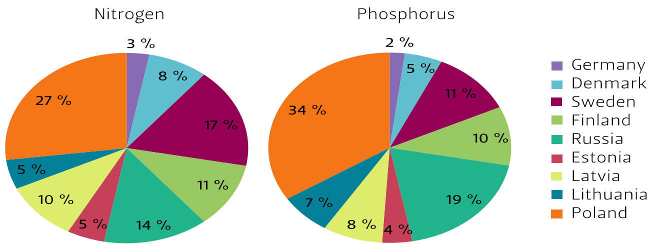

Figure 8.4-Baltic Coastal countries contribution to waterborne nitrogen and phosphorus (HELCOM, 2009

8.3 Methodology

This research uses the concept of adaptive capacity for eutrophication governance to assess the ability of Chesapeake Bay and the Baltic Sea to cope with the stressor of nutrient enrichment. As used in this study, adaptive capacity refers to the ability of Chesapeake Bay and the Baltic Sea to adjust to changing internal demands and external circumstances due to nutrient enrichment (after Carpenter and Brock, 2008). In a governance context, adaptive capacity refers to the ability of stakeholders to respond to variability and change in the state of the system, requiring them to proactively plan for longer term stressors while at the same time coping with current shocks to the system (Adger et al., 2005; Tompkins and Adger, 2005). The concept of adaptive capacity was first advanced in the climate change and resiliency literature (IPCC, 2001; IPCC, 2007; Adger et al., 2005; Tompkins and Adger, 2005), where resiliency adaptive capacity is seen as the ability of social-ecological systems to tolerate disturbances while retaining the core function and purpose (Carpenter and Brock, 2008). While the concept has only been used in the context of climate change, Jetoo and Krantzberg (2015) extended the concept to eutrophication governance, arguing that by virtue of eutrophication being a wicked problem due its complex and uncertain interactions with climate change, adaptive governance and adaptive capacity are particularly relevant. Jetoo and Krantzberg (2015) further developed a framework to assess adaptive capacity for eutrophication governance. This framework uses the six determinants proposed in that framework, **public participation, science, networks, leadership, flexibility and resources,** to assess the adaptive capacity of the governance regimes for the stressor of eutrophication.

This research applies the framework to the cases of Chesapeake Bay and the Baltic Sea to explore adaptive behavior within the context of eutrophication governance. This was a qualitative study in which data was collected through structured interviews with key informants, following

Harding (2013). The key informants were identified as municipal, academic, local and regional stakeholders in water governance in both regions. A total of twenty key informant interviews were conducted in person in Chesapeake Bay and in the Baltic Sea Region, all using a standardized questionnaire. A few interviews were conducted over the telephone where a face-to-face meeting proved impractical. These interviews were recorded and transcribed in Microsoft Word and then coded using the data analysis software Nvivo 10 for Mac, a computer program designed to help in the organization of data associated with qualitative research methods such as interviews. Thematic coding was used to sort the content of the interviews and spot emerging themes in the data. As described by Harding (2013), content analysis refers to the counting of references to key themes or ideas in many forms of qualitative data. The use of computer software helped to organize the data so as to easily identify evidence for the determinants of adaptive capacity in both cases.

8.4 Results

This section presents evidence on the presence of determinants of adaptive capacity in Chesapeake Bay and the Baltic Sea Regions. The results of the analysis support assessment of adaptive capacity for eutrophication governance.

8.4.1 Public Participation

Public participation had different qualities in the context of Chesapeake Bay and the Baltic Sea. The public is given a role and a permanent seat on the Chesapeake Bay Program in the form of the Citizen’s advisory committee (Chesapeake Bay Program, 2015), while for HELCOM (2015) there is no allocated seat for a citizen representative (Figure 8.10). Indeed, the public has been giving input to the Chesapeake Bay Program since 1977, when a Citizens’ Advisory Committee was created as one of the Program’s three advisory committees (Hennessey, 1994). According to the Chesapeake Executive Council Citizens’ Advisory Committee (CAC) bylaws, the purpose of the CAC is to ‘represent residents and stakeholders of the Chesapeake Bay Watershed in the restoration effort’ (Chesapeake Bay Program, 2015).

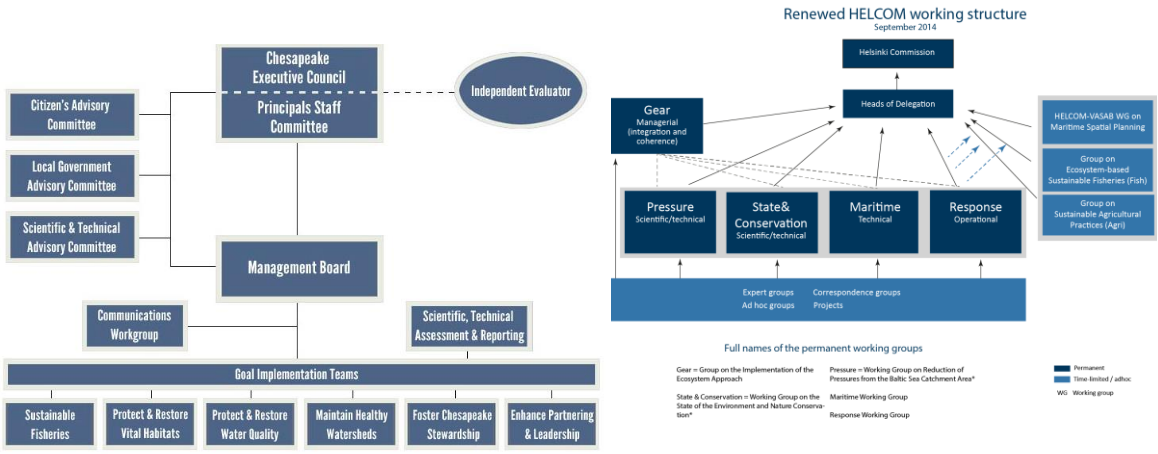

Figure 8.5 - Governance structure of Chesapeake Bay Program (2015) and HELCOM (2015)

The document goes on specify that the CAC will be able to achieve this purpose through providing advice and input to the Chesapeake Executive Council, through input on watershed restoration, through discussion of issues via quarterly meetings, through information sharing, through contribution to the work of the Chesapeake Bay Program (CBP) and through engaging decision makers external to the CBP to help in their stewardship actions of the Bay. One of the challenges for effective participation of the public in the Chesapeake Bay program is the limited number of public participants; there are 25 currently listed members of the CAC representing a total watershed population of eighteen million persons in 2014 (Chesapeake Bay Program, 2015). While there may be other mechanisms for the public to have input through the environmental impact assessment for projects, this is the chief mechanism for input to issues on Chesapeake Bay. Additionally, there is only representation from Maryland, Virginia, Pennsylvania and the District of Columbia, with no representation from the headwater states of New York, Delaware and West Virginia. As Figure 10 shows, there is also representation of the local governments in the Chesapeake Bay Program; however, this is limited to Maryland, Virginia, Pennsylvania and the District of Columbia. While the advisory committees are formally represented on the structure of the Chesapeake Bay Program, they do not have voting power at the management board (Chesapeake Bay Program, 2015). This limits the level of the involvement of the public in the decision making of the Chesapeake Bay

Council and in the Chesapeake Bay Program.

This incomplete public engagement (in terms of jurisdictional coverage) in Chesapeake Bay governance is not due to lack of interest. Key informants in Chesapeake Bay agree that the public is vested and cares greatly about the Bay as they have a strong sense of place; they also noted that the closer the public lives to Chesapeake Bay, the more concerned they are about it. They believe that it was because the livelihoods of many people were impacted by the loss of blue crabs and oysters in the Bay, that the public became concerned about the Bay.

> *People don't know why there is hypoxia in the Bay or what needs to be done to reduce it, or whether they are all that knowledgeable about fisheries and the economy; they just don't like that their Bay is degraded. They think, "I don't like that, so I think we need to improve it"; that sense of place has been very pervasive. It exists in Virginia to a certain degree but the farther you get, the less it is. This is where we live, this is important to us because it is our homes. [CB2Q1]*

> *Many people are connected to Chesapeake Bay. They are eating seafood, harvesting fish, transporting on the water and taking people out on the water. Chesapeake Bay is referred to as the peoples' Bay. Its rivers dominate this part of the world and people have a powerful sense of place, a deep connection to it. [CB5Q1]*

In the Baltic Sea Region, all of the countries except Russia are signatories to the United Nations Economic Commission for Europe (UNECE) Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental matters (also known as the Aarhus Convention, adopted in June 1998) (European Commission, 2015). This convention gives the public the right to live in a healthy environment and a right to access information on the environment. It has three main pillars: i. the right of everyone to access environmental information that is held by public authorities; ii. the right of the public to participate in environmental decision-making, through arrangements made by public authorities to enable the public to comment on environmental projects, programmes and proposals; and iii. the right access of justice if the other two rights or environmental law has been breached. The key informants had some valuable insights with regards to the implementation of the Aarhus convention:

> *While the Aarhus Convention provides a common framework for public participation, it is enacted in the Baltic Sea countries in different ways; for example, in Finland it is operationalized through the Environmental*

Protection Act. [BS5].

Whilst the first pillar is present in each signatory Baltic Sea country, implementing the second two pillars has proven challenging because of the complexities of actors interacting at difference scales for eutrophication governance. The relevance of the decision made at each level (transnational, regional, national, local, community, personal) has to be assessed with regards to each level and with regards to the multi-level governance system as a whole. [BS8].

For example, the Finnish Ministry of the Environment has a public website where the public can access information, communicate their concerns and request information on the environment (BS5). While the Aarhus convention gives the public the right to environmental information and participation, it doesn't guarantee that they will utilize these kinds of opportunities.

For participation at the governmental level, HELCOM was conceived to facilitate cooperation amongst Baltic Sea countries in the Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention). As can be seen from Figure 10, there is no permanent seat for the public in the governance structure of HELCOM. Adequate public representation would prove challenging as there are nine contracting parties (Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden), representing approximately 16 million persons (HELCOM, 2015). However, HELCOM indirectly supports public participation through several integrated coastal zone management programs (ICZM) (BS 3). HELCOM has acknowledged in the Baltic Sea Action Plan (BSAP) that stakeholder participation is important, and since 2006 it has recognized this by organizing annual stakeholder conferences (Backer et al., 2010). However, this might not translate well into action: one key informant expressed the view that participants are not sure how their views are incorporated into HELCOM's work (BS4Q1). Public participation is also facilitated in the Baltic Sea region through the Coastal and Marine Union (EUCC), an association that was founded in 1989 to promote coastal conservation by encouraging collaboration among scientists, environmentalists, site managers, planners and policy makers. The EUCC facilitates public participation through an innovative web-based training package on integrated coastal zone management called 'CoastLearn' (http://www.coastlearn.org/pp/index.html). CoastLearn incorporates a specific module on public participation, illustrated with case studies.

In both Chesapeake Bay and the Baltic Sea, the public obtains information through the media. Both watershed areas are closely connected to human activities, so the public in the archipelago (the island group in the

Baltic Sea) and the public along the coast of Chesapeake Bay can see the effects of eutrophication. For Chesapeake Bay, a survey of boaters found that they would be willing to pay for improvements to water quality (willingness to pay $55-$93 per year, with higher values for those engaged in year round boating). Willingness to pay was however highest amongst those who were concerned about toxic chemical pollution and lowest amongst those concerned about algal blooms (Lipton, 2004). While there is no equivalent willingness-to-pay survey of residents of the whole Chesapeake Bay watershed, a survey of residents in the state of Maryland found that residents were equally divided in their views on solving the problem of polluted runoff. Forty-nine percent of respondents expressed willingness to pay, while 40% were opposed. However, the percentage of support grows to 71% if the Marylanders know that this fee would be enacted across all jurisdictions and that it could be expected to return revenue and create jobs for their communities (Raabe, 2011). In the Baltic Sea region, residents use the Baltic Sea most frequently for beach recreation, swimming, boating and cruising. On average, however, participants in a similar willingness-to-pay survey did not feel they had an effect on the Baltic Sea and on average were not willing to pay more for actions to improve the state of the Baltic Sea, especially in Lithuania and Latvia (Ahtiainen et at., 2013). The authors found that the persons that were most willing to pay for such actions (Swedes, Poles, Finns and Danes) also were the ones that thought they had an effect on its environmental condition. Whilst both Chesapeake Bay and the Baltic sea have public outreach programs, the finding that the public didn't feel that they had an impact on the waterbody (in the case of the Baltic Sea) shows that there is need for more public education programs on anthropogenic impacts on water bodies. In a study on public perception on climate change in the Baltic Sea Region municipalities, Eisenack et al. (2007) found that there is a significant need for communication and public education to boost the capacity of residents in order to structure their perceptions, to engage on the challenge of environmental problems, to assign relevant responsibilities and to make relevant knowledge easily available in order to disentangle the complexities of environmental challenges such as climate change. While there are no similar studies for eutophication, these issues are sufficiently similar for this finding to be transferable.

