EXECUTIVE SUMMARY

As climate change continues to threaten natural environments worldwide, sustainable resource management becomes increasingly significant. In environments where economically, culturally, and ecologically valuable ecosystems cross jurisdictional boundaries—like the Lake Champlain Basin, which falls under New York, Vermont, and Québec’s jurisdictions—stakeholder involvement in all aspects of protection and conservation of the lake becomes additionally complex. Currently, Lake Champlain faces many threats, including high in-lake phosphorus concentrations. Due to nutrient run-off from point and non-point sources, phosphorus can contribute to the growth of algal blooms containing toxic cyanobacteria. In order to manage phosphorus and other pollutants entering the lake, the jurisdictions surrounding the lake have created water quality standards (WQS) and overlapping regulations at both the international, national and local levels. However, the current regulatory framework has several impediments including discrepancies between the jurisdictions’ water quality standards; lack of accurate measurement for in-lake phosphorus levels; inconsistent revision process for in-lake phosphorus standards; restrictive role of the U.S. federal government; and a limited role of the Lake Champlain Basin Program (LCBP) in the water standard development and revision process. As a result, despite the jurisdictions’ best efforts to work together to improve the lake’s health, the current regulatory framework does not always allow for consistent, coordinated, or efficient management that is flexible and addresses uncertainties.

In order to address some of these problems within the conventional regulatory frameworks, adaptive management has been proposed. The theory of adaptive management describes an iterative process that emphasizes three principles: efforts at predictability, flexibility and inclusivity. Translating adaptive management theory to implementation can be difficult because of a misunderstanding of the theory; the spatial variations within each ecosystem; the lag time in the natural response of the ecosystem; and the costs associated with enacting adaptive management. From the theory of adaptive management, this project identified tools that will aid the implementation of adaptive management at any given site. Some of the tools include a learning feedback loop, established hypotheses, policy review process, established timeline, a venue for all stakeholders, and a commitment to enacting adaptive management.

By incorporating the tools of adaptive management, we recommend that a site-specific solution using adaptive management be developed by local organizations that are most familiar with Lake Champlain’s dynamic ecosystem to ensure that all stakeholders fully understand the management approach. Additionally, the underlying interests of different jurisdictions should be understood to develop cohesive management approaches. To increase communication and transparency between jurisdictions, an online database should be established. And lastly, short-term goals should be emphasized to increase public support, such as reducing visible toxic algae blooms. If an adaptive management approach is implemented successfully to reduce in-lake phosphorus concentrations, the framework can also be used for other contaminants present in Lake Champlain.
Acknowledgments

We would like to thank our community partners, the Lake Champlain Basin Program and the Lake Champlain Committee for their incredible support, inspiration, and assistance throughout the semester. They have shared with us a vast amount of knowledge and have been wonderful groups to work with. Specifically, we would like to extend our thanks to Eric Howe, Mike Winslow and Philip Halteman for providing important insights and sharing their time. Without their commitment and interest this project would not have been possible.

We would also like to thank the many other individuals we interviewed at the EPA, New York DEC, Vermont DEC, and the Vermont ANR. Our project would not be nearly as comprehensive without their help and direction.

In addition, we would like to acknowledge the professors and coordinator of the ES401 seminar at Middlebury College, Stephen Trombulak, Catherine Ashcraft, and Diane Munroe, who have tirelessly worked with us to improve our project. Also our peers in ES401 deserve special thanks for providing important feedback.

Finally, we would like to thank the Department of Environmental Studies at Middlebury College for facilitating and supporting this research.

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1. INTRODUCTION

Lake Champlain is a 490 square-mile freshwater lake that sits within the regulatory jurisdictions of Vermont, New York and Québec (Figure 1). This shared lake acts as a year-round resource for many towns and their businesses, provides numerous opportunities for recreation, and serves an important role in local cultures (“Welcome”). In the context of local management, the lake’s many usages demonstrate that the resources of the basin’s soils, tributaries, wetlands, ponds, and bays all have greater significance beyond simple ecological well being (“A Vibrant Region”). Currently, Lake Champlain faces a plethora of anthropogenic environmental problems—high nutrient loading, contaminants, invasive species, and climate change—that put the economy, cultural heritage, and natural processes in jeopardy. Each of these anthropogenic environmental issues not only poses a serious threat to the ecological, social, and economic security of the Lake Champlain region, but also highlights the shortcomings of the existing local political frameworks intended to address and mitigate the issues.

Consider an ecosystem, such as the Lake Champlain Basin. Ecologically, natural systems like this one constantly evolve in response to changes in their surroundings. Although Lake Champlain serves as an important resource for local livelihoods and, as such, locals have learned much about the workings of the basin, there remains a high degree of ecological uncertainty. A Danish study from 2009, for example, suggests that climate change could be expected to increase phosphorus runoff and eutrophication in temperate lakes like Lake Champlain (Jeppesen et al.). Thus, as the realities of climate change and the subsequent changes in weather pattern continue to grow and persist, so will the lake ecosystem change in new and different ways. Taking into account in-lake pollution in this context demonstrates the need for an adaptive water quality standard policy that is able to deal with this complex, dynamic system and the effects that any pollutant, not just phosphorous, might have on it. Such standards are absolutely critical, especially as a great number of residents in Vermont, New York, and Québec depend on the lake as a key resource. Moreover, water quality standards are not only limited to management of the lake itself, but rather effect the rivers and streams that feed into the lake, the management of nearby land, agricultural decision-making, and the process of urban development. Maintaining healthy water quality represents only one small piece of the larger local ecosystem sustainability puzzle.
Yet, such a broad perspective on the importance of an adaptive approach to managing water quality does not convey the extent to which these political changes are necessary right now. The present urgency can be conveyed by Figure 1.2 which shows an algal bloom in Lake Champlain. Higher than normal phosphorous levels in Lake Champlain trigger the mass growth of algae (“State of the Lake”). These algal blooms inhibit swimming and other recreational uses—like kayaking and fishing—harming the lake’s tourism industry. Fishing is further made difficult by the dead zones that are created by dissolved oxygen depletion upon algal decay. These blooms may further be populated by blue-green cyanobacteria, which release cyanotoxins that pose health risks to humans and animals alike. The pollution and subsequent disturbances may have significance for local cultural heritage, especially in the tradition of the Algonquin Abenaki Native American tribes that, as demonstrated in Box 1.1 below, place high value on water spirits and the health of the lake in their stories. Finally, this portion of the lake is aesthetically displeasing and, frankly, no longer serves as an adequate resource for the local population.

The current political framework for water quality standards in Lake Champlain has demonstrated an inability to deal with these phosphorous issues, as evidenced by unfulfilled goals and the continued presence of destructive algal blooms ("State of the Lake"). A lack of flexibility in this current regulatory framework stands as a foundational cause for this lack of success. Without flexibility across standards, policy cannot be counted on to shift to incorporate new scientific discovery.

“When the people saw the water come rushing down, many of them were so happy that they leaped into the water. The one who said he would dive deep and never come up turned into a fish. The one who said he would swim around forever turned into a frog. And the one who said he would drink and drink and never stop also turned into a little fish. Many of those in the village of thirsty people were transformed in that way. To this day there are Abenaki people whose names show that they are descended from the ancestors who turned into water creatures and who still swim around in the water which no one can ever keep for themselves or own.”

- “Gluskabi and the Water Monster” from The Wind Eagle by Joseph Bruchac

Box 1.1. Excerpt from an Abenaki tale demonstrating the importance of water to local cultural heritage.
1.1 Phosphorous Pollution in the Lake

In this paper, we examine this management inefficiency through the lens of the particular issue in the lake responsible for these algal blooms—high phosphorus concentrations. While phosphorous is necessary for the natural growth and development of flora and fauna from the smallest bacteria to larger vertebrates, an overload of the nutrient in aquatic ecosystems encourages an unhealthy environment. The vast majority of phosphorus that flows into the lake comes from non-point sources, a result of erosion and runoff from local forests, agricultural fields, and urban environments flowing into tributaries in the basin. For example, although urban and suburban areas only represent 5% of the watershed land cover, as much as 46% of phosphorous runoff originates from this land use type (Stickney). Due to the nature of its pathway to the lake and, thus, the subsequent difficulty associated with assigning responsibility for this type of nutrient excess, loading from non-point sources proves much harder to control than from its counterpart, point-source pollution. Point-source pollution, by contrast, refers to pollution released into the lake at specific points, such as the wastewater treatment facilities within the Lake Champlain Basin, and accounts for a smaller percentage of total phosphorous concentration.

Once in the lake, dissolved phosphorus follows the steps of its unique phosphorus cycle, as aquatic organisms that require it for growth consume the nutrient. However, high concentrations of phosphorus increase the rate of growth among algae and plant species, contributing to overgrowth of vegetation and large-scale algal blooms. The immediate ecological consequences of this rampant growth are threefold. First, thick vegetation monopolizes nutrient resources and can either hinder the development of—or crowd out—other species. This is especially problematic in cases where invasive species gain an advantage over their native competitors. Second, algal blooms in Lake Champlain may be composed of blue-green cyanobacteria, which, in sizeable concentrations like large blooms, release toxins into the lake that cause health-related issues to humans and animals. Finally, large-scale blooms result in proportionally large amounts of dead material at the end of the algae’s life cycle. As this organic matter sinks to the lake bottom it triggers a boom in the population of decomposers, which use up the water’s store of dissolved oxygen in the process of breaking down the material. Ultimately, the deprivation of oxygen in the microenvironment renders the area uninhabitable for most species, establishing a temporary dead zone (“State of the Lake”). All three of these consequences have serious ramifications for the ecological health of Lake Champlain.

1.2. Research Objectives

An ideal political system in the Lake Champlain region would focus on learning from the implementation and monitoring processes for standards in the natural system and would then bring that knowledge back to an established review process. Our research considers the concept of adaptive management. We accomplish this both in the context of the Lake Champlain Basin and, more specifically, through the lens of the pervasive issue of phosphorous overloading. After researching the benefits and pitfalls of adaptive management and discussing the lake’s issues with our community partners from the Lake Champlain Basin Program (LCBP) and Lake Champlain Committee (LCC), we set out with
four comprehensive objectives to understand if and how the basin’s policy framework may be improved. They are:

1) Identify the processes by which the current Lake Champlain water quality standards for phosphorus were developed and approved across the jurisdictions.

2) Analyze areas of the regulatory framework that are inflexible and research how adaptive management might help achieve water quality goals for phosphorus concentration.

3) Research and compare impediments to changing the water quality standards from humanistic, policy, and scientific perspectives.

4) Finally, make both general recommendations for increasing flexibility in the management of pollutants in Lake Champlain and specific insights for the management of phosphorous.

Ultimately, we hope to provide our community partners, local policy-makers, Champlain region residents, and other readers with guidelines for the creation and implementation of an adaptive management strategy for the Lake Champlain Basin.
2. RESEARCH METHODOLOGY

In order to address our four objectives, we devised a workplan to outline our timeframe, sub-goals, and methodology for obtaining information. We maintained frequent communication with our community partners, Eric Howe of the Lake Champlain Basin Program, Mike Winslow of the Lake Champlain Committee, and Philip Halteman (Doctoral candidate at the University of Vermont working with LCBP and LCC) who provided us with additional resources. We collected data through content analysis of the relevant literature as well as through interviews with various stakeholders.

Exploration of the current regulatory framework for phosphorus standards in New York and Vermont required extensive analysis of state and federal legislation. We studied the original text of these documents, and also referred to the EPA, New York State and Vermont State Departments of Environmental Conservation websites for online summaries of the Clean Water Act (CWA), and explanations of Water Quality Standards (WQS) and effluent standards (TMDL) for phosphorus in Lake Champlain. We also conducted phone and email interviews with the following stakeholders who have expertise on the existing statutory authorities, development of phosphorus standards, and revisions of these standards in New York, Vermont, and/or Québec:

**Eric Smeltzer:** Environmental Scientist for the Watershed Division of the Vermont Department of Environmental Conservation within the state’s Agency of Natural Resources. Responsibilities include “scientific studies, monitoring, and policy analysis to support regulatory and management programs on Lake Champlain and other Vermont Lakes” (“Watershed Management Division”).

**Eric Perkins:** Region 1, EPA New England, Vermont TMDL Coordinator, Watersheds and Non-point Source Branch. Currently working to revise the Lake Champlain phosphorus TMDL for Vermont, which was originally approved in 2002.

**Steve Stoner:** Chief, Standards and Analytical Support Section, Bureau of Water Quality Management, Division of Water, New York State Department of Environmental Conservation. Contact for information regarding the existence of and revision of Title 6 New York Codes, Rules and Regulations (NYCRR) Parts 700-706 on Water Quality Standards (“revisions will add/revise ambient water quality standards, standard-setting procedures, implementation procedures and other regulatory provisions”) as well as for information on existence of and revision of 6 NYCRR Part 830, Lake Champlain Drainage Basin (“Revisions will reclassify surface waters as needed to provide water quality protection consistent with designated best usages, as well as the Clean Water Act (CWA) Section 101(a)(2) goals”) (“Regulatory Agenda”).

After uncovering the ways in which phosphorus in Lake Champlain is regulated, we proceeded to deconstruct the regulatory framework and identify potential pitfalls. The result is an outlined description of how we feel the current frameworks’ effectiveness may be improved. This analysis leads into a discussion of adaptive management, both as theory, and as a set of tools that may be implemented to reduce potential weaknesses within
current processes of phosphorus regulation. This discussion was informed by literature on adaptive management, as well as by several case studies in which adaptive management was implemented in environments analogous to Lake Champlain. Our conception of adaptive management and how it may be applied to our case also required extensive communication with our community partners, and specifically with:

**Eric Howe:** Technical Coordinator for the Lake Champlain Basin Program (LCBP). Coordinates the LCBP Technical Advisory Committee and manages Basin-oriented research at the federal, state, and local level.

**Philip Halteman:** PHD Doctoral candidate at the University of Vermont working with LCBP and LCC to research water quality issues in Lake Champlain and community involvement within the watershed.

**Mike Winslow:** Staff Scientist for the Lake Champlain Committee (LCC) and chair of the Technical Advisory Committee for LCBP.

This paper draws heavily upon communication with these stakeholders as well as the previously mentioned content analysis conducted throughout the semester.
3. CURRENT REGULATORY FRAMEWORK IN LAKE CHAMPLAIN

The current political landscape for Lake Champlain is characterized by an overlapping scheme of standards and regulations in diverse forms. These vary on a scale from international and national systems to state, provincial, and local levels. This section summarizes the political structure of key jurisdictions.

3.1. Federal Clean Water Act and State Responsibilities

While the United States federal government ultimately has the authority to oversee the management of any interstate waterbody, New York and Vermont have significant roles in developing water quality standards for Lake Champlain, especially with respect to phosphorus (“The Clean Water Act”).1 In order to address phosphorus pollution in Lake Champlain, New York and Vermont have assumed their responsibilities within the Clean Water Act’s (CWA) Water Quality Management (WQM) process. Through this process, these states have been given the authority to develop and revise Water Quality Standards (WQS) for pollutants, such as phosphorus for Lake Champlain. These standards are set according to what New York and Vermont state environmental agencies deem appropriate, and should account for non-point sources of pollution from urban, agriculture, and silviculture, as well as point sources of public and industrial pollution (“Water Quality Division”). Section 303 (e) of the CWA mandates each state prepare plans to achieve water quality standards for each watershed in the state. So, while New York and Vermont state environmental agencies have ultimately considered phosphorus WQS in Lake Champlain, this federally mandated responsibility also requires states to divide their attention across numerous water bodies.

3.2. Vermont

Vermont Water Quality Standards (VWQS)

In Vermont, the Agency of Natural Resources (VT ANR), the Vermont Water Resources Panel, and the Agency of Agriculture, Food and Markets—which share the administration of the federal CWA in Vermont—are mandated to carry out water quality planning and protection. The Vermont Water Quality Standards (VWQS) serve as the basis for protecting Vermont’s surface waters, which include Lake Champlain. The VWQS are regulations that classify each body of water, establish uses (e.g. swimming, drinking, fishing) that must be protected, and set minimum physical, chemical, and biological standards that must be met in all of Vermont’s waters. The VWQS are broadcast by the Vermont Water Resources Panel and help to plan, manage and regulate programs to protect Vermont’s surface waters (“Water Quality Division”). They are used by the Vermont Department of Environmental Conservation (VT DEC), within the VT ANR, to determine surface water conditions, including whether the water meets or does not meet (exceeds) certain criteria. The outcome of the Department’s assessment is a categorization of Vermont’s surface waters as either “full support,” “stressed,” “altered,” or “impaired.”

For phosphorus the general policy in all Vermont waters is “total phosphorus loadings shall be limited so that they will not contribute to the acceleration of
eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses” (“Vermont Water Quality Standards”). There are numeric in-lake total phosphorus concentration criteria for each segment of Lake Champlain, which were incorporated into the Vermont Water Quality Standards in 1991 following a public rule-making process (see Figure 3.1.). The specific phosphorus criteria for each segment of the lake were derived, in part, from a lake use survey analysis of the relationship between aesthetic values, uses, and total phosphorus concentrations (Lake Champlain Phosphorus TMDL). In order to ensure phosphorus concentrations in each segment of the lake are not being exceeded, Vermont established the Lay Monitoring Program in 1979. The Lay Monitoring Program is a cooperative effort between the Vermont DEC and lake users to describe water quality conditions, establish a database useful for documenting future changes in lake water quality, and to educate and involve lake residents in lake protection (“Vermont Lay Monitoring Program”).