8.4.2 Science

Science has played a key role in the understanding of eutrophication of both watersheds. In the case of Chesapeake Bay, the region had the institutional capacity to develop and provide scientific information that dates back to 1925 before eutrophication was fully understood; this capacity was held then in the University of Maryland (University of Maryland Centre for Environmental Science) and the University of Virginia (Virginia Institute of Science) (CB2Q1). This capacity was further supplemented by the formation of the Chesapeake Research Consortium, Inc. (CRC) which was founded in 1972 and consisted of the Virginia Institute of Marine Science, Johns Hopkins University, the University of Maryland, and the Smithsonian Institution (through Chesapeake Bay Center for Environmental Studies) (Smithsonian Institution Archives, 2011). The membership later extended to include Old Dominion University and Pennsylvania State University. CRC's mission is 'to assemble a team of scientists, engineers, managers and public policy specialists to design and undertake multi-disciplinary projects related to the protection and restoration of Chesapeake Bay, the watershed and surrounding lands and air' (Chesapeake Research Consortium, 2011). CRC also collaborated and supported the work of the Scientific and Technical Advisory Committee of the Chesapeake Bay Program (Figure 10 and from the early 1980s to 2000 this group conducted extensive research to improve the scientific understanding or Chesapeake Bay (CB5Q2). The key informants acknowledged that it was challenging to obtain precise scientific results on the causes of ecosystem problems because of variation in salinity levels, weather and multiple circulation patterns, all of which lead to high variability in the Bay (CB2Q2, CB3Q2, CB4Q2, CB5Q2). Despite these challenges, scientists estimate that about 60% of Chesapeake Bay's nutrient loading comes from nonpoint source pollution, including agriculture, and that about 40% of the total nitrogen load is airborne (EPA, 2015).

The key informants believe that the Baltic Sea is one of the most researched marine areas in the world, with a long research tradition and significant research funding from the governments and from the European Union (EU) (Interviews BS2Q2, BS3Q2, BS4Q2, Bs5Q2, BS11Q2). Several said their primary sources of information included peer reviewed journals and HELCOM (BS2Q2, BS3Q2, BS7Q2, BS11Q2). HELCOM has a monitoring and assessment strategy with these aims: to assess progress on meeting the Baltic Sea Action Plan goals; to evaluate how management actions affect the quality of the environment; to facilitate implementation of the ecosystem approach; to coordinate monitoring; to serve as a clearinghouse for dissemination of data and information on pollution and state of the ecosystem; and to create a system to raise the awareness of the public of the Baltic Sea and HELCOM (HELCOM, 2015). For scientific information, key informants also referred to BONUS (Science for a Better Future of the Baltic Sea Region), a EU-funded joint Baltic Sea research and development programme. BONUS will operate from 2010 to 2017 and is intended to set the research agenda and issue calls for research in the scientific community. BONUS aims to produce knowledge, scientific evidence and innovative solutions, and also to engage end users and society in knowledge based governance of the Baltic Sea (BONUS, 2015). Some key informants felt, however, that BONUS has failed in its mandate, because its focus is limited to science and the agency does not engage social scientists enough (BS2Q2, BS11Q2).

In both Chesapeake Bay and the Baltic Sea, scientists have made use of models and monitoring for provision of scientific information for the clean up efforts. In the case of Chesapeake Bay, a lot of the initial investment in the Bay ($40-50M per year from 1984-2000) was spent on developing computer simulation models (Shields, 1997), including a watershed model to estimate past and current loadings, and an estuary model (also known as the water quality model) that uses the findings of the watershed model to predict water quality (Blankenship, 2000). However, the use of these models has come under heavy criticism for lack of accurate representation of real world information and for overstating the success of the clean up efforts. In the words of one key informant:

> *The problem is that we are not integrating the modeling with the monitoring. We have these committees to do these various tasks in the Bay program; we have a modeling committee and a monitoring committee. I suggested to the managers of the program that what we need to reorganize our structure, have one committee with scientists and engineers. Their job is to advance the model and also the monitoring and make them integrate the two. They said we couldn't do that, because the people are really different; we have computer guys on one hand to do the models and we have people who go out in the field, and their personalities are different and approaches are different. [CB2Q2]*

The Chesapeake Bay program established the Chesapeake Bay water quality monitoring program in 1984 (Chesapeake Bay Program, 2015). This was complemented in 1985 by a volunteer citizens' monitoring program initiated by a non-government organization, the Alliance for the Chesapeake Bay (Alliance for the Chesapeake Bay, 2015). In this program, 145 trained citizens conducted weekly water quality testing to track the water quality in Chesapeake Bay. However, this monitoring information was not used as input for the model and, as a result, faulty assumptions were made in the model. For example, even though (after much debate and experimental work) a consensus was reached that nitrogen was also a limiting nutrient, it took many years before this was incorporated into the model, because engineers assumed that nitrogen was not important to the Bay's condition (CB6Q2). Academic scientists were very critical of the model in the year 2000, saying that "the Water Quality Model does not currently provide information suitable for major management decisions and that use the model for such purposes should be suspended" (quoted in Blankenship, 2000).

These modeling uncertainties and criticism of the modeling approach are mirrored in the Baltic Sea Region. The Baltic Sea Action Plan used the Swedish Baltic Nest Institute MARE research program decision support system Nest to calculate annual loads to the Baltic Sea and simulate connections across the entire Baltic ecosystem, from the Baltic Sea to the offshore ecosystems (Wuff et al., 2013). The models describe the physics and biogeochemistry of the Sea and its food webs, and support the simulation of scenarios representing different ways in which eutrophication, fisheries and climate change can affect the ecosystem. According to the BSAP (HELCOM, 2009), this decision support system estimated that annual load reductions to the Baltic Sea of 15 250 tonnes of P and 13 5000 tonnes of N would be necessary to achieve the set targets. One of the criticisms of the MARE Nest system was that the pollution reduction targets were decided ecologically, without taking social and economic information into consideration (BS11Q2). Another key informant thought that the model contains too many aggregations and focuses too much on diffuse loads, without fully considering the load reduction potential of wastewater treatment systems (BS6Q2). Further, a scientific review of the MARE Nest system found that "for operational reasons in Nest, several of its components are simplified models. In the current version of Nest there is insufficient information about the limitations of these model components; also the model needs to make changes to be able to address societal and environmental changes" (Båmstedt et al., 2007).

8.4.3 Networks

The Chesapeake Bay Commission was formed in 1980 (Figure 10) to formalize cooperation on Chesapeake Bay by the states of Maryland, Virginia and later Pennsylvania. The Chesapeake Bay Program acknowledges that federal and state governments need to cooperate as Chesapeake Bay transcends political boundaries and that partnerships lead to time and cost savings, and better results overall (Chesapeake Bay Program, 2015). In 1984, five US federal agencies (US EPA, the US Army Corp of Engineers, the US Fish and Wildlife Service, the National Oceanic and Atmospheric Administration (NOAA) and the US Geological Survey) signed interagency agreements to cooperate on Chesapeake Bay; today, 14 additional federal agencies participate, for a total of 20. In addition to the original five, the group now includes the Cooperative State Research Education and Extension Service the Farm Service Agency; the National Arboretum; the National Ocean Service; the National Park Service ; the National Weather Service; the US Army Corps of Engineers; the US Coast Guard; the US Department of

Agriculture; the US Department of Defense; the US Department of Education; the US Department of Homeland Security; the US Department of the Interior; the US Federal Highway Administration; the US Fish and Wildlife Service; the US Forest Service; the US Geological Survey; the USDA's Natural Resources Conservation Service; and USGS Chesapeake Bay. The Chesapeake Bay partnership also includes nearly 40 state agencies, 1800 local governments, more than 20 academic institutions and more than 60 non governmental organizations (Chesapeake Bay Program, 2015). The key informants recognize the strength of these networks; in the words of one key informant:

> *I'd say there are networks of various types; networks of scientific community where scientists work within their disciplines across institutions and across regions. In governance, the CBP is a partnership between federal and state government, so it always had the mechanism to bring together the responsible people across state boundaries working on this issue. This has been a very powerful network engaging state boundaries. [CB2Q3]*

Cooperation in the Baltic Sea began even earlier, in 1974 (entered into force in 1980), when Denmark, Finland, West Germany, East Germany, Poland, USSR and Sweden signed the first Convention on the Protection of the Marine Environment of the Baltic Sea (The Helsinki Convention) (HELCOM, 2015). A new convention was signed in 1992 by Czechoslovakia, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden and the European Union (EU) in 1992 , and entered into force in 2000. All key informants in the Baltic Sea Region credited HELCOM and the EU with promoting networks in the region.

> *The governance of the Baltic Sea is very networked with many actors. They all have common discussion grounds and common points. There are actors who know each other well. The strongest networks are within areas of interest. For example, the producers' organization deals with eutrophication through a production lens. HELCOM addresses policy issues. They participate in all different types of working groups.* [BS8Q3].

The European Union Baltic Sea Strategy (EUBSS) also facilitates networking amongst EU Baltic Sea Countries; the Horizontal Action Neighbours is one networking action that was included in the EUBSS (CBSS, 2015). The Horizontal Action Neighbours states that its aim is to connect stakeholders in EU member states and neighbouring countries (especially in the northwestern countries of the Russian Federation and Norway) to tackle challenges in the Baltic Sea Region by promoting educational strategies, strengthening cross border environmental competence, fostering labor market relations, promoting student and youth exchanges, promoting tourism and economic development, developing public-private partnerships (PPP) and cultural heritage and creative industries (CBSS, 2015). This strategy is operationalized through seed funding and flagship projects. There are other networks that support the EU initiatives. Other examples of networking strategies in the Baltic Sea region include:

- Interact - a networking organization that facilitates interaction of Baltic Sea Countries around issues relevant to the Baltic Sea, through networking summits, meetings and workshops (BS9Q3).
- BalticLab - promotes the Baltic Sea region as a region of innovation by training and mentoring talented individuals to further their ideas and careers and to engage young people in Baltic Regional issues.
- The Pilot Financial Initiative - another networking organization which serves as a platform for financial cooperation to finance small and medium business innovations and PPP projects in Baltic Sea Region (CBSS, 2015).
- The the Union of Baltic Cities - network of Baltic Sea cities for sustainable development of Baltic Sea Region (www.ubc.net);
- Baltic 21 - was developed in 1996 by the Prime Ministers of the Baltic Sea region and claims to be the first effort ever of a region to adopt common regional goals for sustainable development (www.Baltic21.org);
- The Baltic University Network – a regional network of university organized around research on Baltic Sea issues (www.balticuniv.uu.se) ; and
- the Baltic Environmental Forum Group - founded in 1995 by the Baltic Ministries of Environment, Germany and the European Commission as a technical assistance project aiming at strengthening co-operation among the Baltic environmental authorities (www.befgroup.net).

These networks actively engage with each other at conferences on issues affecting the Baltic Sea.

Various non governmental networks have arisen out of the concern of civil society with the growing pollution in both the Chesapeake Bay and the Baltic Sea region. In the case of Chesapeake Bay, civic environmental cooperation began in 1967 with the formation of the Chesapeake Bay Foundation (CBF), when a group of Baltimore business people, waterfowl hunters and anglers decided to unite to represent the best interest of Chesapeake Bay against the looming problems of increasing number of boats, people, houses, poor sewage treatment and more industrial discharges

(Chesapeake Bay Foundation, 2015). All of the key informants interviewed listed the CBF as the main NGO networking group. As noted previously, there is also the Alliance for the Chesapeake Bay, which was formed in 1971 as the Citizens Program for Chesapeake Bay and later became the Alliance for the Chesapeake Bay (Alliance for Chesapeake Bay, 2015). Both the CBF and the Alliance started out to save the Bay through non confrontational means such as partnership and collaboration to build consensus. More recently, however, the CBF became frustrated with the lack of enforcement action of the EPA to protect the Chesapeake Bay and sued the EPA for its failure to implement the Clean Water Act (as part of the 2010 settlement, EPA agreed to implement TMDL) (CB6Q3). The American Farm Bureau Federation (AFBF) is another NGO network that represents agricultural interests by 'working through grassroots organizations to enhance and strengthen the lives of rural Americans and to build strong, prosperous agricultural communities' (AFBF, 2015). The AFBF was created as a network linking the Pennsylvania Farm Bureau, the National Association of Homebuilders, the National Chicken Council, the National Corn Growers Association, the National Pork Producers Council, the National Turkey Federation, the Fertilizer Institute, and the US Poultry and Egg Association. The strength of this network was demonstrated in a lawsuit against the EPA to revoke the TMDL for Chesapeake Bay. When the federal district court rejected the Federation's lawsuit the strength of this network was again displayed when it was joined by 21 state attorneys general in its appeal of the ruling to the 3rd US Court of Appeals (Chesapeake Bay Foundation, 2015). The attorneys general argued that they joined this lawsuit because of concerns that if it were to be passed in Chesapeake Bay, it might be a replicated in other parts of the country (CB4Q5).

There are also many non-governmental networks in the Baltic Sea region. A comprehensive list can be found on the website of the Baltic Sea Forum, a network of NGOs, companies and institutions that supports cooperation in the Baltic Sea Region (www.baltic-sea-forum.org). There is also an international NGO presence in the Baltic Sea Region: NGOs such as the World Wildlife Fund (WWF) and the Global Water Partnership are official observers of HELCOM (BS4Q3). In addition, the following networks are active in the region (information sourced from their respective websites):

- Baltic Sea Project Coalition – This network amongst schools spans all the countries in the Baltic Sea Region, working together for a better environment in the region.
- Coalition Clean Baltic – This NGO network brings together 21 organizations from Belarus, Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany, Denmark, Ukraine and Sweden. The

CCB has membership of over 800 000 members in the Baltic Sea littoral countries.

- Council of the Baltic Sea States – This network facilitates regional intergovernmental cooperation focusing on three key areas: Regional Identity, Safe & Secure Region and Sustainable & Prosperous Region. These areas address the themes of environment, economic development, entrepreneurship, education, culture, civil security, children's rights and trafficking in human beings.
- Union of the Baltic Cities – This is a voluntary network of cities in the Baltic Sea littoral countries that aims to maximize resources and work together for democratic, economic, social, cultural and environmentally sustainable development of the Baltic region

The NGOs in the Baltic Sea region serve diverse functions such as educational advancement through training and dissemination of information (e.g., the Baltic University Network) and engagement of government bodies such as HELCOM. All the key informants also mentioned the work of the foundations as important action networks; the John Nurminen Foundation, Baltic Sea 2020 and the Baltic Sea Action Group (BSAG) were mentioned by all key informants. The work of these foundations is more focused on practical projects, and the partnerships with the public and private sector necessary to implement these projects. Baltic Sea 2020 has worked on watershed restoration projects with communities, while the John Nurminen Foundation has networked for reduction in nutrient loadings from a waste water treatment plant in Russia:

> *We had really effective networking for phosphorus removal in St. Petersburg. The John Nurminen Foundation got the message through to decision makers that doing this one thing in St Petersburg would reduce P load by 30%. Everybody got on board and now wants to meet the Mayor of St. Petersburg; the President, Minister of Commerce, Minster of Foreign Affairs of Finland. Through this networking we removed 20% of P into the Gulf of Finland and introduced chemical P removal.* [BS11Q3]

BSAG currently uses crowdsourcing and the making of a commitment to create a network of persons taking action to improve the Baltic Sea; in the words of the key informant of the Baltic Sea Action Group (BSAG):

> *We used social invention; we used crowdsourcing and asked people to take part in a huge initiative to save the Baltic Sea. We ask anybody*

> *through our contact website to come along and be part of this initiative. A person or institute comes along and makes a commitment – a Baltic Sea commitment – it is a non-legal, non-binding document. The standard is the same for everybody. Our approach has been that we don't need new networks but we need to make action. There are many networks but they should start to act. We work in project development and connect people together. We also organize high-level forums of Ministers to connect them with the businesses and NGOs on Baltic Sea Issues. In 2008 and 2010 we had attendance of the Finnish President and PM at the Baltic Sea Action Summit; we invited all heads of state and other organizations and the ticket to the summit was commitment to action to improve the Baltic Sea. All states attended including Norway, Belarus, Russia.* [BS7Q3]

While there are many networks in the Baltic Sea Region, it is difficult to assess their effectiveness in the currency of ecological improvement of the Baltic Sea. In the words of one key informant,

> *People around the sea like networks; all projects like to make networks but we cannot see the meaning and role of networks. There are so many networks that there is overlapping of networks and it is hard to see their contribution.* [BS11Q3]

This overlap and inefficiency of the networking is one challenge that has to be overcome to build adaptive capacity in the Baltic Sea Region.

8.4.4 Leadership

A eutrophication governance system will have more adaptive capacity when there is a culture of leadership that promotes action and innovation. For the case of Chesapeake Bay, informants pointed to key individuals in the past that spurred action Chesapeake Bay and lead to significant agreements. According to one informant:

> *Leadership in Chesapeake Bay was a cast of characters; over the years there were a number of leaders that led to a climate of action. Governor Harry Hughes, a former governor of Maryland, was a major leader in it all; he made the restoration of Chesapeake Bay part of his lifelong work. Other leaders were Bill Ruckelshaus of the EPA, the former Virginia governors Jerry Baliles (1986) and Tim Caine (2010) and Will Baker, President of the Chesapeake Bay Foundation. Will*

> *Baker is an inspiring leader, for the whole 31 years he has a stack of us behind him and he is in a position to influence policy at all levels.* [CB3Q4]

All the key informants pointed to the Chesapeake Bay Foundation (CBF) as a visible leader in Chesapeake Bay Restoration efforts. CBF is an NGO with a mission 'to save the Bay and keep it saved' (CBF, 2015). As head of the CBF, William Baker has led visible efforts around action to save the Bay. The lawsuit of the CBF against the EPA for failure to take action under section 303a of the Clean Water act resulted in the 2010 decision by the EPA to enforce the TMDL of the impaired Chesapeake Bay. Key informants also pointed out key scientific leaders (reputational leadership) such as Dr. Mo Lynch, who was past chair of the Chesapeake Research Consortium; Dr. Cliff Randall, who was Dean of Environmental Sciences at Virginia Tech and was responsible for driving dialogue and experiments that led to recognition of nitrogen as a limiting nutrient in Chesapeake Bay and therefore the importance of introducing biological nitrogen removal in sewage treatment plants; Dr. Don Boesch, current head of the University of Maryland Centre for Environmental Sciences (UNCES). All key informants also pointed to the clear leadership of past Maryland Senator Bernie Fowler, who brought awareness to Chesapeake Bay environmental problems through his sneaker index; each year Bernie Fowler wades into the Patuxent River (a tributary of Chesapeake Bay) and measures how far he can go and still see his sneakers; in 2014, he could see it through 23 inches, compared to a benchmark of 63 inches in the 1950s (CBF, 2015). Key informants also agreed that the EPA displayed leadership at various stages through the leadership of Bill Ruckelshaus, through the agency's role in the Chesapeake Bay Program, and through scientific study on the Bay:

> *Leadership from EPA came at a couple of points. There was EPA leadership in doing scientific study from1978–1983 on Chesapeake Bay. There were parts of EPA that did not want to spend money. EPA did do studies, and the results were shared through pulling together the first modern conference on the Bay in 1983, and that led to the first Chesapeake Bay Program agreement. Also, William Ruckelshaus was a good leader as environmentally he was very active. The most recent example of EPA leadership came around 2009 when they decided with states that CBP was not working well and that they would take a more regulatory and less voluntary approach by imposing more regulations for controlling nutrient pollution. Lot of administrators and farmers not liking that and the Republicans vowed to weaken EPA. For many years, the program didn't take a strong leadership role but leadership*

and a lawsuit by CBF led to EPA taking leadership on the TMDL.[CB1Q4].

In the case of the Baltic Sea, key informants felt that leadership varied with time and across the region. Generally speaking, leadership is not clear, but there are times that leadership is shown by individual countries. For example, Sweden is proactive when it comes to Baltic Sea environmental issues and Finland displays leadership depending on the political situation (BS8Q4). According to one key informant, there are three pools of leadership: the governmental level for policy-making, science for the provision of reliable information (key informants pointed to BONUS for scientific leadership) and non-governmental organizations for the representation of the public voice (BS4Q4). Some key informants felt that the EU is not the leader in managing eutrophication, as it does not span the entire region (Russia is excluded) and that HELCOM is in fact the leader:

EU can't be the leader; they should take the whole region as members. The EU has a Baltic Sea strategy and so we agreed on cooperation in such a way that HELCOM provides political background on where action is needed. The EU Baltic Sea strategy provides funds for implementation. HELCOM is the policy messenger for implementation.[BS4Q4]

HELCOM displays clear leadership; it is staffed by leading scientists who are experts in their fields. [BS6Q

HELCOM is the main instrument. HELCOM's action plan is active. HELCOM recommendations are stronger than EU's. Although participation is voluntary, HELCOM recommendations influence national laws. [BS2Q2]

These views were however voiced mainly by science-based organizations. Most key informants were vocal that HELCOM does not display leadership. Key informants felt that because it is located in Finland, there is more focus on issues there:

Although HELCOM is in the position of a leader, there is a lack of leadership. The organization consists of many different countries; they have so many different issues on the table so they are not focusing on anything. If you are in an official position, you need to keep working in Finland where HELCOM is located for action to be taken. [BS11Q4]

> *HELCOM is a secretariat that coordinates working groups and writes reports. Nobody reads the reports. They meet each other and network; that is all they do. [*BS7Q4]

> *There is no clear leadership. There are different ministries and different policies and different decision-making. There is no point that has clear leadership on the question of eutrophication – environment question. The Ministry of the Environment has a leading role but cannot tell us what to do on agriculture*. [BS10Q4]

Organizations also felt that this lack of leadership by HELCOM is displayed in their inability to resolve conflicts due to their model of decision-making by consensus:

> *On the international level, the main leader is HELCOM. They make political decisions mainly in the compromising mode. If there is a conflict on the international level, they are a consensus-based organization. For example, a burning issue is the waste stream (gypsum) from fertilizer production in the Luka River (2000lbs) .The gypsum piles in Poland are leaking into Baltic Sea. HELCOM is unable to deal with the issue. Poland is denying dealing with the situation and denying to deal with leakage. They are saying that the issue is resolved when we know it isn't. At the national level the Minister of Environment is trying to deal with it.* [BS11Q4]

> *The problem with the HELCOM normatives is that they are not legally binding. There are no ways to make them do this. You cannot go to European Court to sue them for not fulfilling norms. It is cheaper not to fulfill the norms*. [BS11Q4]

> *HELCOM processes are slow; they always can proceed with the pace of the slowest country. They are deciding on acting based on mutual agreement. If there is a conflict, the matter just doesn't proceed. HELCOM has been toothless on the issue of gypsum that is leaching phosphorus into the Baltic Sea in Poland. [BS5Q4]*

Most of the key informants interviewed pointed to clear leadership by the foundations, especially the Baltic Sea Action Group and the John Nurminen Foundation. In the words of a key informant from the latter organization:

> *Our foundation started environmental work in 2005. The board of the foundation became frustrated with the state of eutrophication of Baltic*

> *Sea. There were so many talks, plans etc. but things were getting worse. This issue was around since 1970, but the situation got worse. The Board of the foundation is a board of entrepreneurs, so they looked at the problem of eutrophication in a businesslike manner. They interviewed Baltic Sea researchers – there was a legitimacy crisis of the Finnish government in dealing with it – they wanted to find out the most effective way of dealing with the issue of eutrophication.* [BS11Q4]

Most key informants pointed to the need for clear leadership. In the words of one key informant, there should be a proposal for clear leadership and perhaps a strong Minister should take leadership on Baltic Sea issues [BS5Q4].

8.4.5 Flexibility

In both watersheds, there is some degree of monitoring that is fed back into the system. However, the capacity for learning and the presence of feedback loops varies between the two systems. In the case of Chesapeake Bay, there is the Chesapeake Bay Program water quality monitoring program that was implemented in 1984. This program sampled water monthly from 49 stations (Chesapeake Bay Program, 2015). However, there was no potential for feedback loops or learning to be incorporated back immediately into the system as this data was not analyzed and was not integrated into the Chesapeake Bay models. There was no learning through carefully designed experiments (CB2Q5). In the case of the Baltic Sea, one key informant felt that there have been some attempts at flexibility. There are monitoring programs in all countries but feedback loops and learning are varied depending on the individual programs of each country (BS7Q5). Another key informant felt that flexibility is a continuous struggle of what can be changed. This informant added that there is a will and potential to do more monitoring and learning, but there are feedback loops with national goals to reduce nutrients and these vary by country (BS1Q5).

With regards to legal measures, adaptive capacity includes the ability to change laws and policies when you need to meet new environmental goals. When it comes to flexibility in policy measures to protect the watersheds, there are stark differences in practices between the cases. In terms of legal instruments, Chesapeake Bay is governed primarily by the Federal Water Pollution Control Act 2002 (originally passed in 1972, and often called the Clean Water Act), with primary responsibility for point and non point source pollution being vested in federal and state authorities respectively. The Clean Water Act has the objective to ‘restore and maintain the chemical, physical and biological integrity of the Nation's waters' and still has the goal 'that the discharge of pollutants into navigable waters be eliminated by 1985' (EPA, 2015). For pollution that is discharged into receiving waters from point sources, the controls are regulated through the National Pollutant Discharge Elimination System (NPDES) permitting system. However, the NPDES system does not regulate non point source pollution (NPS), where control rests solely with the states. This delegation of responsibility for non point source pollution to states resulted in inconsistent approaches from state to state. Most states have used voluntary measures for agricultural nutrient pollution, with varying levels of technical and financial support for implementation of best management practices (BMPs). This approach has had varying degrees of success; in the words of key informants:

> *The way this has been approached is that we will do this in a voluntary way through best management practices (BMPs) and essentially it has only really worked here to any degree in places where it has been subsidized. If you pay farmers to do something and have them apply it, it works. If you have them do it voluntarily, it hasn't worked. I don't know of any successful situation in any non point source pollution field but I have not seen where significant result is achieved without regulation.* [CB2Q5]

> *The original program was voluntary in 1983 and remained voluntary into the 1990s. It became clear that it failed miserably to meet the water quality deadlines. Beginning in the 1990s it became clear that a shift to more mandatory, regulatory standards was needed or restoration won't work. Mandatory measures will work better than voluntary ones*. [CB1Q5]

> *The strong arm of the law is needed for nutrient pollution control. Every state had to deal with agriculture being exempt from water quality regulations for political and technical reasons. Agriculture has to be regulated; we've regulated point sources past the limits of technical possibility*. [CB4Q5]

This failure of the voluntary approaches led to the lawsuit by Chesapeake Bay Foundation against the EPA to impose total maximum daily loading (TMDL) on the states. This is a provision for cases where point source controls are not enough to meet state water quality standards, contained in section 303d of the Clean Water Act, that requires submission of impaired waters by states to the EPA and also the reasons for the impairment (EPA, 2015). The TMDL was later challenged in court by the American Farm Bureau Federation, was rejected in the federal district court, and is now in the appeals court. As noted above, this appeal had the support of 21 state attorneys general.