<table>
<thead>
<tr>
<th>Lake Segment</th>
<th>Criterion (mg/l)</th>
<th>Measured Value (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Lake B</td>
<td>0.025</td>
<td>0.058</td>
</tr>
<tr>
<td>South Lake A</td>
<td>0.025</td>
<td>0.034</td>
</tr>
<tr>
<td>Port Henry</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>Otter Creek</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>Main Lake</td>
<td>0.01</td>
<td>0.012</td>
</tr>
<tr>
<td>Shelburne Bay</td>
<td>0.014</td>
<td>0.015</td>
</tr>
<tr>
<td>Burlington Bay</td>
<td>0.014</td>
<td>0.013</td>
</tr>
<tr>
<td>Cumberland Bay</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>Mallets Bay</td>
<td>0.01</td>
<td>0.009</td>
</tr>
<tr>
<td>Northeast Arm</td>
<td>0.014</td>
<td>0.014</td>
</tr>
<tr>
<td>St. Albans Bay</td>
<td>0.017</td>
<td>0.024</td>
</tr>
<tr>
<td>Missisquoi Bay</td>
<td>0.025</td>
<td>0.035</td>
</tr>
<tr>
<td>Isle LaMotte</td>
<td>0.014</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Figure 3.1. Lake Champlain total phosphorus criteria (Lake Champlain Management Task Force 1993, Vermont Water Resources Board 1999) compared with measured 1990-1991 mean concentrations in each lake segment (Vermont DEC and NYSDEC 1997) (Lake Champlain Phosphorus TMDL 8).

WVQS: Process of Development

Until the 2012 Legislative Session, Vermont had a unique system for managing surface waters and wetlands. The State previously had a citizen’s panel called the Water Resources Panel (formerly the Water Resources Board) that operated under the Natural Resources Board and was the organizing body that wrote the initial Water Quality Standards (“Natural Resources Board”).ii The panel was independent of the three branches of government and was supported by administrative staff including lawyers. The panel frequently consulted with VT ANR calling on their staff’s technical expertise. Recently, the water rulemaking authority was transferred from the panel to VT ANR, possibly because of the agency’s greater familiarity with local environmental conditions and its employment of several specialists and field researchers. As a result, the VT ANR and more specifically, the VT DEC, now amends and revises the water quality standards (Welts 4/20/13). Under the Clean Water Act, the standards are supposed to be revisited every three years, but that has
VWQS: Process of Revision

In order to determine appropriate standards, the VT DEC conducts research and presents the findings to an informal advisory group that was recently formed called the Water Quality Advisory Committee (WQAC). The WQAC consists of seven members and one alternate who represent different stakeholder interests (e.g., environmental advocates, higher education, businesses, regional planning commissions). The VT DEC is currently using the WQAC to help understand some of the stakeholder concerns with proposed revisions. After receiving the WQAC’s input, the VT DEC engages in a public participation process. They hold public meetings and receive public comments on their proposed revisions. Then the VT DEC provides a response summary that responds to comments received during this comment period, which typically lasts 30 days. Multiple meetings may be held if there are especially contentious issues like the anti-degradation policy (“Antidegradation Overview”). Once they have received comments and responded, decisions about whether to move forward into rulemaking proceedings are made. This involves filing the proposed changes with the Secretary of State and the Interagency Committee on Administrative Rules (ICAR) (Welts 4/20/13).

There are 4 filing stages in the normal adoption process of an administrative rule. First, ICAR reviews it to make sure it is consistent with other administrative agency rules. Secondly, the proposed rule is filed with the Secretary of State. This begins the public comment period where further comments are received and reviewed. After this, the VT DEC files their proposed final rule with the Legislative Committee on Administrative Rules (LCAR), where state legislators discuss whether the rule is appropriate. Once LCAR has voted to approve or object to the rule, DEC will file the final rule with the Secretary of State, making the VWQS revisions final. Interestingly, the DEC can file a final rule over LCAR’s objection, but this is an extremely rare occurrence (Filing Instructions).

In summary, for water quality standards to be changed in Vermont, DEC files the proposed rule (the VWQS revisions decided upon after receiving advice from the WQAC and public input) with the Secretary of State and the Interagency Committee on Administrative Rules. The process is lengthy and, according to the Staff Attorney at the VT DEC, this process takes the best part of a year at its quickest and can take many years if there are contentious issues that require several public hearings. However, once rules are finalized they are difficult to overturn, so the long process upfront is important to ensure the rules are appropriate. In relation to new information, it is clear that if a new pollutant was introduced into Lake Champlain, creating, approving, and perhaps one day changing those rules or standards would not be a quick process. The sluggish process of the current conventional framework has potential for serious consequences if a pollutant’s concentration increases rapidly and is harmful.

![Figure 3.2. Process of Revision for VT WQS.](image)
3.3. **New York**

*New York Water Quality Standards (NYWQS)*

New York has also developed its own Water Quality Standards (WQS) through the coordination of the USEPA, and the New York Department of Conservation (NYSDEC). Established through the Environmental Conservation Law (ECL) in July 1970, the NYSDEC serves as the regulatory and permitting authority that oversees all state programs designed to protect and enhance the environment. The agency’s mission is “[t]o conserve, improve and protect New York’s natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being” (“About DEC”). Headed by a commissioner, who is assisted by executive managers, the DEC has 24 divisions and offices and is organized into several bureaus in order to carry out the responsibilities identified in the ECL (“About DEC”). One of these responsibilities is to establish water quality standards for all state waters. The Water Quality Standards and Classification program is responsible for setting state ambient water quality standards for surface waters and ground waters, classifying surface waters for their “best use.” While this program is overseen by the USEPA, it is actually a state program that predates the CWA (“Water Quality Standards and Classifications”). Within the New York Codes Rules and Regulations (NYCRR), Title 6 describes water quality standards either as a narrative or as a numeric concentration. If no standard exists for a certain pollutant, the values may be derived and compiled in Division of Water guidance through technical “Fact Sheets” (“Water Quality Standards and Classifications”).
Although New York has agreed to numeric standards that Vermont proposed, the official WQS for phosphorus concentrations in New York freshwaters is narrative (“Part 703: Surface Water”). Seen in Figure 3.3 below, according to the NYSDEC, phosphorus concentrations in water bodies such as Lake Champlain are measured along the following restriction: “[n]one in amounts that will result in growths of algae, weeds, and slimes that will impair the waters for their best usages” (“Part 703: Surface Water”). The best uses of Lake Champlain’s water are classified under the following categories: health of the water with respect to drinking and fish consumption, health of aquatic species and other wildlife, the aesthetics of the lake, and recreational uses of the lake (“Part 701: Classifications”).

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste-, color-, and odor-producing,</td>
<td>None in amounts that will adversely affect the taste, color or odor thereof, or impair the waters for their best usages.</td>
</tr>
<tr>
<td>toxic and other deleterious substances</td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>No increase that will cause a substantial visible contrast to natural conditions.</td>
</tr>
<tr>
<td>Suspended, colloidal and settleable solids</td>
<td>None from sewage, industrial wastes or other wastes that will cause deposition or impair the waters for their best usages.</td>
</tr>
<tr>
<td>Oil and floating substances</td>
<td>No residue attributable to sewage, industrial wastes or other wastes, nor visible oil film nor globules of grease.</td>
</tr>
<tr>
<td>Garbage, cinders, ashes, oils, sludge and other</td>
<td>None in any amounts.</td>
</tr>
<tr>
<td>refuse</td>
<td></td>
</tr>
<tr>
<td>Phosphorus and nitrogen</td>
<td>None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages.</td>
</tr>
<tr>
<td>Radioactivity</td>
<td>Should be kept at the lowest practicable levels, and in any event should be controlled to the extent necessary to prevent harmful effects on health.</td>
</tr>
<tr>
<td>Thermal discharges</td>
<td>None in amounts that will impair the waters for their best usages.</td>
</tr>
<tr>
<td>Flow</td>
<td>No alteration that will impair the waters for their best usages.</td>
</tr>
</tbody>
</table>

**Figure 3.3.** Narrative Water Quality Standards for New York State (“Part 703: Surface Water”).

Another way in which the USEPA and the NYSDEC collaborate to set the phosphorus standards for Lake Champlain is through the NPDES program outlined in sections 402 and 404 of the CWA (“The Clean Water Act”). The purpose of the NPDES program is to enable authorized states to control water pollution by regulating point sources that discharge pollutants into waters of the United States (point sources are defined as discrete conveyances such as pipes and man-made ditches) (“National Pollutant Discharge”). Such regulation is also in accordance with the state’s Soil and Water Conservation District Law, which addresses non-point source abatement and control projects for pollutants such as phosphorus that may have originated from farms or backroads. Furthermore, in August 2010, the NYSDEC amended the ECL to include a section prohibiting the sale and commercial use of household cleaning products that exceed specified concentrations of...
phosphorus (§§ 35-0103–0105). Most recently, in January 2012, the NYSDEC pushed through a restriction on the sale and use of phosphorus fertilizer on lawn or non-agricultural turf (§17-2103) (Wroth 172).

NYWQS: Process of Development

Although interstate efforts to improve Lake Champlain’s water quality have been focusing heavily on phosphorus concentrations as of late, New York’s narrative WQS is not a recent development. According to Scott Stoner, the current Chief of the Standards and Analytical Support Section for the Bureau of Water Assessment and Management within the NYSDEC’s Division of Water, the narrative phosphorus standard has been in place for at least 25 years (Stoner 4/15/13). Though some minor revisions may have taken place since New York’s narrative standards were originally set in 1967 (this section of the NYCRR has been re-filed in 1972, 1978, 1991, and amended in 2008), these adjustments are likely to have “involved the NYSDEC with oversight by EPA and would have been part of a larger triennial review rulemaking, so in total, would have taken a couple of years.” Nevertheless, “just crafting the language for this one narrative standard would have been a short process” (“Stoner 4/15/13”).

Despite New York’s long-standing enforcement of a narrative WQS for phosphorus, the U.S. EPA is currently requiring the NYSDEC to “identify nutrient criteria values—initially focusing on phosphorus in fresh waters—that are protective of water quality in New York State” (“Nutrient Criteria”). New York has avoided establishing nutrient criteria thus far for several reasons: first, nutrients are naturally occurring and everywhere in our environment, so more stringent criteria are expected to affect many activities, stakeholders, and regulatory programs; second, some levels of nutrients are necessary for a healthy ecosystem and appropriate levels of nutrients vary from water-body to water-body, depending on a variety of characteristics (for example, depth, stream flow, water temperature, etc.); and third, elevated nutrient levels by themselves do not normally cause direct impairment (except at extremely high levels), but rather, they can produce conditions, such as reduced clarity, weed/algal growth, and low dissolved oxygen, that can impair aquatic life, water supplies and recreational uses (“Nutrient Criteria”). Nevertheless, the EPA may consider nutrient criteria and numeric standards to enable the NYSDEC to monitor phosphorus concentrations in Lake Champlain with greater precision and effectiveness. So, once the NYSDEC decides on an appropriate numerical value, the public will have an opportunity to comment on the proposed criteria at various public and informational forums, and the nutrient criteria can then be enforced (Stoner 4/11/13).

NYWQS: Process of Revision

Such revisions to the existing phosphorus WQS, however, are supposed to be part of an ongoing process of collaboration between the NYSDEC and the U.S. EPA. According to the CWA 303 (c):

\[(c)(1) \text{The Governor of a State or the State water pollution control agency of such State shall from time to time (but at least once each three year period beginning with}\]
\[\text{the date of enactment of the Federal Water Pollution Control Act Amendments of}\]
\[\text{1972) hold public hearings for the purpose of reviewing applicable water quality}\]
\[\text{standards and, as appropriate, modifying and adopting standards. Results of such}\]
\[\text{review shall be made available to the Administrator (“Clean Water Act Section 303”).}\]
Based on the CWA, state-determined WQS—both narrative and numerical—are supposed to undergo triennial review. However, “the reality of state rulemaking processes mean that these deadlines are not always met” (Stoner 4/11/13). New York claims to review its standards periodically, with the last review having been completed in 2008 (Stoner 4/11/13). Currently, the NYSDEC is working with EPA Region 2 in order to conduct the next federally mandated "triennial review" of the State’s water quality standards, including the narrative WQS for phosphorus ("Revision of New York’s Water"). Despite the apparent difference between narrative and numerical WQS, the two types of standards are revised the same way. The NYSDEC proposes new language in a public rulemaking process. This responsibility is carried out by the NYSDEC’s Division of Water Standards Section Chief (currently Scott Stoner), but must be approved at the Executive level (Stoner 4/11/13). This process is simplified in Figure 3.4. below.

![Figure 3.4](image)

**Figure 3.4. Process of Revision for NY WQS.**

For any problems that may arise, it is through this process that these issues would be addressed. This includes concern about pollutants in the future, as well as current efforts to review existing standards. In the review process that is underway, the department is only in the pre-public proposal phase of this process. The NYSDEC and EPA staff are considering a wide range of revisions/additions to water quality standards regulations and the NYSDEC expects to be completing a draft proposal over the next several months (“Revision of New York’s Water”). After the draft is completed, the DEC will conduct an assessment of the regulatory impact of proposed changes. Once the assessment is finished and the proposal has undergone full internal review, it will be released for public comment, at which point the department will hold a public hearing at several public information settings around the State in order to receive feedback. For the current revision process, this public involvement is likely to occur by the end of the year and will be promoted via the New York State Register and the DEC’s Environmental Notice Bulletin (“Revision of New York’s Water”).

**3.4. Vermont and New York Total Maximum Daily Loads (TMDL)**

Despite the development and revision of in-lake phosphorus standards, water sampling and the increased presence of algae blooms in the lake demonstrate that the in-lake WQS had been exceeded. Therefore the standards may be particularly ineffective or phosphorus is hard to regulate. As a result, the states collaborated to create an effluent standard for phosphorus loading into Lake Champlain. This loading standard, is called a
Total Maximum Daily Load (TMDL) and is established by the CWA Section 303 (c) which explains that

\[(d)(1)(C)\] Each State shall establish for the waters identified in paragraph (l)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality (“Clean Water Act Section 303”).

Thus, the phosphorus TMDL set by Vermont and New York and approved by the USEPA is “the maximum amount (load) of a single pollutant [phosphorus] from all contributing point and non-point sources that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources” (“What is a TMDL?”). A TMDL is required for Lake Champlain because both states have deemed the lake as an “impaired” water body and states may be unable to meet their in-lake WQS. The following figure illustrates places in the lake where the phosphorus concentrations in Lake Champlain exceeded Vermont’s numeric phosphorus WQS from 1990-2001. This discrepancy is the basis for Vermont and New York’s 2002 TMDL.
Figure 3.5. Annual mean total phosphorus concentration (mg/l) in Lake Champlain segments during 1990-2001, in comparison with in-lake criteria (horizontal lines) (Source: United States EPA, New York State Department of Environmental Conservation, and Vermont Agency of Natural Resources, Department of Environmental Conservation (Lake Champlain Phosphorus TMDL)).

**TMDL: Process of Development**

Before establishing such a TMDL, states must assess whether their water quality standards are met in their rivers, lakes, and streams. The CWA mandates such a process, for states are required to "periodically assess and report on the quality of waters in their
state,” but also to “identify impaired waters, where designated uses are not fully supported.”

For waters that are found as impaired, states are required to develop a TMDL or other pollutant reduction strategy to reduce the input of the specific pollutant(s) restricting water body uses, in order to restore and protect such uses. These results are then summarized in Section 303(d) lists which states produce every 2 years (“Water Quality Assessments”). These lists are separated into three main parts: (1) Individual Water Bodies with Impairment Requiring a TMDL; (2) Multiple Segment/Categorical Impaired Water Bodies - Includes Acid Rain Waters, Fish Consumption Waters, and Shell Fishing Waters; and (3) Water Bodies for which TMDL Development May Be Deferred - Includes Waters Requiring Verification of Impairment, Waters Requiring Verification of Cause/Pollutant, and Waters Where Implementation/Evaluation of Other Restoration Measures is Pending (“New York State Section 303(d)").

After classifying Lake Champlain as a “priority” water body and listing phosphorus as a “pollutant of concern,” the NYSDEC sought to determine a TMDL for the lake, which Vermont also agreed was necessary (The Final New York State 2012 Section 303(d)). Thus, in 2002, after 12 years of research and negotiation, VT ANR and the NYSDEC created the “Lake Champlain Phosphorus TMDL” (Smeltzer 4/9/13). This document set the effluent phosphorus limits for Lake Champlain such that the states could consider “seasonal variability and include[d] a margin of safety that accounts for uncertainty of how [phosphorus] pollutant loadings may impact the receiving water’s quality” (Lake Champlain Phosphorus TMDL). While the TMDL was developed in accordance with Section 303(d) of the Clean Water Act, 40 CFR 130.7, and other relevant USEPA guidance documents including USEPA New England Regional Guidance on Submittal Requirements for Lake and Reservoir Nutrient TMDLs (USEPA 1991, 1999a, 1999b), it also needed to be reviewed by Vermont and New York citizens. Thus, after the public had an opportunity to review and comment on the report at public informational meetings, VT ANR and NYSDEC submitted the TMDL to the USEPA, who approved the TMDL in 2002, and it has subsequently been incorporated into state water quality management plans (Lake Champlain Phosphorus TMDL).