By contrast, it can be argued that the Baltic Sea is one of the most regulated regions of the world, with several layers of regulations, including international agreements (International Council for the Exploration of the Sea); EU law (with the exception of Russia, all littoral countries are part of the EU) including the EU water framework directive, the EU Marine Strategy Framework directive, the EU Urban Waste Water Directive, the EU Nitrates Directive and the EU Common Agricultural Policy (CAP); national and local laws; and non binding agreements, all acting together. While the EU sets the common policy, it is up to each country to implement laws for these policies. The legal instruments that are designed to prevent nutrient enrichment "depend on the central top level country transposed EU laws and rarely incorporate local decisions" (BS11Q5). The newest members of the EU, the Baltic States (Estonia, Latvia and Lithuania), have changed their national laws to incorporate EU directives, but they may lack the resources to implement these laws as they are poorer countries (BS4Q5). One key informant felt that the EU laws are too general and ignore the local context of each country (BS11Q5). When it comes to legal vs. voluntary measures, key informants felt that a mixture of both is better to build adaptive capacity:

> *The base must be legal responsibility. One big problem in Finland is the win win ideology where everybody wins. A company makes so much more profit because of inaction due to this ideology, as in the case of a mining company that polluted and closed down because of bankruptcy. Now the government has to clean up the pollution. There is a conflict in environment and economics and people always choose economics because they believe "we are good and nature is there to serve us." I always thought people are good but can see that we can't always trust people. In Finland people are going the easiest path. We need a good strict legal framework. On top of that it is great to have voluntary measures; we need to have tariffs and laws.* [BS11Q5]

> *The question of using legal or voluntary measures depends on partners; whether it is big or small farmers and what is the nature of the project. It depends on context, objectives and experience. A mixture of both legal and voluntary measures are needed– we could not go back to the EU saying be more flexible with your policies if someone in a member state wishes for more flexibility. The awareness of environmental problems in Latvia is missing in the country and I don't*

see why. [BS9Q5]

It depends on the area; changes can be made more readily to waste water systems for they are maintained and financed by the municipality. For agriculture, it is more complicated and more sensitive from a personal point of view. Lots of people are active. They would not like voluntary implementation of new techniques as they don't want to bear more financial burden associated with these measures. It also depends on the country. In Russia, more legal measures would work best, whereas in Nordic countries like Finland and Sweden, voluntary measures are also important.. For agriculture in Poland, it doesn't matter the measure, it is complicated to change the practices as they are so linked to economics. [BS4Q5]

Farmers do more and more for the environment. I like to tell farmers better to do this measure (BMP) for less money, less incentive, for if we don't do it, I think we might have stricter legislation". [BS10Q5]

It is also felt that the many policies of the EU are not integrated well and do not complement each other. For example, the EU common agricultural policy (CAP) puts an emphasis on increasing the areas under cultivation through specialized and large-scale farming. This is in contrast to the EU Baltic Sea strategy of saving the sea (BS10Q5). This is further aggravated by the EU policy that calls for increasing cultivation of crops that go towards energy production (EC, 2015). Across the region, the CAP is not implemented equally and there is a feeling amongst farmers that the policies are not fair as they are implemented more in some countries than in others, and lead to the loss of productivity (BS10Q5). Generally all key informants felt that the HELCOM Baltic Sea Action Plan is not taken as seriously as the EU regulations (in EU littoral countries) as the HELCOM agreement is non-binding.

8.4.6 Resources

In the case of Chesapeake Bay, various funding and market mechanisms are used to fund nutrient reduction programs (Figure 8.11).

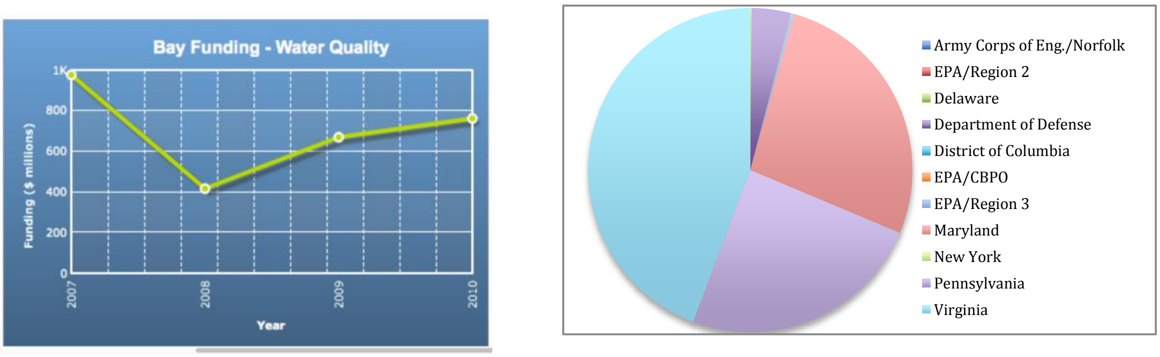

Figure 8.6-Chesapeake Bay Funding for water quality a. total funding b. funding sources for municipal and industrial wastewater (Chesapeake Bay Program, 2015)

As shown in Figure 8.11a, over US$2B was spent on restoring Chesapeake Bay Water Quality during the period 2007-2010. The lowest funding occurred in 2008, which corresponded to the worst financial downturn the US has seen since the Great Depression, so there was limited money to allocate to Chesapeake Bay Programs (CB4Q6). This is a good illustration of how the economy is closely linked to financing for the Chesapeake Bay Program. Figure 8.11b illustrates the range of major funding sources (either state or federal) to protect and restore water quality during 2007-2010 by reducing nutrient loads from municipal and industrial wastewater. Over 50% of the US$2B spent was funded by the states, while federal grants from the Clean Water Act (Clean Water State Revolving Fund) and other sources funded the remainder (Chesapeake Bay Program, 2015). Funding is also allocated under President Obama's Executive Order 13508 issued in 2009 for the clean up of Chesapeake Bay. Through this order, a total of approximately US$0.5B was allocated annually during period 2011-2015 by the federal leadership agencies for Chesapeake Bay cleanup activities (Federal Leadership Committee, 2015). The Regional Conservation Partnership program (RCPP), a program of the US Department of Agriculture National Resources Conservation Service (NRCS) has also provided funding of US $24.3M for nine projects across the Chesapeake Bay watershed (Chesapeake Bay Program, 2015).

While it may appear that there is a lot of funding for Chesapeake Bay programs, money is less readily available for research. According to one key informant,

> *In the case of science, many people including my colleagues have the misconception that Chesapeake Bay Program has a big budget allocated for research. It doesn't; it has nothing for research. Most of that funding is provided for by the universities that fund facilities and*

> *faculty members and scientists, but also by competitive grants from various agencie,s mostly federal grants like from NSF and NOAA and any other group. It is not a well-financed and organized system. It really depends on the individual's ingenuity and from a lot of different people bringing resources that create new knowledge in the process.* [CB2Q6]

Individual states use a suite of funding mechanisms for nutrient reduction projects. For example, Maryland implemented a flush tax in 2004, an increase of $2.50 monthly on sewage and septic users to raise money for upgrading of wastewater treatment plants; this measure was combined with a 50% cost share to help municipalities upgrade treatment plants (CB6Q6). In the words of one key informant:

> *One of the big challenges now, the one sector which we've had no reduction in, is the increasing in urban and suburban storm water. This is because the developed footprint is always expanding. So there are major new requirements driven by commitments but also by new permits under CWA, as storm water discharge has to be permitted. It requires different standards so how to do that is a challenge. States do it in different ways but in MD there is a law that required jurisdictions and counties that constitute most of urban suburban surface area to implement local fees to fund retrofits, storm water management retrofits. However, there has been a backlash against that, as people don't want more taxes. In the last campaign it has been labeled the rain tax; in the words of people "they have taxed everything else, now they are taxing the rain". And so it is a struggle to find out how to continue to pay for these improvements. [CB2Q6]*

It is estimated that the state of Pennsylvania needed to invest $28 billion in wastewater treatment for the next 20 years, yet appropriation from the Clean Water Act decreased to $53 million in 1981. Recognizing the funding gaps, Pennsylvania voters approved a $400 million bond for water and wastewater infrastructure (ASCE, 2014). In addition to funding from bonds, Pennsylvania is one of the states that use the market funding initiative of nutrient trading for nutrient reduction programs. The county of Lycoming bought $51,000 in nitrogen and phosphorus credits from local farmers in the local nutrient trading program; these credits were certified independently by the Pennsylvania Department of Environmental Protection (PA DEP) (Campbell, 2015).

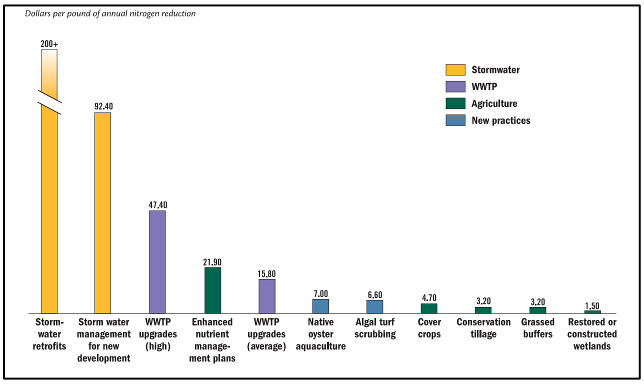

Figure 8.7-Dollars per pound of annual nitrogen reduction (Jones et al., 2010)

Each credit represents reduction of one pound of nutrient pollution through voluntary agricultural best management practices geared at reducing nutrient pollution into the soil.

Nutrient trading programs aim to improve water quality by allowing point or non-point polluters who have met and exceeded their nutrient regulations to earn credits that can be sold to others who need these credits to meet their targets. According to Jones et al. (2010), nutrient trading exists to capitalize on the cost variations for nutrient reduction across sectors and creates opportunities for more nutrient reduction. As shown in Figure 12, in the Chesapeake Bay region, nitrogen reduction costs the most when it comes from stormwater retrofits and stormwater management infrastructure for new development. Jones et al. (2010) synthesized the results of studies conducted in the US to show that the costs of nitrogen reduction were highest for stormwater retrofits and new stormwater infrastructure and lowest for restored and constructed wetlands. According to one key informant, nutrient trading is especially useful for removing phosphorus in rivers (CB5Q6). According to the EPA (2012), nutrient trading among public treatment plants in Connecticut that discharge to Long Island Sound are expected to achieve the TMDL nutrient reduction targets whilst saving over US$200M in control costs.

Under the Chesapeake Bay Program (2015), nutrient trading is not allowed for sources that receive federal funding and until a 40% cutback goal is achieved, only ‘like sources trading’ (point source to point source and non point source to non point source) is allowed. Currently nutrient trading is practiced within four Chesapeake Bay states; Maryland, Pennsylvania, Virginia and West Virginia and is only permitted within small watersheds. This limiting of nutrient trading locally prevents taking full advantage of cost differentials amongst states in the watershed. According to Van Hootven et al. (2012), a full Chesapeake Bay wide nutrient trading system has the potential to increase cost savings from nutrient trading programs by as much as 35%.

In the Baltic Sea Region, there is no similar market-based funding mechanisms such as nutrient trading programs. According to Hyytiäinen and Ahlvik (2015) the total cost for implementing the revised HELCOM Baltic Sea Action plan is EUR2008M annually, with improvements in waste water treatment and measures to improve retention capacity of agricultural soils being the costliest investments (Figure 8.13). As Figure 8.13 shows, the most costly measures can be made less expensive with flexible arrangements for nutrient reduction in one basin and offset in another, much like the nutrient trading in Chesapeake Bay. It is recognized that the potential downside of this is the worsening of pollution in the impacted area.

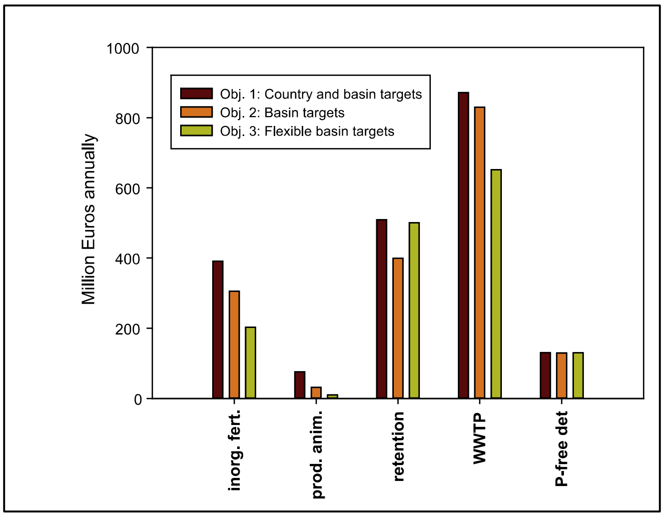

Figure 8. 8 - Optimization investment for actions in BSAP (Hyytiäinen andAhlvik, 2015)

Nutrient trading could also potentially allow for more effective cost sharing. On a Baltic-wide watershed scale, nutrient trading mechanisms could help to address the problem of nutrient loadings that fail to consider the socio-economic position of the littoral country (Elofsson, 2010b). As Figure 8.14 shows poorer countries such as Poland has a large abatement cost as compared with richer countries such as Germany.