**TMDL: Process of Revision**

On January 24th, 2011, in response to a federal lawsuit filed by the Conservation Law Foundation (CLF), the EPA reconsidered and eventually revoked its previous approval of Vermont’s 2002 Lake Champlain TMDL. The CLF asserted that the previous standard contained insufficient assurance for water quality protection. The main issue the EPA is focusing on during the current revision is developing stronger reasonable assurance that sufficient non-point source phosphorus reductions will be achieved moving forward. Under federal law, the EPA is responsible for establishing a new TMDL to implement the applicable water quality standards. The EPA initiated the process of developing a new TMDL for Lake Champlain in 2011, in cooperation with the State of Vermont, and should be approved in 2014 (“The Vermont Lake Champlain Phosphorus TMDL”). Once the EPA establishes the TMDL, it will be up to the State of Vermont to determine how to reduce total phosphorus loading. The state can require reductions from any of the major phosphorus contributors, including sewage treatment facilities, storm-water systems, and agricultural land uses.
Typically, however, a TMDL is only reviewed and changed when a state decides that some aspect of the TMDL is in need of a major update. For example, a new TMDL might be needed if new discharges are added that were not accounted for in the original TMDL, or if the water quality standards affecting the waterbody were modified (Perkins 4/11/13). Despite the current revision to the Vermont TMDL, from a process standpoint, such revision is quite rare, due primarily to resource constraints of state and federal monitoring agencies (Smeltzer 4/9/13). Furthermore, most TMDL revisions are completed by states and then submitted to EPA for approval. With respect to the ongoing revision of Vermont’s TMDL, EPA’s review of the effluent standard is part of the settlement agreement between the federal government and the suing party (CLF). Under EPA regulations, if EPA disapproves of a TMDL, EPA is required to revise and issue a new TMDL itself. Although the disapproval of Vermont’s TMDL does not apply to the New York portion of the Lake Champlain TMDL (which was approved separately from the Vermont portion in 2002), EPA plans to involve New York in the development of the new Vermont TMDL which might affect the New York TMDL, including for example, any updates to the lake modeling work used to develop the phosphorus loading capacity of the lake (“EPA Takes Step”).

3.5. Québec

Québec Water Quality Standards (QWQS)

In Canada, provinces, such as Québec work with the Federal government to regulate discharges of waste into “prescribed water quality management areas” and participate in federal water quality management programs for inter-jurisdictional waters (“EPA Takes Step”). As a result, Québec’s water quality standards for phosphorus in Lake Champlain must be consistent with Canadian Environmental Quality Guidelines. Because in-lake phosphorus concentrations vary depending upon water depth, area of the waterbody, etc., Canada has developed a guidance framework with trigger ranges, thus allowing for site-specific management of the nutrient. The trigger ranges are <4, 4-10, 10-20, 20-35, 35-100, and >100 micrograms of total phosphorus per liter of water, and correspond to the labels: ultra-oligotrophic, oligotrophic, mesotrophic, meso-eurotrophic, eutrophic, and hyper-eutrophic (“Canadian Water Quality Guidelines” 1). If the upper limit of the range is exceeded further assessment of the water quality is required. Currently, no national environmental quality guidelines exist for phosphorus, however, the Canadian Environmental Protection Act, and other general policies set levels for phosphorus in laundry detergents and prohibit the manufacture and sale of products that contain phosphorus exceeding these levels (Wroth 172).

Similar to the way in which the U.S. CWA delegates WQS development and revision to states, the Canada Water Act gives provincial governments the authority to oversee water resource management. Québec’s Ministère du Développement durable, de l’Environnement, de la Faune, et des Parcs (MDDEFP) is analogous to the NYSDEC and VT ANR, for it also oversees environmental quality at a provincial level. The MDDEFP has been given the task of establishing requirements for the protection of human health and biological resources with a purpose of preserving, maintaining, and recovering the use of water and aquatic biological resources. With respect to phosphorus, the agency has
established its own general numerical criterion of 0.020 mg/l of total phosphorus applicable to all lakes and 0.030 mg/l for streams. These criteria were set to eliminate nuisances caused by algae proliferation in water bodies and to protect values and uses including aquatic life, recreational water contact activities, raw public water supplies, and aesthetics (Environment Canada).

With respect to Lake Champlain, this involves providing environmental discharge objectives (EDOs) for sources of water pollution. Such objectives are based on the desired level of quality, defined in terms of real and potential uses of the water. The MDDEFP established quality criteria for each use of water which include drinking, consumption of fish, shellfish and crustaceans, aquatic life, terrestrial and avian piscivorous wildlife, and recreational activities (“Surface Water”).

The table below compares the ways in which New York, Vermont, and Québec monitor their in-lake and effluent phosphorus standards for Lake Champlain.

<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Water Quality Standards</th>
<th>TMDL</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Yes, narrative</td>
<td>Yes, 2002 with Vermont</td>
</tr>
<tr>
<td>Vermont</td>
<td>Yes, numerical</td>
<td>Yes, undergoing revision</td>
</tr>
<tr>
<td>Québec</td>
<td>Yes, numerical</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 3.6. A comparison of current regulations across the U.S. state and Canadian provincial jurisdictions.

Process of Development and Revision

Similar to the Vermont and New York WQS development and revision process, the federal government in Canada also refers such responsibilities to the provincial governments. Yet while the Québec MDDEFP has the authority to set these standards, the Canadian government must ultimately approve the numbers according to their own federal guidelines. This federal development and approval process is described in the chart below.
Figure 3.7. Canadian Guidance Framework for management of phosphorus in freshwater (source: Canadian Council of Ministers of the Environment).

The general trigger ranges in this chart refer to those mentioned in the earlier section with respect to phosphorus concentrations in Canadian freshwater. The Recommended Assessment Tools outline the potential for a revision process, or adjustment to the WQS if the need arises.

3.6. U.S.-Canada Cooperation

The way in which Québec develops and establishes its WQS also reflects the province’s collaborative efforts with its equivalent agencies in New York and Vermont. The LCBP, for example, provides a forum through which these jurisdictions can communicate about Lake Champlain’s water quality. Participation in non-binding agreements with New York and Vermont helps Québec regulate in-lake and effluent phosphorus concentrations in
the lake. For example, Québec and Vermont signed an agreement to reduce phosphorus in Missisquoi Bay in 2002, and Québec's provincial government has repeatedly signed Memorandums of Understanding on Environmental Cooperation on the Management of Lake Champlain with the State of New York and State of Vermont (“Cooperation Agreement”).

Furthermore, in 1993, the Lake Champlain Phosphorus Management Task Force established phosphorus criteria in VT, NY, and Québec for Lake Champlain. Based on the Task Force’s report numeric criteria were endorsed as a set of consistent phosphorus management goals for the lake in a New York, Québec, and Vermont Water Quality Agreement (Lake Champlain Phosphorus TMDL). The 1993 Water Quality Agreement established in-lake total phosphorus concentration goals ranging from 0.010-0.025 mg/l for 13 segments of Lake Champlain (see Figure 3.1.). Though these criteria were never adopted as the official WQS in New York or Québec, they do continue to serve as management goals for the lake in all three jurisdictions. So, while these values are not considered to be binding standards, they are considered to be guidelines throughout the lake basin (Smeltzer 4/9/13).

Much of Québec’s collaboration with New York and Vermont also falls under the International Joint Commission’s (IJC) authority. Established by the Boundary Waters Treaty signed by the United States and Canada in 1909, “the IJC has two main responsibilities: regulating shared water uses and investigating trans-boundary issues and recommending solutions” (“Role of the IJC”). In addition to fulfilling these responsibilities with respect to the Great Lakes, and several rivers, the IJC oversees New York, Vermont, and Québec communication regarding Lake Champlain. Yet despite the LCBP’s collaborative efforts, and the IJC’s connection to the U.S. and Canadian federal governments, there is still the potential for communication lapses and ineffective non-binding agreements across New York, Vermont, and Québec with respect to Lake Champlain’s water quality standards and phosphorus concentrations, specifically. This will be described in further detail in the section below.
4. ANALYSIS OF CONVENTIONAL REGULATORY FRAMEWORKS AND RECOMMENDATIONS FOR ADAPTIVE MANAGEMENT

4.1. Impediments within the Current Regulatory Frameworks

Although some aspects of current regulatory frameworks allow for effective water quality management, the current phosphorus levels in Lake Champlain indicate that the existing regulations in New York, Vermont, and Québec may need to be improved in order to sufficiently protect this trans-boundary waterbody. Outlined below are some impediments within the current frameworks that prevent more efficient, consistent, and coordinated water quality management within the Lake Champlain Basin.

(1) Discrepancies between NY, VT, and Québec WQS:
- While Vermont and Québec rely on numerical standards to measure phosphorus concentrations in Lake Champlain, New York’s standard is narrative. As a result, the three jurisdictions may not share the same short-term goals for improving Lake Champlain’s water quality (and reducing phosphorus pollution).
- New York is working to develop numerical standards, however, developing specific numeric criteria for nutrients is complicated by a number of factors mentioned earlier.
- Despite the agreements that have been made between the state and provincial governments, the overarching framework of U.S., Canadian, and International law lacks a focal point that allows for smooth and enforceable coordination. Organizations such as LCBP have attempted to serve such a function, yet may still be limited by different expectations—and therefore varying participation—from each jurisdiction ("Mission"). A more adaptable framework would further encourage jurisdictions to address environmental, economic, and cultural issues that confront the lake, not just respond to the pollution that results from these issues (Wroth 173).

(2) Inconsistent review and revision process for in-lake and effluent standards
- In-Lake Standards: despite the U.S. CWA requirement that states review their WQS every three years, this does not always occur. As mentioned in the NY WQS Revision section, New York is currently reviewing standards that had not been revisited since 2008 (Stoner 4/11/13). This suggests that the NYSDEC, and likely the Vermont and Québec WQS regulatory agencies as well, lack the financial and/or personnel resources to review these standards at the necessary frequency.
- Effluent Standards: At the state level, the TMDL revision process is perceived to be difficult and there is little incentive to motivate states to take on this effort. As a result, Vermont and New York did not actively review their 2002 TMDL after it was established. It was only after CLF sued over Vermont’s insufficient progress in lowering the in-lake phosphorus concentrations that the state re-evaluated its TMDL (and continues to do so).
- States may be hesitant to review their standards on a regular basis, for frequent revision suggests that the standards are flexible to change. While flexibility may be
perceived positively, it may also mean that there is the possibility that new controversy or political pressure could result in backsliding on water quality goals rather than moving forward (Perkins 4/11/13). In other words, changes in the greater political atmosphere may lead to changes in water quality standards if they appear extremely malleable.

(3) Existing WQS and TMDL for phosphorus may not provide regulating agencies with the most accurate way to measure or manage in-lake nutrient levels

- WQS: Even though New York is currently revising its narrative WQS for phosphorus in an effort to improve the standard’s accuracy, numeric nutrient criteria are still not part of the state’s review. “Nutrients are a notable national problem and cause of many water body impairments. EPA has been pushing states to adopt nutrient criteria for at least 10 years, and [NY] recognizes that nutrients are an issue that it needs to address. [Nevertheless, NY’s] nutrient criteria will be in guidance and not regulations, at least initially” (Stoner 4/14/13).
- TMDL: Effluent water quality standards have long been regarded as outdated when considering nutrient overloading from non-point sources. These regulations were written for cases where traditional point sources (WWTFs) were the primary or only concern. Even though states are required to identify non-point sources, explain how they contribute to non-attainment of water quality standards, and design control programs to address the non-point sources causing non-attainment, it is not happening in all states (Smeltzer 4/16/13).
  - As mentioned previously, this is the main reason the TMDL in Vermont is being rewritten. Although the TMDL was not initially written to reduce non-point source pollution, some believe there are ways to work around that, and EPA guidance has helped with this over the years.

(4) Restrictive role of the federal government in standard review and monitoring process

- NYSDEC seems to closely work with EPA Region 2 to revise phosphorus standards and monitor the condition of the lake. However, this EPA branch proved reluctant to become involved in VT’s TMDL revision process, as evidenced by its lawsuit with CLF regarding the TMDL’s ineffectiveness. The EPA only became involved during the lawsuit and through its settlement with CLF.
- While both the U.S. CWA, and Canada’s Water Act grant states/provinces the authority to develop their own water quality standards, these federal laws do not permit states/provinces to engage in binding international agreements. Thus, despite the collaborative efforts between NY, VT, and Québec, these efforts are more indicative of a willingness to adhere to guidelines but not of a commitment to abide by specific regulations.

(5) How defined are the roles of LCBP and other organizations with respect to standard development and revision?

- Although the LCC encourages interstate collaboration, and the LCBP and IJC enable the three jurisdictions to discuss trans-boundary water quality, these organizations may be limited in their ability to effect change at a state or federal policy level. While
members of NY, VT, Québec and federal regulatory agencies participate in these organizations, their agendas may not always be considered as high priority within greater political and economic spheres.

- These organizations garner significant public support for cooperative water resource management. The LCBP’s Citizen Advisory Committees (CACs) in New York, Québec, and Vermont, for example, provide a forum for citizens, interest groups, and local governments to discuss lake issues; distribute funds to community based projects through LCBP Partnership Program grants; advise the Steering Committee regarding state legislative bodies and local groups; make recommendations to the Steering Committee about Plan priorities; and encourage agencies to follow through with their commitment to the Plan. Nevertheless, the actual impact that these CACs have with respect to the WQS and TMDL revision and development process is difficult to measure.

- Without a defined role in the WQS or TMDL development and review process, these organizations may struggle to determine how they can most effectively contribute to the effort, and may therefore fail to sufficiently communicate. Thus, there is the potential for these organizations to become fragmented and disconnected from other stakeholders.

These impediments within the current regulatory frameworks may be preventing effective management of Lake Champlain, especially with respect to phosphorus. Although the current regulations have reduced point-source phosphorus pollution, addressing the non-point sources have proved much more difficult. Phosphorus pollution from these sources cross jurisdictional boundaries and negatively impact the lake’s water quality. In order for New York, Vermont, and Québec, to reduce in-lake phosphorus, their regulatory frameworks must be flexible enough to account for and address phosphorus pollution that is not contained within one jurisdiction.

So, in order to improve the existing frameworks so that they better reflect Lake Champlain’s dynamic system, they must be made more adaptable to changes to the lake’s water quality and changes to in-lake phosphorus levels. In comparison to the conventional framework through which phosphorus is monitored and regulated for Lake Champlain, an adaptive management approach will better enable the jurisdictions to protect this valuable trans-boundary waterbody.

### 4.2. Adaptive Management: Introduction and Theory

**Brief History and Background**

The idea of adaptive management first appeared in academic literature roughly fifty years ago courtesy of Beverton and Holt (1957) (Williams; Beverton and Holt). Since then, numerous works in academia have developed and shaped the concept. For example, Kai Lee made one of the most notable contributions to the structural formation of adaptive management in his book, *Compass and Gyroscope: Integrating Science and Politics for the Environment* (1993). As a board member of the Northwest Power Planning Council trying
to manage the Columbia Basin, Lee recognized the need for a new constructive way to manage efforts at sustainability. He emphasized the importance of the role of learning in environmental management, thereby contradicting more popular tendencies that simply employed trial and error methods. The fundamental difference between what Lee proposed and trial and error is that the former is testing a specific hypothesis or assumption, while the latter does not incorporate predictions into methods in a systematic fashion. Trial and error methods, Lee claimed, fail to deliberately learn from the process and make use of the acquired knowledge. These *ad hoc* methods were consequently inefficient and needed alterations. This revolutionary realization and supporting insights served as a new foundation for adaptive strategies, becoming a universal reference for many adaptive management cases (Appendices 1-4).

**What is Adaptive Management?**

The Lake Champlain Basin, like any ecosystem, is comprised of and influenced by a multitude of evolving ecological and social processes. Adaptive management theory recognizes that an ecosystem is more than simply the sum of its natural and social components and, thus, an adaptive policy framework seeks to create a management scheme in the context of this fluid and multi-dimensional reality. While the primary idea of adaptive management stresses making decisions in the face of ecological uncertainty, the ultimate goal is an effective policy that accepts dynamism in the system it seeks to govern. This necessitates an operation that stresses the importance of both experiential and experimental knowledge and a political “learning by doing” process. Adaptive management, then, sees environmental management and policies as experiments with observable enviro-socio-political outcomes (Lee). This results in a framework in which uncertainties are embraced, rather than conveniently ignored. Often in conventional management practices, such uncertainties are expressed as disagreements among stakeholders who have differing opinions on issues such as the effectiveness of the practice and the impacts of management interventions. Thus, in fear of introducing points of confrontation amongst different stakeholders, uncertainties are often unmentioned in favor of presenting management strategies that assert certainty. This leads to rigid management strategies, as a single management strategy is agreed upon for an indefinite amount of time. Such rigidity remains vulnerable to the changing ecosystem, changing available technologies and changing stakeholder values. In order to achieve continually effective policy in any natural system, adaptive management utilizes three key components: efforts at predictability, flexibility, and inclusivity.