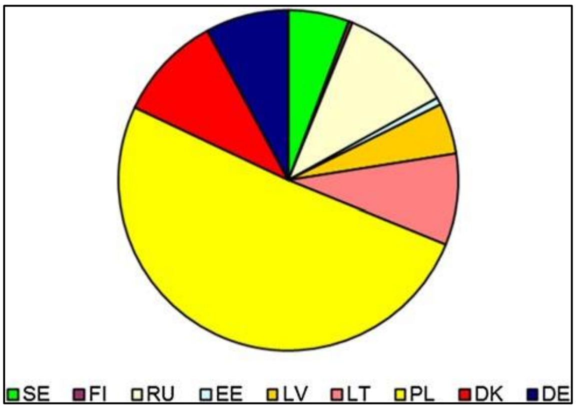

Figure 8.9 - Distribution of each country's (SE-Sweden, FI-Finland,RU-Russia, EE-Estonia, LV-Latvia, LT-Lithuania, PL-Poland, DK-Denmark, DE-Germany) abatement costs for delivering nutrient reduction targets (Wulff et al., 2014)

All key informants commented on this difference amongst the Baltic Sea countries. In the words of one key informant:

In the Baltic Sea Region as a whole, the only whole thing is sea. There

> *are big differences between countries; differences in interest in environmental policy and resources. You will still find big differences in the economic backdrop of the countries; how rich they are and their traditions in steering systems and government systems. Generally, Finland, Sweden, Denmark and Germany are considered forerunners in environmental policy.* [BS8Q6]

Projects under the Baltic Sea Action Plan have received funding through the Nordic Environment Finance Corporation (NEFCO) to aid in implementation of the BSAP; Sweden contributed EUR9M and Finland contributed EUR2M to the fund for the period 2014-2020 (NEFCO, 2015). This fund aims to enhance opportunities for greater capital investment from financing institutions. Funding is also available under the EU strategy for the Baltic Sea region. According to the expert from the Finnish Ministry of the Environment who is on the nutrient (designated Nutri) priority area, a total of EUR250M is available for seven years (2014-2020) to enable joint projects among the Baltic Sea Countries. There is also seed money (funding to prepare projects to contribute to the EU Strategy for the Baltic Sea Region) available through the EU SBSR, the Swedish Institute, the Council of the Baltic Sea States and the Nordic Council of Ministers). The Joint Baltic Sea System Research Programme (BONUS), which was set up to integrate transdisciplinary Baltic Sea Research, has funding of EUR100M for the period 2010-2017, funding from pooled resources from member countries, and funding from the EU (BS6Q6). EUR55 billion was also allocated for Baltic Sea projects under the EU cohesion funding for poorer countries during the period 2007-2013. The EU SBSR has a comprehensive list of funding sources in an excel database available on its website (http://www.balticsea-region-strategy.eu/funding-sources). Despite this proliferation of funding sources, there are still challenges related to funding of Baltic Sea Nutrient reduction projects. According to key informants:

> *The allocation of funding is a problem. It is connected to the will to commit resources. Finland is willing to put resources into projects. We need cost piloting; funding for pilot projects such as taking manure 'from shit to fertilizer'. How money is spent redefines eutrophication. One brave way to allocate money is to buy in the best knowledge and the best skills.* [BS7Q6]

> *There is some funding but not enough. More funds are needed for sewage treatment on the municipal level. For private sewage, residents need to find their own solutions. It is expensive and hard to find solutions working well on time scale of decades.*[BS1Q6]

> *Funds are never enough. The EU provides financial support for countries. More funding is needed for studies, for developing new techniques and technologies.* [BS4Q6]
>
> *There is more funding for research and not for implementation. There is a problem with financing on the EU level; we couldn't get the funding for implementation. We know the problems and the issues but need money for implementation. There is the possibility for financing but there is more funding for strategy initiatives rather than funding for grassroots level projects.* [BS3Q6]

As can be seen from these comments, whilst financing is more readily available in the Baltic Sea Region than in Chesapeake Bay, there are problems with the allocation of the funding and access to the funding.

8.5 Discussion and Recommendations

This paper sets out to compare the adaptive capacity for eutrophication governance of Chesapeake Bay and the Baltic Sea. This is a comparison of similar ecosystems; both are brackish, shallow water bodies with a large ratio of land to water volume (15:1 and 4:1 respectively) that makes them susceptible to anthropogenic pollution. Both are under the stressor of excessive nutrient enrichment from both phosphorus and nitrogen with the similar outcome of eutrophication. In addition to these ecosystem similarities, these watersheds have had comparable successes with lowering nutrient loads from point sources through successful policies such as regulatory limits on sewage treatment plant discharges. While both water bodies have been the focus of environmental protection for the past 35 years, they have different governance settings and policies that have led to differences in adaptive capacity for eutrophication governance. This section will compare and contrast some of the key findings for both watersheds in order to offer insights to decision makers for the successful eutrophication governance of Chesapeake Bay and the Baltic Sea and other comparable regions.

Whilst both watersheds are multi-jurisdictional, Chesapeake Bay is located entirely within the country of the United States while the Baltic Sea is shared by nine littoral countries: Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany and Denmark. Even though Chesapeake Bay is located wholly within one country, it is shared by the District of Columbia and six other US states. However, each of these states has a similar socio-economic context, whilst this differs amongst countries in the Baltic Sea

Region, resulting in varying adaptive capacity for eutrophication governance. The economies of the countries of the Baltic Sea vary between the richer Scandinavian countries and Germany, and the poorer new democracies on the western coast. The Scandinavian countries have more developed environmental programs and better public participation than the Baltic States. Cooperation is facilitated through EU mechanisms (for countries except Russia) and through the Helsinki Commission. In Chesapeake Bay, cooperation is facilitated amongst the watershed states by Chesapeake Bay Program and the watershed agreement. Protection of Chesapeake Bay for eutrophication is governed under the US federal Water Pollution Control Act, with states given responsibility for non point source pollution. The protection of the Baltic Sea is influenced by EU environmental policies (for all countries except Russia) and by the regional Helsinki Commission guidelines. Russia receives funding under the BSAP. For example, during the period 2012 – 2014 Russia received EUR2.5M from the EU for implementation of projects under the BSAP; this funding was made possible by HELCOM (HELCOM, 2015). This funding supported projects geared at reducing nutrient discharges to the Baltic Sea from small municipalities and scattered settlements and funded pilot activity to promote increased capacity for organic manure management.

In both locations, eutrophication governance is characterized by numerous actors who are highly networked. The willingness to cooperate is illustrated in the Baltic region by membership of countries in the European Union, but there is more room for cooperation as Russia is excluded. A lesson from both the Baltic Sea and Chesapeake Bay is that having a large number of stakeholders does not guarantee improved policy implementation or greater adaptive capacity. The environmental quality of Chesapeake Bay and the Baltic Sea has only marginally improved despite over 35 years of efforts to reduce nutrient input into the water bodies. One of the problems in the Baltic case was the absence of leadership to overcome the many challenges that are associated with multiple actors and networks. Whilst Chesapeake Bay has clear leadership from the EPA (through the TMDL requirement), this is missing in the Baltic Sea as the European Union does not include all members and HELCOM is often gridlocked on key issues. There is a gap in leadership in the Baltic Sea that could be filled by a council of senior decision makers who could be united in a joint effort to combat eutrophication of the Baltic Sea.

Leadership was however present at smaller scales in the Baltic Sea Region. The John Nurminen Foundation working with both governmental and non governmental actors in Finland and Russia to upgrade waste water treatment plants in Russia is one example of the adaptive capacity that results from the devolution of management responsibilities and the sharing of power and resources to promote participation. The example of collaboration on the upgrading of wastewater treatment plants further illustrates visionary leadership. In this case, that leadership recognized the opportunity for significant loading reduction through the action of reducing the discharge of phosphorus from a waste water treatment plant, recognized the political conflicts (Russia is not a member of the EU and hence does not have access to the funding or cooperation mechanisms of the other EU littoral countries), and took action to resolve the differences and work at a common solution. The successful upgrade of the wastewater treatment plant in St. Petersburg, Russia illustrates the important role that external actors like the John Nurminen Foundation can play in creating forums for dialogue that fosters successful partnerships on nutrient reduction programs. Informal networks such as these have been referred to as policy communities, where the formal lines of authority are blurred as diverse actors are knitted together to focus on common problems, while stimulating collaboration, trust building, information sharing and the development of common perspectives on challenging issues (Schneider et al., 2003). This adaptive capacity was also mirrored in Chesapeake Bay when actors were brought together under the leadership of Chesapeake Bay Foundation in a lawsuit against the EPA, an action that resulted in an out of court settlement by the EPA to enforce the TMDL for Chesapeake Bay.

Ecosystem changes in both regions were driven by the use of science to guide decision-making. In both Chesapeake Bay and the Baltic Sea, there is continuous monitoring to gather data on nutrient pollution and ecosystem response. However, there is more connectivity between modelers and monitors (engineers and scientists) in the Baltic Sea Region, leading to more representative science. This enhances adaptive capacity, as it allows for more rapid and responsive actions. It allows knowledge mobilization through integration of all sources and leads to better understanding of the ecosystem processes and functions and more realistic representation of ecosystem by the computer models. Integration of monitoring data into the computer simulation models leads to improved understanding of the system dynamics as a whole and translates into better decision making. Hence, through the lens of the determinant of science, adaptive capacity for eutrophication governance may be less in Chesapeake Bay than in the Baltic Sea Region because of less effective integration of monitoring information into simulation and loading models.

In assessing the determinant of flexibility in both regions, a core tension was revealed. The challenge of balancing flexible, adaptive voluntary measures with the legal certainty and enforcement necessary for instituting change was common in both regions. In Chesapeake Bay, the main non-governmental actors such as the Chesapeake Bay Foundation started out with a collaborative model of working, with the core premise that collaboration is vital for restoration actions. However, this group eventually resorted to legal measures that resulted in more regulatory measures by the EPA to enforce total maximum daily loading limits. In the Baltic Sea Region, key informants cited the main weakness of HELCOM as its focus on voluntary action; as a result HELCOM's recommendations are not taken as seriously as those of the EU, which are mandatory. In both areas, key informants highlighted the need for a mixture of legal measures coupled with financial incentives to drive agricultural nutrient reduction measures.

In both watershed areas, use of diverse funding measures builds adaptive capacity for eutrophication governance as it facilitates implementation. There is more diversity of funding mechanisms in the Chesapeake Bay region, where market mechanisms such as nutrient trading are used. While the Baltic Sea region has access to significant resources through the European Union, these resources are not accessible to non EU members such as Russia. Additionally, there is the challenge of implementing actions across the Baltic States. In the Baltic Sea, the loading allocation is based on each country's share of pollution to the Baltic Sea and does not take social and economic factors into consideration. The variation in cost of nutrient abatement amongst littoral countries is neglected in setting up the abatement allocations. Following the lesson from Chesapeake Bay, implementation of nutrient trading could aid in leveling these socio-economic differences and lead to more efficient abatement measures.

8.5.1 Recommendations

8.5.1.1 Interagency/Country Agreements to facilitate working on common issues

There are several interagency cooperation agreements in Chesapeake Bay that can serve as a model for the Baltic Sea. This cooperation facilitates communication and commitments amongst the different federal agencies for Chesapeake Bay. Whilst HELCOM facilitates collaboration amongst the different countries, a binding inter-country agreement can facilitate cooperation and pooled resources for common issues that affect the Baltic Sea. The case of the cooperation led by the Nurminen Foundation that resulted in improved phosphorus removal at Vodokanal's three largest waste water removal plants is an illustration that this can work in practice. This model of cooperation should be replicated in other neighboring countries with different capacities through formal agreements to work on nutrient hot spots that originate in one country but affect the Baltic Sea as a whole. This can help significantly to reduce the socio-economic and cultural differences that exist amongst the countries. This is in keeping with the literature, which has shown that for successful policy implementation, the cooperation of multiple actors is required (Joas et al., 2007)

8.5.1.2 Public impact on the environment

In the Baltic Sea Region, residents on average felt that their actions do not affect the sea; similar data for residents of Chesapeake Bay is lacking. This points to a need for more public perception research in Chesapeake Bay. There is a need for more environmental education programs in both regions. While the EU has the reputation of being environmental leaders, there is a lot to be done for environmental policies and public awareness in the Baltic Sea Region. In both watersheds, education needs to play a key role in increasing the public's awareness of their impact on nutrient enrichment in both watersheds. This should encourage more rapid and local responses to pollution issues, including the possibility of more public pressure on agriculture. This could also lead the public to examine their own consumption patterns once the link between the products they consume and the impact on the water is realized.

8.5.1.3 Integrated Agriculture

An agricultural policy such as the EU common Agricultural Policy (CAP) has led to intensification and rationalization of agricultural production and has resulted in a geographic separation of crop and animal production (Larrson and Granstedt, 2010). Historically, before World War II, nutrient cycling was localized within a watershed, but after the war, P tended to move from areas of grain production to areas of livestock production (Sharpley and Beegle, 2001) (Figure 8.15).

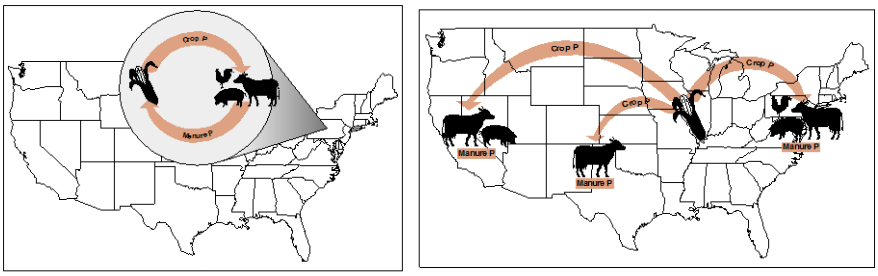

Figure 8.10 - The shifting nutrient cycle (Sharpley and Beegle, 2001)

A sustainable alternative that could result in non point nutrient reductions from agriculture to both the Baltic Sea and Chesapeake Bay is Ecological Recycling Agriculture (ERA). Larrson and Grandstedt (2010) explain that an ERA farm is organically managed according to the standards of the International Federation of Organic Agriculture Movements (IFOAM), using neither pesticides nor fertilizers while adopting a high rate of recycling of nutrients through organic, integrated crop and animal production. This is a more traditional means of integrated agricultural farming that promotes lower animal density farms from which manure is used to fertilize neighboring crops. ERA is in use in Sweden and Larrson and Grandstedt, 2010 argue that replication of that system in the Baltic Sea Region could result in a marginal decrease in aggregate crop production but an increase in animal production while decreasing nitrogen surplus by over 60% and eliminating the surplus phosphorus. It would be worthwhile exploring these kinds of strategies across a broader region.

8.5.1.4 Leadership for adaptive capacity for eutrophication governance

Chesapeake Bay and the Baltic Sea Region both have a history of water governance for over 35 years. However, it can be seen that despite these long traditions, there has not been a concomitant improvement in water quality. The EPA has taken leadership for nutrient pollution in Chesapeake Bay watershed through the implementation of the Total Maximum Daily Loading (TMDL) 'pollution diet' for Chesapeake Bay. This model can serve to inform the Baltic Sea, where there is no clear leadership for eutrophication governance. Whilst the EU has several policies for eutrophication governance, they do not apply to non-members such as Russia. What is needed is a council of senior decision makers for Baltic Sea restoration, recognizing the important role that environmental health plays in economic growth. The Prime Ministers for each littoral country could be invited to demonstrate leadership for the issue through a new Council of Senior Decision Makers for Baltic Sea Restoration. This could be the body that advances key policies related to eutrophication governance in the region.

8.5.1.5 Utilization of market trading mechanisms for nutrient abatement in the Baltic Sea Region

Maryland, Virginia, West Virginia and Pennsylvania have developed nutrient trading programs within small watersheds. Research by the World Resources Institute has shown that a full Chesapeake Bay wide nutrient trading system has the potential for a 35% increase in cost savings (Van Hootven et al., 2012). The Baltic Sea Region can learn from the Chesapeake Bay states' nutrient trading schemes, as there is no such flexible market trading initiatives for nutrient in that region. Such mechanisms have the potential to offset the substantial differences in nutrient abatement costs in the Baltic Sea littoral countries (Wuff et al., 2014). The cost differentials as shown in Figure 13 make the Baltic region especially suitable for nutrient trading as they hold the promise of potential efficiency gains from nutrient trading schemes. There may however be implementation challenges in aligning such flexible market instruments with the EU CAP, which states that only costs can be compensated. However, there are already studies that have outlined scenarios to overcome challenges to nutrient trading in the Baltic Sea Region (NEFCO, 2015), so the notion is worth exploring.

8.6 Conclusions

This research compared the adaptive capacity for eutrophication governance of Chesapeake Bay and the Baltic Sea. More specifically, it applied Jetoo and Krantzberg's (2015) framework for assessing the determinants of adaptive capacity to other water bodies under the stressor of eutrophication. The results demonstrate that these determinants (public participation, science, networks, leadership, flexibility and resources) are useful for assessing adaptive capacity for eutrophication governance for water bodies that have different governance settings and policies.

The results reveal that the level of adaptive capacity varies between governance systems. On the one hand, adaptive capacity in both areas is strengthened by the networking of numerous actors in eutrophication governance but on the other hand is weakened by lack of full public engagement on eutrophication issues. Similar tradeoffs are found in other determinants. Adaptive capacity in Chesapeake Bay is strengthened by the recent strong leadership by the EPA and the use of diverse funding mechanism such as the market mechanism of nutrient trading. At the same time, it is weakened by the lack of integration of monitoring information into the computer simulation models, the results of which guide key decision making such as the determination of loading limits for nutrients into the Bay. In the Baltic Sea, adaptive capacity is strengthened by strong science and availability of resources, but weakened by the lack of diversity of funding mechanisms and the absence of strong leadership.

The work of this paper and previous work on the Great Lakes (Jetoo and Krantzberg, 2015) have only examined the adaptive capacity of three water bodies but the results seem to suggest that certain determinants (e.g., leadership, public participation, networking and flexibility) may be important in building adaptive capacity while others (e.g. strong science), while certainly desirable, may be less necessary. For example, if a system has excellent leadership, public participation, networking, and flexibility, but science and resources are relatively weak, that system could still be considered to have good adaptive capacity. In such a system, strong leadership, well-informed stakeholders and a flexible governance system would allow effective, proactive response to variability and change. This notion that the six determinants may be of different importance can be verified through additional research, for instance involving the development a rating or scoring system.

In cases where deficiencies in determinants of adaptive capacity are identified, there is need for targeted action by decision makers to strength the adaptive capacity. For example, this research identified socio-economic differences amongst littoral countries in the Baltic Sea as an important consideration in adaptive capacity. Following the lessons from Chesapeake Bay, implementation of economic incentives such as nutrient trading could aid in leveling those differences amongst littoral countries in the Baltic Sea and lead to more efficient abatement measures. Adaptive capacity can also be strengthened through more centralized leadership, for example by a council of senior decision makers that represent all the countries in the Baltic Sea Region.

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Chapter 9

Conclusions and Recommendations for Future Research

9.1 Purpose and objectives

In this concluding chapter of the thesis, I summarize the key findings of the thesis and reflect upon their implications for policy and practice. The escalating challenge of nutrient enrichment requires a focus on more adaptive eutrophication governance systems that include technical and hard infrastructure engineering solutions, but these are only a piece of the puzzle. It is time that our attention turns to the social and institutional infrastructure that defines the decision making environment for technical and physical innovations for building adaptive capacity for eutrophication governance. Water bodies such as the Great Lakes that are subject to the stressor of nutrient enrichment need water governance regimes that are adaptable to the complex and interconnected factors that drive eutrophication. These governance regimes also need to be structured to foster elements of adaptive capacity that allow the SES to respond to the stressors before they drive the ecosystem past the point of irrevocable change.

My overall purpose for conducting this doctoral research has been to make a contribution to knowledge for the development of the Great Lakes Nearshore Framework, as set out the Great Lakes Water Quality Protocol 2012. My main goal was to make theoretical, methodological and practical contributions to the governance of complex systems in an uncertain environment. I have situated this research in the context of the stressor of eutrophication to empirically investigate adaptive capacity for eutrophication governance in the Great Lakes Region and in two other nutrients stressed watersheds, Chesapeake Bay and the Baltic Sea. In Chapter 1, I presented these research objectives to aid in achieving my overarching purpose:

1. Contribute to the dialogue on the need for a nearshore governance framework, including identification of the challenges in framework development and the type of thinking that is needed to advance its development.

2. Identify the recurring themes in the history of Great Lakes governance that impact its sustainability and use them to imagine future potential scenarios, including a best-case scenario of a sustainable Great Lakes and St. Lawrence River Basin with robust governance in place, the status-quo scenario of business as usual and, a worst-case scenario of poor governance that contributes to potential ecological disaster.

3. Analyze the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the Great Lakes Water Quality Agreement Protocol 2012 to aid in deducing strategies to maximize strengths and opportunities and minimize weaknesses and threats to achieving the purpose of the Protocol and in the development of the nearshore governance framework.

4. Acquire evidence from primary and secondary literature to assess the effectiveness and potential leadership role of the International Joint Commission as a transboundary bi-national governance institution involved in implementation of the Great Lakes Water Quality Agreement Protocol 2012.

5. Link eutrophication to public health so as to frame eutrophication governance under the public health lens and thus motivate key stakeholders to take action; use the water safety planning approach and the Toledo drinking water crisis as a case study to demonstrate that a risk management approach could help with prevention of contamination of the water supply and ultimately, with lessening nutrient enrichment of source waters

6. Propose a framework for assessing the presence of adaptive capacity for eutrophication governance based on determinants of adaptive capacity derived from the scholarly literature; validate these determinants thorough semi structured interviews in a baseline case of Lake Erie that went from severe eutrophication to restoration of resiliency.

7. Using the framework developed above, analyze the adaptive capacity for eutrophication governance in the Chesapeake Bay and Baltic Sea regions and compare these two cases and develop recommendations to inform governance reform for the Great Lakes.

9.2 Contributions of Research

Chapter 2 of the thesis introduces the nearshore framework and justifies the need for a governance framework for the nearshore areas of the Great Lakes. It shows that the problems in the nearshore result from governance failures and as such, an improved nearshore governance framework is needed. It also shows that the creation of the nearshore framework is challenging due to the uncertain, complex nature of the stressors to the nearshore and thus requires innovative, lateral thinking. Chapter 2 uses Edward DeBono's 'six thinking hats' model to look at the challenge of developing the nearshore governance framework through multiple lenses to spur innovative thinking and to examine each feature of the problem. This chapter showed that while the creation of the nearshore framework faces the challenges of a highly complex, multijurisdictional environment, there is optimism in its inclusion in the Great Lakes Water Quality Protocol 2012. This chapter also showed that the nearshore governance framework will benefit from working with existing institutional mechanisms for a more participatory, integrated and flexible approach that can respond to the integrated sources of stress that are degrading the nearshore areas. Chapter 2 recommends that to advance the ideas into practical implementation, a coordinating body such as the IJC, in cooperation with the Great Lakes Executive Committee, should identify a representative cross section of stakeholders for input in the process of defining or re-defining the nearshore zone. While work is being done on the Great Lakes nearshore monitoring framework, as outlined in Annex 2 of the Great Lakes Water Quality Protocol 2012, there has been no effort thus far to redefine the nearshore zone. Instead, there are conflicting definitions that should be resolved as a basis for future policy and implementation actions.

Chapter 3 adds further context to the development of the nearshore governance framework by providing an overview of governance and geopolitics as drivers of change in the Great Lakes-St Lawrence Basin. This chapter traces historical themes in Great Lakes governance and geopolitics and uncovers recurring themes that have potential impacts on eutrophication governance: institutional fragmentation, the changing relationship between federal and sub-national levels of government in Canada and the US, governance capacity, and the impact of geopolitics on governance. The chapter then goes on to explore these themes under three potential future scenarios: a best-case scenario of a sustainable Great Lakes and St. Lawrence River Basin with robust governance in place, the status-quo scenario of business as usual and, a worst-case scenario of poor governance that contributes to potential ecological disaster. This historical analysis and future projections demonstrate that governance and geopolitics will continue to be significant influences on

Great Lakes sustainability. These problems of governance impact not only water quality and quantity, but also the successful implementation of policies regarding the other potential drivers of change in the Great Lakes Basin such as nutrient enrichment. The chapter shows that governance can be seen as a meta-driver that profoundly influences the degree to which the challenges posed by the other drivers of change will be successfully managed in the future. This chapter makes key policy recommendations: the increasing cooperation between jurisdictions evident in agreements such as the 2008 Great Lakes Compact and Sustainable Water Resources Agreement and the 2012 Protocol must be encouraged in order to overcome the institutional fragmentation that has characterized governance in the basin; the relationship between the states and provinces and their respective federal governments needs to be strengthened; the recent trend of reduced funding for Great Lakes protection must be reversed, the engagement of all stakeholders in the basin must be institutionalized; and there must be a recommitment to the bi-national character of the IJC in order to avoid destructive conflict and competition between Canada and the US.

Chapter 4 makes a contribution by providing the first assessment of the Great Lakes Water Quality Protocol 2012, the policy tool for implementation of nutrient reduction programs in the Great Lakes Region. This paper conducts a SWOT (strengths, weaknesses, opportunities and threats) analysis on the Protocol and shows that it has maintained the basic visionary infrastructure retaining the purpose and main objectives of the original Great Lakes Water Quality Agreement, while broadening the scope to include three new Annexes: Aquatic Invasive Species, Habitat and Species and Climate Change Impacts. This chapter shows that the Protocol has retained the spirit of binationalism of the 1987 Agreement and has expanded to include participation of the public including the Indigenous Community (First Nations, Métis and Tribal leaders), with accommodations for representation of these and other groups on the Great Lakes Executive Committee. The public is also allowed participation through the triennial Great Lakes Public Forum. Chapter 4 shows that key weaknesses of the Protocol include instances of ambiguous language, lack of a distinct Annex on Indigenous engagement and discrepancies between the principles and the Annexes. A key threat remains the lack of resources for the implementation of the Protocol. Chapter 4 provides information that will prove useful for implementation of the Protocol by inviting decision makers to consider important properties of the internal and external aspects of the Protocol.

Chapter 5 builds on Chapter 4 by examining the effectiveness of the International Joint Commission (IJC), the transboundary bi-national institution that could be positioned at the helm of governance to enable the implementation of the Great Lakes Water Quality Protocol 2012 and the goal of sustainability of the Great Lakes ecosystem. Using archival analysis, this chapter shows that the Protocol contains many provisions to enable effective governance by the IJC. The IJC's membership structure, differentiated organizational structure, provisions for public engagement and scope of operations empower that organization, in theory, to achieve the goal of restoring and maintaining the chemical, physical and biological integrity of the waters of the Great Lakes. This review shows that although the Protocol is not a legally binding document, there are sufficient international water law principles in the Protocol to enable the effectiveness of the IJC. Such principles include 'the polluter pays', the precautionary principle and the concept of equitable sharing. However, this analysis also shows that the IJCs effectiveness is hindered by a lack of adequate funding and conflict arising from the lack of timely provision of information of data and information by the Parties to the IJC and the inability or unwillingness of the Parties to implement the recommendations of the IJC. It also shows that there is no mechanism to enforce IJC recommendations. These findings have important policy consequences as they show that failure of the governments of Canada and the United States to follow through on the provisions in the Protocol demonstrates the IJC's limited effectiveness and ultimately could prove damaging to the sustainability of the waters of the Great Lakes ecosystem.

Chapter 6 advances dialogue on eutrophication governance in the context of public health. It investigates a risk management approach to eutrophication governance by examining the August 2014 Toledo 'do not drink' water advisory through the context of the Water Safety Planning (WSP) process. This chapter shows that the Toledo water crisis, where microcystin contaminated municipal drinking water supplies, could have been averted had the WSP approach been employed. This approach would have mitigated risks associated with hazardous events such as unmonitored source water, increased algal blooms, increased microcystin concentrations in source water and lack of treatment capacity to remove contaminants. This chapter shows that this event can be seen as a key focusing event to stimulate action on eutrophication governance, and motivate action to protect water at its source. It also shows that a water safety planning approach could lead to improved operational and maintenance planning, resulting in a higher probability of safe drinking water. This chapter makes a key contribution by re-framing the problem of eutrophication in a new way, telling a story with linkages to human health, and thus guidance toward more effective governance. By shifting the focus of the problem from solely protecting the environment to protecting our own health, and regulating from a public health standpoint (through WSP), the framework for eutrophication governance is broadened and strengthened.