**Efforts at Predictability**

Efforts to predict how a dynamic system acts are essential in that they help to identify the previously unknown knowledge that will ultimately feed back into the policy itself. Efforts to predict events, even as adaptive policy “expects the unexpected,” facilitate the learning process by differentiating between expected events and unexpected events. Preconceived hypotheses of the management strategy allows for lessons to be learned even if the outcome was not as expected. From the outcome, knowledge is accumulated about the environmental and social responses, which can be used to revise the management approaches and policy.
**Flexibility**

Flexibility within a managerial structure means that policy is capable of identifying and responding to issues that arise within the policy’s jurisdiction, needs little adjustment to cope with new information, and does not get derailed by unexpected social or natural events (Swanson et al.). An effective policy attempts to achieve this flexibility in two ways. First, it must embrace ecological and social uncertainties, from the moment of conception and throughout the duration of the policy and management processes. Second, policy must permit the incorporation of the evolving scientific, social, economic, political, and ecological status quo, which, like the system itself, is constantly shifting. The evolving status quo is evaluated through both time and space and may include not only innovation in technology or scientific discovery, but also changes in stakeholder interests.

**Inclusivity**

Inclusivity refers to the need to have all stakeholders present from the outset during the policy-making process and, further, the need for their subsequent participation throughout the implementation, monitoring, and revision phases. Including all stakeholders ensures the legitimate representation of all interests, without unreasonable privilege. Where conflicts arise, adaptive management encourages stakeholders to embrace differing opinions in efforts to work towards developing tradeoffs within the inclusive policy (Ashcraft 36). In cases that span many jurisdictions and interests, such as the Lake Champlain system, including all invested stakeholders proves exceedingly difficult. However, total inclusivity ensures that management schemes avoid fragmentation from the start and is therefore essential for success.

Moreover, adaptive management not only focuses on inclusivity in relation to the stakeholders, but also with regard to different sectors. The adaptive scenario is founded on a holistic approach to developing policy, incorporating all scientific disciplines and social systems within the case.

### 4.3. Adaptive Management: From Theory to Implementation

In theory, the practice of adaptive management is ideal in its capacity to minimize uncertainty in environmental management practices. Yet, in cases where this scheme has actually been enacted worldwide, the framework has proven easier said than done. In fact, just defining how the conceptual underpinnings of adaptive management translate into a tangible plan has posed a formidable problem for the realization of policy implementation. From case to case and at times among stakeholders involved in a single ecosystem, just the definition of adaptive management varies significantly. Similarly, this ambiguity often produces a disconnect between policymakers and implementers, many of whom understand adaptive management in different, conflicting ways. In some locations, stakeholders even mistakenly believe that they are successfully implementing adaptive policies. Moreover, in many other cases, the framework has simply failed in its efforts at management efficiency and flexibility.

Similar issues may occur within the Lake Champlain Basin. The analysis of adaptive management theory and of the subsequent implementation of these management schemes
in different cases illuminates a fundamental discrepancy between theory and implementation. Stakeholders in the lake basin, and many before them, have found themselves asking “why is adaptive management so hard to implement?” Below, we suggest broad contributing factors that tend to limit the successful realization of adaptive management policies in natural systems. These underlying obstacles in the implementation of adaptive management inhibit the achievement of flexibility, inclusivity, and efforts at predictability and, ultimately, set a project up for failure from the start.

*Systems’ natural response timeline does not help the promotion of AM*

The fundamentals of economic cost-benefit analysis introduce the idea of discounting the value of benefits and costs in the future based on the perception that humans place a higher value on the present than on the future. Often, natural timelines, meaning the span of time needed in order to see change in a system, are not conducive to an implementation scheme that will please people intent on seeing tangible results. Instead, as our community partners in the LCBP and LCC have constantly reminded us, there is a significant time lag between action and response with regards to phosphorous. For example, the ecosystem response might take on the order of hundreds of years given the state of today’s policy procedures, bureaucratic obstacles, and natural processes (Winslow and Halteman 3/21/13). Such a gap between implementation and results hinders adaptive management approaches, since they are founded upon the flexibility that comes from a learning feedback cycle. Time lags then act as a force that delays the learning process to an unfeasible and unrealistic scope. Moreover, for people unfamiliar with the science behind phosphorous and its aquatic effects, priorities favor management that gives results, positive or negative, which further increases the risk of losing the conceptual foundation of adaptive management.

*Focus on individual issues confuses management due to spatial discontinuity*

It is easy to consider a focus on the health of a single part of a system as translating into benefits for the system as a whole. However, given spatial variability in the development of management benefits, this approach can lead to its own dead ends in the context of adaptive management. Similar to the time lag, spatial discontinuities render large-scale management difficult due to the aforementioned interest on the part of many stakeholders in tangible results. The discontinuity becomes apparent when the costs of point-source and non-point source pollution in a section of an ecosystem are realized in an entirely different location. In Lake Champlain, for example, given that the water flows south to north, Québec’s Missisquoi Bay has a relatively high phosphorous load due to accumulation, despite its waters representing only a small portion of the total area of the lake (State of the Lake). Attempting to solve this particular issue in this location necessitates action all throughout the southern portions of the lake in New York and Vermont. The inherent problem lies in the fact that those who arguably need to be the most committed to maintaining system health for Missisquoi Bay’s phosphorous problem would not necessarily see the fruits of their labor and are therefore less inclined to partake in the solution.
A need for an incredible amount of resources and the associated opportunity costs

Finally, the project simply requires an accumulation of financial and human resources that can prove too difficult, or for which there may be little support at the local, state, or even federal level. Adaptive management entails a continuous connectedness to the implementation and monitoring of natural systems and the opportunity costs of the resources dedicated to such a program are great. Lake Champlain, for example, saw spending on phosphorous reduction, aquatic invasive species prevention, and other goals reach a total of $3 million in the basin. While this certainly is a step in the right direction, the total barely compares to the $142 million dollars that the *Clean and Clear Action Plan* by LCBP estimates necessary for an adaptive plan to solve the lake’s phosphorus issue alone (Stickney). Moreover, these management schemes often go up against other framework structures—like the current regulatory policy for Lake Champlain—which simply provides an answer for the problem, and then facilitates moving onto other issues and not necessarily monitoring the outcome (Ashcraft 38). Although the latter framework frequently does not entirely resolve management issues in an ecosystem, in political and economic systems strapped for resources, applying such a management structure allows for policy-makers to check managing the system off their list of accomplishments.

Misunderstanding the foundation of adaptive management

Adaptive management is founded on the idea that operating in a system characterized by uncertainty is possible and can be efficient provided that the policy learns and reincorporates knowledge into its own structure. While this still necessitates a strong policy-planning phase, the emphasis must be on the later implementation and monitoring phases that facilitate the learning feedback loop. This explains the weight given to adaptive management’s fundamental principles that stress the need for efforts at preliminary predictability and established hypotheses. Our research demonstrates that many cases, while committed to the theory of adaptive management, fall short in the key post-planning steps. This is apparent in the intense complication of management schemes that come out of the planning stage, illustrated by Figure 4.1. Furthermore, cases seem to squander resources in order to research and develop these incredibly complicated plans and consequently have trouble achieving or even enacting implementation and monitoring. In effect, by micromanaging the plan for an adaptive policy, policy-makers impede the core principle of AM that touts experiential and experimental learning.
In the Lake Champlain region, despite being only "a quasi-governmental, public-private partnership" among jurisdictions, the LCBP has made clear its commitment to the theory of adaptive management for lake governance (Stickney). The LCBP, through its Steering Committee, describes its intent in the 128-page *Opportunities for Action Plan* (OFA), noted as a document that takes into account the evolving future of the lake and basin. However, this plan appears to reflect the theory-to-implementation discrepancy outlined above, most notably in its inclination towards an incredibly complicated and micromanaged planning stage. This is clear in the bulk of the OFA that highlights over one hundred different activities, deemed "priority actions and tasks" ("Opportunities for Action"). In creating a long list of action priorities that range from increasing educational opportunities and writing grants to changing farmstead land management and developing a method for adaptive management monitoring, the committee essentially introduces the need to prioritize among the priorities (which has not been done) in order to actually achieve the action in an efficient and rational way (Haleman 5/9/13). Certainly an adaptive scheme needs planning, but too much planning complicates the effort and contradicts the concept itself. How does one achieve and maintain that balance? The first step is to go back to the basics of adaptive management and understand how an ideal system looks.
4.4. Adaptive Management: Tools for Implementation

Much of our research has been about understanding the concept of ideal adaptive management and attempting to draw out the foundational elements from the complicated definitions and planning strategies. From the fundamental principles of adaptive management, we have derived practical tools. These tools, outlined below, are necessary in some form if adaptive management is to be effectively applied. Simply, they represent the components of an ideal management scheme.

Learning Feedback Loop

Change is expected within adaptive management. Any system we would be dealing with through adaptive management is dynamic. So a policy will need to be evaluated and redesigned and there need to be mechanisms in place for monitoring and feedback that evaluate how a system responds (Ashcraft 39). The learning feedback loop is the process where the ecological and social responses from the implementation of a management approach are used to adapt the approach itself (Figure 4.2.). If a plan was implemented, and a monitoring system uncovered that the outcomes were undesirable, the management approach would be evaluated and improved, until the desired outcome was achieved. The implementation and outcomes of a policy can be very different than the expected outcomes of a policy. So it is important to have a feedback loop in place that monitors a management approach and uses the new accumulated knowledge to form a more effective policy.