Chapter 7 makes a major methodological contribution to the study of eutrophication governance. It shows that eutrophication is a wicked problem that needs a novel governance solution, such as adaptive governance. It advances the concept of adaptive capacity for eutrophication governance and develops a framework for the assessment of adaptive capacity. The determinants of adaptive capacity that this framework uses were sourced from the literature and empirically tested through key informant interviews in a specific case study where adaptive capacity for eutrophication governance was displayed. The case study was eutrophication in Lake Erie, a system that went from severe eutrophication the 1960s to significant nutrient reduction and ecosystem restoration in the 1990s. The research advances the key determinants of adaptive capacity for eutrophication governance as: **public participation, science, networks, leadership, flexibility and resources**. Results of this analysis are used to identify gaps in adaptive capacity for current eutrophication governance of Lake Erie.

Chapter 8 applies the framework developed in Chapter 7 to compare the determinants of adaptive capacity for eutrophication governance in Chesapeake Bay and the Baltic Sea. It shows the framework developed can be applied to other water bodies that are similarly stressed by eutrophication. Both cases are brackish, shallow water bodies with a large land-to-water ratio that makes them more susceptible to the anthropogenic stressor of excessive nutrient enrichment from both phosphorus and nitrogen, and leads in both cases to the similar outcome of eutrophication. In addition to these ecosystem similarities, these watersheds have had similar successes with lowering nutrient loads from point sources due to successful policies such as imposing discharge limits for sewage treatment plants. While both water bodies have been the focus of environmental protection for the past 35 years, there are also different governance settings and policies that have led to variation in adaptive capacity for eutrophication governance. This research shows that adaptive capacity varies in each watershed with key differences in determinants of adaptive capacity. While public participation has been an established part of the governance of the Chesapeake Bay Foundation, in both that system and the Baltic Sea, the public is not fully engaged, leading to lessened adaptive capacity. Science has played a major role in building adaptive capacity in both watersheds but adaptive capacity is weakened in the Chesapeake Bay by lack of integration of monitoring information into the simulation and loading models that guide decision-making in the Bay. Both areas are highly networked with numerous actors, but this did not lead to a significant improvement in environmental quality. The gap in adaptive capacity is explained by the lack of leadership in both areas; in the case of the Chesapeake Bay, the EPA has assumed strong leadership through the implementation of the Total Maximum Daily Loading but strong leadership is still lacking in the Baltic Sea Region. The work of this paper and a previous one (chapter 7) seems to indicate that some determinants (such as leadership, public participation, networking and flexibility) may be more important in building adaptive capacity than others (such as strong science). This can be verified through further research that ranks determinants. This research also suggests that for areas where there are weaknesses in adaptive capacity, that capacity can be strengthened through focused action by decision makers. For example, benchmarking from the lessons in Chesapeake Bay, adoption of diverse funding mechanisms such as nutrient trading schemes could help in levelling the socio-economic differences amongst littoral countries in the Baltic Sea and lead to more efficient abatement measures. Adaptive capacity can also be strengthened through clearer leadership, for example by a council of senior decision makers that represent all the countries in the Baltic Sea Region.

9.3 Recommendations for Future Research

9.3.1 Build upon the assessment of adaptive capacity

As discussed in Chapter 7, assessing adaptive capacity is difficult as it is mostly latent in nature. While this difficulty does not invalidate the findings of this study, future research should seek to further refine its assessment. This can be done through more extensive data gathering, investigating more cases of ecosystems that proved resilient to eutrophication. For example, Lake Balaton of Hungary went from rapid eutrophication during the 1970s to rapid nutrient reduction during the 1980s (Istvanovics, 2001). Similarly, Lake Biwa in Japan went from severe deterioration due to nutrient enrichment in the 1960s to successfully overcoming the problem of eutrophication decades later (Chunmeng, 2007). Research on assessment of adaptive capacity could also be accomplished through more extensive and iterative surveying and interviewing coupled with physical and environmental data, such as weather information and nutrient loading, to better assess adaptive capacity. Further research should also contain a quantitative element to rank determinants of adaptive capacity in order of importance. This will help to answer questions about how determinants can or should interact and what combinations of determinants are most essential to building adaptive capacity. This in turn can help to inform resource allocation in a resource-scarce environment.

9.3.2 Assessment of adaptive capacity at different scales

One limitation of this research is that it mainly focused on national level actors. While this research focused at the strategic level where eutrophication policies are usually developed and passed into regulations, adaptive actions typically take place at the local scale. This is congruent with climate change adaptation policies, which are typically planned at the national level, but implemented through at local levels by communities (Brunner, 2010). This is seen as a problem of 'fit' by Young et al. (2008), where not enough attention is focused on the complex linkages between social ecological systems and their manifestations at different geographical scales. This problem of fit was addressed by multi-level governance systems in the case studies, where policies and implementation actions for eutrophication governance occurred at different scales. As such, it is recommended that future research focus more on assessing adaptive capacity across a variety of scales: local, river basin, regional, national and international. This can be done by conducting more extensive interviews with stakeholders at each of these scales.

9.3.2 Adaptive capacity across governance contexts

This research assumes that adaptive capacity for eutrophication governance is built through decisions made by stakeholders in various constituencies. These can be decisions by individual farmers to implement best management practices, decisions by organizations such as wastewater utilities to upgrade sewage treatment plants, decisions by civil society to advocate for changes and decisions by governments to enact legislation to accomplish environmental change. The ways in which nutrient enrichment is governed depend on the multiple interactions amongst these decision-making institutions. Institutional adaptive capacity is the capacity of institutions at varying levels to cope with and make adjustment to unwanted change. In the current context, it means the capacity of such institutions to counteract the impacts of eutrophication by implementing measures to reduce nutrient enrichment and encourage a return to ecosystem resiliency. Each governance type can be linked to the presence or absence of determinants of adaptive capacity, and their combination across scales. Further research should investigate whether the presence of certain combinations of determinants result in particular governance typologies. I hypothesize that governance systems that react to stressors after they have resulted in eutrophication have fewer determinants of adaptive capacity compared to systems with more determinants and thus better flexibility to anticipate and proactively respond to stressors. I recommend that this hypothesis be investigated in future research.

9.3.3 How do exogenous factors influence adaptive capacity

The determinants for adaptive capacity that were developed in this study did not take into consideration exogenous factors: those that influence nutrient enrichment of waters but are beyond the watershed scale. These factors include practices that allow trading mechanisms such as large-scale imports/exports from the US and Europe. For example, in 2010 the EU imported US$320M of feed and fodder from the US, while the US imported US$217M of feed and fodder from the EU. These practices have resulted in excessive nutrient discharges in both the US and the EU, arising from over-fertilization of crops with manure and (where manure transport or use ifs infeasible) from the use of high yield chemical fertilizers (HELCOM, 2009). Another exogenous factor what would be worthwhile investigating would be the impact of information about phosphorus source and supply on farmers' phosphorus conservation practices and hence the impact on adoption of best management practices. Phosphorus is sourced from a finite supply of phosphate rock and its worldwide use is increasing due to increasing population and increasing food consumption and wastage. Recycling and the closing of phosphate loops are essential to conserving this vital resource and will help in reducing nutrient enrichment to aquatic systems.

9.3.4 Further research on the Great Lakes multi-level governance systems and network analysis

This research has touched on the topic of multi-level governance and has shown that it is necessary to build adaptive capacity across governance levels. As all the case studies have shown, stakeholders such as the former Great Lakes United, the John Nurminen Foundation and the Chesapeake Bay Foundation are playing a key role in eutrophication governance, changing the narrative from traditional top-down (e.g., federal) governance to more collaborative governance forms. This research describes networking amongst local government stakeholders, civic organizations, and subnational units that introduce their own policies and coordinate common efforts to influence eutrophication governance. As the John Nurminen Foundation pointed out, non governmental actors became involved because they were frustrated by the failures of government to take effective action. The results of this research reveal a clear need for both horizontal and vertical coordination, a clear need for multi-level governance to help in building adaptive capacity for eutrophication governance. It was beyond the scope of this research to conduct a detailed network analysis of actors and the multi-level governance systems. Further research should be conducted with the aim of answering questions such as what networks exist and what strengths they might have in addressing issues of eutrophication governance. Deeper questions include what kind of institutional variation can be observed in the governance regimes, what kind of multi-level governance structures exist, and what participatory mechanisms are available. How is representation determined and how does it materialize? Is there variation in multi-level governance structures across cases? If so, how does it affect governance effectiveness? And finally, how do these influences differ for national, regional and international watersheds?

9.4 Policy recommendations

This research has shown that eutrophication is a wicked problem characterized by high levels of complexity and uncertainty. It has demonstrated that lack of leadership is one of the key barriers to building adaptive capacity for eutrophication governance in the Great Lakes Region, and that institutional fragmentation and lack of effective coordination are challenges to Great Lakes governance.

The efficacy of adaptive governance in building adaptive capacity against nutrient enrichment is the capacity to deal with complex, uncertain issues associated with Social Ecological Systems and how collective action can be designed to cope with this complexity. Greater leadership capacity in two areas is the best hope for adaptive change. As Miller (1999) has suggested, the key may lie in more effective leadership from the bureaucratic and scientific establishment and the inclusion of wise advisors in collaborative problem solving. In the current study, the Baltic Sea case study showed that effective leadership by the John Nurminen Foundation during periods of adaptive change encompassed a blend of traditional (vision and action, e.g., through upgrade of wastewater treatment plants) and new collaborative leadership styles (bringing together the governments of Finland, players in Russia and other stakeholders to fund and implement the project). Chrislip and Larson (1994) studied over 50 leadership case studies and highlight the following characteristics of collaborative leaders: they inspire political and personal commitment and action; they function as peer problem solvers; they build broad based involvement in collaborative enterprise; and they work to sustain hope and encourage participation in the consensus building process.

As shown in Chapters 5 and 7, the International Joint Commission has taken on this collaborative leadership role in the past, leading to effective policy instruments during the previous eutrophication of Lake Erie (1970s-1990s). During this period, there were higher levels of vertical (federal, provincial/state and municipal) and horizontal (wastewater, detergent manufacturers, community groups) coordination, with the state actors (federal governments) effectively integrating non governmental actors. However, as this research has shown, the IJC is no longer empowered to be as effective as it once was. This could be due to the view, as expressed by one key government official, that the IJC is no longer as needed as it was in the past: “In the past the IJC facilitated government to government interaction, which was needed at the time. We do not need the IJC to play the same role now” (GL9). However, other key informants recognize the potential and experience of the IJC as the leader and wish to see a reinvigorated IJC. In the words of one key informant: “The IJC during the 1970s had real clout, it was the watchdog and it had teeth. In the 1980s this power was taken away. Give me magic power for one day and I will create a strong IJC.” (GL1) The key recommendation from this research is therefore increased collaboration through investment in a culture of leadership in the Great Lakes. This should be done in a number of ways: i. A renewed IJC supported by resources appropriate to its role; ii. Collaboration through economic incentives, such as nutrient trading in the case of Chesapeake Bay and, because key informant interviews reflect a loss of leadership capacity over the last several decades, iii. Fostering Great Lakes leaders of the future through a GL leadership center jointly funded by the United States and Canada. The latter notion is discussed in more detail in Section 9.4.3.

9.4.1 The nearshore governance framework and a renewed IJC

This research has advanced the concept of adaptive capacity for eutrophication governance, recognizing eutrophication as a wicked problem. It has shown that six determinants - public participation, science, networks, leadership, flexibility and resources – are necessary for building adaptive capacity in a nutrient enriched environment. A further recommendation of this research is therefore that the nearshore framework as outlined in Annex 2 of the Great Lakes Water Quality Protocol should be further defined to include provisions for a nearshore governance framework and should empower the IJC to take on a collaborative leadership role.

As discussed in Chapters 2 and 3, the current Great Lakes governance system is highly fragmented and characterized by players at both vertical (federal governments, states and provinces, municipalities) and horizontal (municipalities) levels interacting in a multilevel binational setting. As such, a single impartial coordinating body is needed. An obvious choice is be the IJC, which has already been assigned this role under the Boundary Waters Treaty. Positioning the IJC in a central coordinating role would, however, require the (re)building that organization's capacity to do the work it was originally envisioned to do. Relevant text in Article III of the Boundary Waters Treaty clearly places the IJC in a leadership role, and grants it the sole authority to oversee changes in uses or modifications to the boundary waters between the US and Canada:

> It is agreed that, in addition to the uses, obstructions, and diversions heretofore permitted or hereafter provided for by special agreement between the Parties hereto, no further or other uses or obstructions or diversions, whether temporary or permanent, of boundary waters on either side of the line, affecting the natural level or flow of boundary waters on the other side of the line shall be made except by authority of the United States or the Dominion of Canada within their respective jurisdictions and with the approval, as hereinafter provided, of a joint commission, to be known as the International Joint Commission.

Article IV also points to this key leadership positioning of the IJC:

> The measurement and apportionment of the water to be used by each country shall from time to time be made jointly by the properly constituted reclamation officers of the United States and the properly constituted irrigation officers of His Majesty under the direction of the International Joint Commission.

A proposed model for a nearshore governance framework that positions the IJC in the key leadership role is shown in Figure 9.1. In this model, the Great Lakes ecosystem is envisioned as a highly adaptive system that is fostered by the determinants of adaptive capacity from the adaptive capacity "ball". A ball is seen as the appropriate construct for an adaptive Great Lakes ecosystem that is resilient to nutrient enrichment and has the ability to bounce backward or forward into a new state while retaining core function and purpose, buffering stressors and retaining its core function and purpose. The lines separating the determinants of adaptive capacity (or segments on the ball) are 'squiggly' as they flexibility. This highly adaptive, resilient system facilitates the adaptive governance structure at the center of the 'ball'.

At the center of this adaptive governance structure is the IJC in a collaborative leadership role. In this role, the IJC can act as a connector, to encourage and combine different types of knowledge and create opportunities for greater partnerships on nutrient reduction projects. The Great Lakes Executive Committee (GLEC), under the Great Lakes Water Quality Protocol 2012, is positioned to bring stakeholders together; however it is also the implementer and thus too finely focused on implementation issues to effectively collaborate and act as a connector. As noted by Folke et al. (2005), leadership can institute meaningful change in governance by fostering institutional processes that encourage and combine different sources of knowledge, create opportunities for self organization and nurture the capacity for self renewal. As this research has shown, public learning and cooperation from all stakeholders is very important for building adaptive capacity. It is envisioned that in this adaptive system, the IJC could take leadership as the fountain of cooperation, where other cooperative actions and agreements cascade from the networks facilitated by the IJC. In this newly empowered state, as illustrated in Figure 9.1, as the fountain of cooperation, the IJC would be provided with adequate resources to bring together a core policy network of trusted government officials and leaders representing key stakeholders at all levels of society.

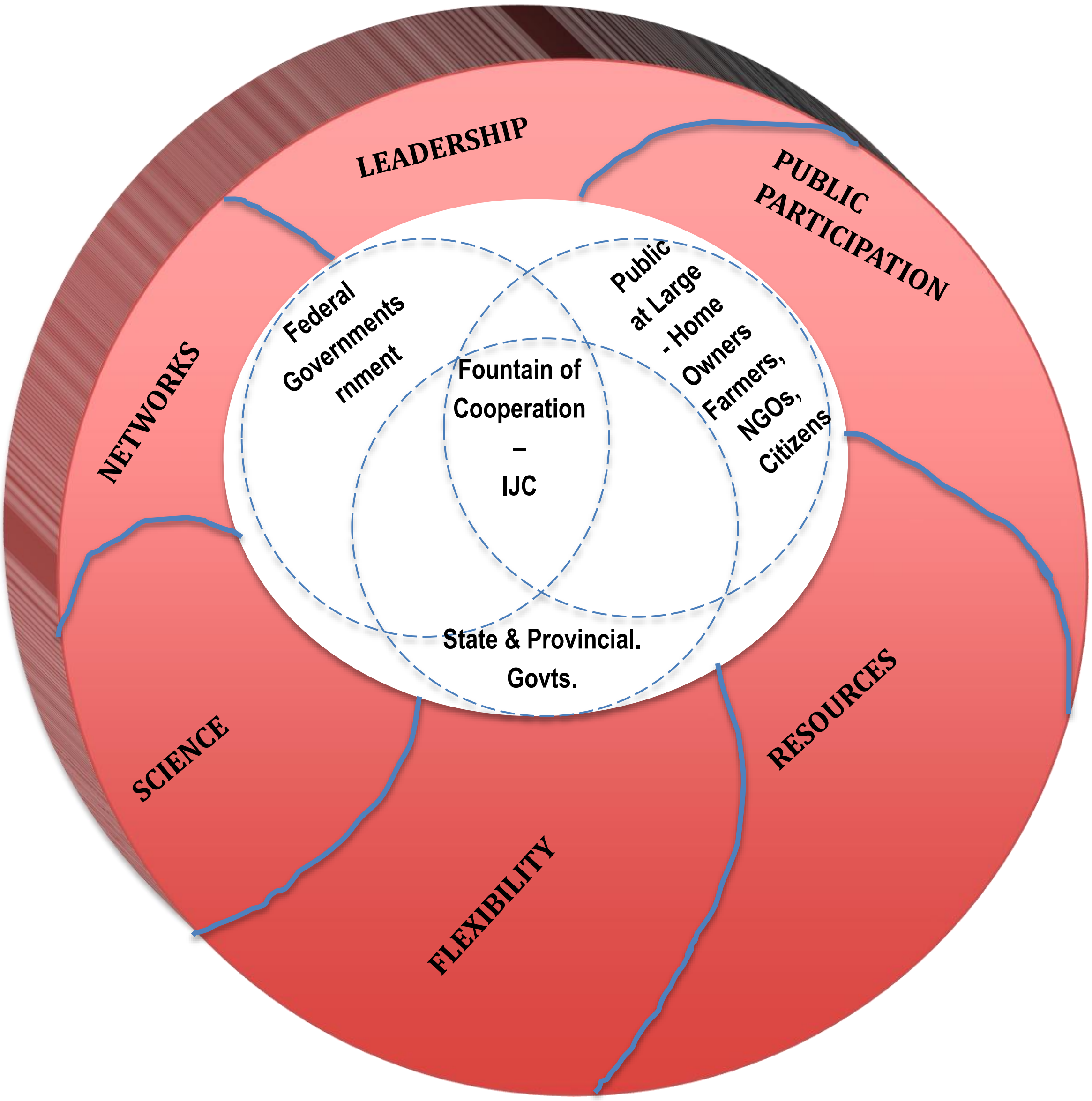

Figure 9.1 –The Adaptive Capacity Ball – The proposed nearshore governance framework showing the IJC in key collaborative leadership role

As shown in Figure 9.1, the IJC would act as the bridge, facilitating dialogue and cooperation between the federal governments, the local governments, the states, province and the public at large. The dashed lines in Figure 9.1 show the fluid interactions that facilitate the free flow of information across all stakeholder groups, in an environment where there is trust in the leadership of the IJC. In this role, the IJC's role would be much like that of HELCOM in the Baltic Sea, getting stakeholders to the table and holding governments accountable for their actions or inaction. It would also have a strengthened role for fact-finding, science and conflict resolution.

This framework directly engages the determinants of adaptive capacity that emerged in Chapter 7 by:

- Facilitating public participation through engagement in forums (such as conferences) on eutrophication governance and other key issues that encourage comprehensive and meaningful participation of all stakeholders. A key task here would be to determine the timing and scope of the engagement. This also entails the gathering of disparate voices in the cases of disagreement on key issues so as to facilitate the reaching of agreement;

- In coordination with the Great Lakes Executive Committee (GLEC), establishing channels for the productive and respectful exchange of information and also for the establishment of testing protocols for measuring nutrient runoff, for measuring eutrophication water related parameters;

- Facilitating respectful networking through the establishment of protocols and interagency agreements to forge working agreement on issues to be resolved and to help ensure linkages to formal decision making;

- Providing leadership by expertly guiding parties to discern the key interests of all stakeholders, help them to discover and create joint gains and mutually win-win solutions, and assist them in making informed choices;

- Facilitating learning and feedback processes through helping to clarify a shared vision, helping participants adjust to new roles and responsibilities in monitoring and assessment of progress, and making changes based on new information. The IJC should help in raising tough questions that foster creative learning and problem solving; and

- Conducting cost benefit analysis of proposed nutrient reduction strategies to motivate funders to invest in actions to reduce nutrient pollution and spur innovation. Facilitating effective allocation of resources to optimize nutrient reduction per dollar invested; this should also include studies on market mechanisms and the potential to improve the efficacy of nutrient reduction programs.

This fountain of leadership facilitates cooperation between non government organizations, farmers, industries, First Nations and Tribes, local governments, provincial and state governments and federal governments through interagency agreements, and through forums that enable them to present and exchange views. The fountain becomes the nexus for public learning by spanning the local government agencies and grassroots leaders such as farmers' cooperatives. Local governments can tap into wider provincial/state and federal networks that include scientists and federal agencies such as Environment Canada and the US Environmental Protection Agency. The resulting intergovernmental coordination could facilitate harmonization of regulatory and legislative rules and the sharing of essential information. As shown by the overlapping circles of the Federal Government and the public at large in Figure 9.1, in this model the IJC facilitates more effective engagement of these two key groups through meetings, conferences, public forums and workshops. Under this model, the public at large, the grassroots level, would be more able to access expertise available in the federal government and the local government networks and also their own networks to share information and encourage overall cooperation with adaptive governance rules. The interaction that is facilitated by the fountain of cooperation - the IJC - brings together groups of actors that are often in conflict, and thus enhances social capital and acts as an incubator of cooperation.

The IJC can facilitate cooperation among the public and federal, aboriginal, state and provincial governments through its Boards; currently the IJC's boards (Great Lakes Science Advisory Board, Great Lakes Water Quality Board, Air Quality Advisory Board, and Health Professionals Advisory Board) include participation by the public (academia, citizens, industry). These Boards are led by US and Canadian Co-Chairs, and are charged with investigating issues and reporting on them to the IJC's Commissioners, who may or may not adopt the boards' recommendations. It is recommended that the IJC facilitate communication between governments and the public at large through the hosting of international forums on key priority issues and issues identified in the Boards' reports, such as implementation of best management practices and responding to and reporting on nuisance algal blooms. These should be forums where the IJC ensures (through invitation) that there is targeted representation of government agencies, Tribes and First Nations, municipalities, affected stakeholder groups, and the public at large. The IJC can facilitate cooperation by enhancing dialogue among governments and

Great Lakes stakeholders. An example would be the initiation of a formal Water Safety Planning process for each of nutrient hotspots in the Great Lakes, as outlined in Chapter 6, The IJC could facilitate dialogue to strengthen existing governance mechanisms through a common focus on risk management to assure drinking water safety.
Over time, this framework builds adaptive capacity for eutrophication governance by helping to develop cooperative ventures between stakeholders. This could draw from the experience of organizations such as INTERACT in the Baltic Sea Region, which brings stakeholders together through workshops and communication to focus on best practices for key areas such as communication, programme management, financial management and knowledge management to foster communication and coordination on key issues throughout the region.

9.4.2 Collaboration through the use of incentives

This thesis has shown that the Great Lakes governance landscape is highly fragmented and that there is need for greater integration. A governance model for collaboration was advanced. Whilst the governance structure is important, the case of the Chesapeake Bay shows that incentives (and disincentives) can also foster collaboration. For example, the lawsuit of the Chesapeake Bay Foundation against the EPA led to the imposition of a TMDL rule and a watershed agreement amongst the states. Also in Chesapeake Bay, nutrient trading has led and continues to lead to collaborations and partnerships amongst varying degrees of nutrient dischargers, where nutrient offsets can be bought from discharger with lower control costs. According to Scholz and Stiftel (2005), many cooperative outcomes depend on the use of a ‘carrots and sticks’ reward approach, where consensus building efforts can promote learning but sustaining long term relationships for goal attainment can be difficult without threats and promises. As the case of the Great Lakes shows, nutrient reduction in Lake Erie from the 1970s to the 1990s was achieved with the help of regulations that controlled phosphates in detergents and that set limits on effluents from waste water treatment plants. It is therefore recommended here that further study be done on the potential use of market incentives such as nutrient trading to combat the issue of nutrient enrichment in Lake Erie.

9.4.3 Fostering Great Lakes leaders

Chapter 3 of this thesis was part of the Great Lakes Futures Project, whose aim was to "assess past and potential future states of the Great Lakes-St. Lawrence River Basin, inform strategic policy formulation, frame research priorities, and help train the next generation of Great Lakes leaders." (Great Lakes Futures Project, 2013). This project brought together researchers from 21 research organizations in the US and Canada to mentor over 40 graduate students to research drivers of change to the Great Lakes Basin and to imagine future leadership scenarios. While this is a first step of building leadership skills through mentorship and knowledge transfer, there is a clear need for an ongoing Great Lakes leadership center to foster leadership skills both amongst the next generation of leaders and also to build more collaborative leadership skills in persons in positions of leadership. The highly uncertain, complex environment presented by eutrophication calls for flexible, adaptive leadership skills, in contrast to the ad hoc leadership that often emerges in crisis situations. Other leadership programs such as Waterlution (2014), 'Transformative Leaders of the Future', provide forums for fostering leadership skills such as communication, but do not focus on the development of collaborative leadership skills, and thus fall short of the current need in the Great Lakes

The University Network for Collaborative Governance (UNCG) at Portland State University is perhaps a better example of an initiative aimed at fostering collaborations. According to its website, the UNCG has the following aims (Portland State University, 2015):

- Advance teaching, research, and outreach in public deliberation, collaborative problem solving and multi-party conflict resolution;
- Share knowledge, information, and best practices among members;
- Assist universities in shaping and adapting their research, teaching, and outreach to enhance their effectiveness;
- Acquaint university leaders, policymakers, and the public with the role universities can play in carrying out collaborative governance practices;
- Provide linkages between university centers and programs and leaders interested in using collaborative governance practices; and
- Promote policies that support the use of and best practices for collaborative governance.

While this model is focused on the university system and not a more complex suite of stakeholders, it still provides useful guidance for building leadership skills for an increasingly uncertain environment. The UNCG (2015) believes that leaders provide a neutral, transparent setting, include all interests willing to contribute and ensure that government and others implement these solutions together; these are important traits to foster for leadership that builds adaptive capacity, and important lessons for a potential Great Lakes Leadership Centre.

Such a center could initially be funded through a major public sector partnership grant (e.g., through Canada's Social Sciences and Humanities Research Council partnership development grant program), through foundation funding, through collaborative arrangements with academic institutions, or possibly even through public-private partnerships. Such a center could be used by governmental agencies, NGOs, municipalities and academia to provide participants with opportunities to develop leadership skills through diverse programming modes. Examples could include experiential learning, conferences, and training workshops focused on building the leadership skills most useful in a highly complex, uncertain environment: skills that would help in building adaptive capacity.

9.5 Summary

Overall, this research makes a contribution to knowledge for development of the nearshore governance framework. By showing that eutrophication is a wicked problem, it advances the concept of adaptive capacity for eutrophication governance and develops and tests determinants of adaptive capacity. This framework for adaptive capacity is then tested in the context of the Baltic Sea and the Chesapeake Bay, and found to be effective and appropriate.

This work is just the beginning of this conversation; more work need to be done to apply this framework to other watersheds and to expand the strategic lens through which we look at eutrophication governance. Further work will help to build empirical evidence that can be translated into policy measures for more effective eutrophication governance.

The most important finding of this work is that the key barrier for building adaptive capacity for eutrophication governance in the Great Lakes is the lack of adequate leadership and resources. A key recommendation is therefore that the IJC be strengthened in its role to function as a collaborative leader to foster adaptive capacity.

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