Consider the 15-mile Reach and the Florida Everglades case studies (see Appendix 1 and 2). The 15-mile Reach case study shows that a learning feedback loop serves as a guarantee that the management system will be responsive to the ecosystem and the interests of its stakeholders. It allows management to begin even though there are uncertainties because the learning feedback loop will allow the system to adjust accordingly. On the other hand, the Florida Everglades case study shows that the lack of a learning feedback loop—weakened by the lack of a monitoring program discussed below—rendered the management unadaptive and inflexible.

![Figure 4.2. A model of a learning feedback loop.](image)
Established Hypotheses and Assumptions

Within a particular system, there is an outcome that is desired and expected. However, policies will be made and implemented without a full understanding of the outcomes, due to environmental and social uncertainties within the system. Therefore, management approaches should be based on hypotheses and assumptions. Establishing hypotheses, rather than simply relying on trial and error, utilizes pre-existing knowledge. Hypotheses can be tested using experiential knowledge gained from the system and based on how the system reacts to management approaches.

Monitoring System

Monitoring is essential to the iterative process of adaptive management. Without monitoring, the agencies involved will not be able to understand how the implementation of the policy is affecting the ecosystem. For example, in Lake Champlain the water quality should be tested to understand how the management approaches are influencing the discharge of phosphorus or the in-lake phosphorus standards. Monitoring is also how uncertainty is resolved and hypotheses based on the implementation are experientially tested. Adaptive management stresses that the ecosystem being monitored is dynamic, so monitoring efforts cannot be linearly extrapolated for the entire ecosystem. A monitoring system should recognize that the system is non-linear, and should utilize widespread monitoring efforts. Further, a monitoring system can help to accumulate knowledge on a system that will aid the policy review process.

Refer to the Florida Everglades case study (see Appendix 2). This case study shows the importance of a monitoring system in order for adaptive management to work. In this case, the monitoring program was under-prioritized and management targets were unclearly defined. Therefore, the lack of an effective monitoring system jeopardized the learning feedback loop. As such, the program could not meet its goals to 1) assess responses of the system to implementation of the plan, 2) determine whether or not these responses match expectations, 3) determine if the plan should be modified to achieve the goals, and 4) seek continuous improvements based upon new information.

Policy Review Process

The policy review process is central to the flexibility of adaptive management because it allows the policy to be reviewed and revised without further needing to be approved by any agency or form of government. Policy changes are inevitable within adaptive management and so we can plan for changes to take place (Walker). The ecosystems that we are dealing with are dynamic, and we can use the learning feedback loop to adapt the policy. The policy review process relies on a learning feedback loop, because in adaptive management the research is an integral component of the policy. The policy should be experimental, because our understanding of an issue is not fully comprehensive and uncertainties are present (Holling). The policy will not be able to control for all outcomes, but with a review process in place, the policy will be able to be adapted no matter what the outcome.
Established Timeline
To be able to have an efficient policy, it is crucial that a timeline is established for the policy-making, implementation, monitoring and review stages of adaptive management. Without a timeline it is hard for progress to be made.

Venue for all Stakeholders
Adaptive management incorporates all stakeholders in the policy-making process and therein after. Adaptive management embraces the conflict that may arise between stakeholders as an inherent part of the process. The differences between stakeholders can provide value, ensuring that the policy is integrative, incorporating different stakeholders’ interests (Brunner). Adaptive approaches aims to clarify and understand the interests of every stakeholder to be able to account for and integrate interests in the policy or compensate stakeholders (Ashcraft 43). To be able to incorporate all stakeholders, it is necessary to have a venue that can hold all of the stakeholders involved. The venue does not necessarily have to be a physical space, it can also be a means of communication such as conference calling.

Refer to the 15-mile Reach and El Camino Real de Tierra Adentro case studies (see Appendix 1 and 4). Successful cases of adaptive management emphasize stakeholder involvement. Management does not simply affect the environment in question, but also the industries, local communities, governmental organizations, and other social entities involved. The socio-political aspect of adaptive management is just as important as the ecological improvements. Noticeably, it is the mismanagement of human activities in these environments that necessitate reevaluation of the conventional framework. This was the case in both the 15-mile Reach and El Camino Real de Tierra Adentro studies. In the case of the 15-mile Reach, adaptive management effectively invited more stakeholder input by implementing community-based initiatives. Through more stakeholder involvement, the panic caused by U.S. Fish and Wildlife Services (FWS)’s tightened regulatory stance (due to the conventional recovery program’s failure to meet the standards set to offset the activities of the basin) subsided. In the case of El Camino Real, the Camino Real Ranger District (CRRD) acknowledged the changing needs of its stakeholders and allowed flexibility in its policies to accommodate their dynamic needs. Stakeholders in both cases became increasingly involved. Their knowledge and services became valuable resources, not points of contention.

Commitment to Enacting Adaptive Management
Finally, it is important that all stakeholders understand adaptive management and believe that adaptive management is for their benefit. A briefing or a seminar needs to occur, where stakeholders and parties involved are aware of the theory behind adaptive management and the mechanisms by which it will be implemented.

Refer to the El Camino Real de Tierra Adentro and the Missouri River Dam and Reservoir System case studies (see Appendix 4 and 3). In the El Camino Real case, the CRRD established respect and trust by allowing the inputs and the interests of stakeholders to guide their policies. In response, the stakeholders were collectively on board to work towards the greater good of the forest. On the other hand, the Missouri River Dam and Reservoir System case shows that the lack of stakeholder support for the newly adopted adaptive management plan served to hinder effective management. Without support for
adaptive management, the changes to management policies allow new venues for disagreements and friction.

4.5. Adaptive Management: Applied to the Lake Champlain Basin

Recognizing the way in which different definitions and practices of adaptive management have been implemented in diverse ecosystems, we believe that these tools can be used to construct a single definition of adaptive management specific to Lake Champlain. Those best equipped to develop such definition need to be familiar with the lake’s dynamic ecosystem, with the current regulatory framework and with adaptive management. This is why local organizations such as LCC and LCBP are not only important for raising awareness about the lake’s condition, but also may be in the best position to establish a definition of adaptive management that fits with the situation in Lake Champlain.

Beyond OFA: Using AM Tools to Bridge the Theory to Implementation Gap

These organizations have already demonstrated their interest in pursuing adaptive management in Lake Champlain, for LCBP’s Opportunities for Action Plan incorporates many ideas presented in this paper. Again, however, there are discrepancies between theoretical support of adaptive management and on-the-ground implementation. Theorists believe implementation of adaptive management is simple, and it is hard to “get [them] on the same page” with those implementing the management approach (Winslow 4/8/13). The simple ideas within the adaptive management theory become convoluted and complicated in the implementation stages. Moreover, since adaptive management has a very comprehensive structure with various strategies, many people participating in the implementation of adaptive management only see a fragment of the whole picture.

AM Principle: Inclusivity

AM Tools: Venue for Stakeholders, Commitment to Enacting Adaptive Management

In order to prevent fragmentation that is quite likely within the conventional regulatory framework, we propose that stakeholders create a model that utilizes the AM tools to illustrate the long-term and short-term goals within the basin. Such a model, or other forms of simplified communication, can be facilitated by the LCBP and the LCC and will enable stakeholders to discuss adaptive management and the lake’s issues in an open and inclusive forum. Thus, we recommend that with LCBP’s operating structure (See Figure 4.3.), a special task force be assigned to oversee the conceptualization of adaptive management and its implementation. The organization’s Technical Advisory Committee (TAC) seems to be the best fit for this task. Comprised of professionals from academia, and natural resource management agencies, the TAC currently presents the Steering Committee and LCBP staff with objective information about the lake’s condition and provides professional review of proposals. As a result, the TAC facilitates communication and action among the multi-jurisdictional stakeholders invested in the lake’s water quality.
Figure 4.3. This is the current operating structure of the LCBP. Although it is comprehensive, there is no committee that specifically oversees adaptive management operations ("A Strategy for Implementing the Plan").

**AM Principle:** Inclusivity

**AM Tools:** Venue for Stakeholders, Commitment to Enacting Adaptive Management

In order to improve coordination efforts among these stakeholders and the conventional frameworks through which they operate, the TAC should further introduce adaptive management into the discussion. In addition to providing regulatory agencies and stakeholders within the LCBP with basic information about the lake’s condition and the region’s future goals, the TAC can also ensure that these stakeholders understand AM as a theory, and how specific AM tools can advance coordinated conservation efforts. As a committee designed to provide professional information to both managers and implementers, they seem to be in the best position to oversee and advise the operations of AM within Lake Champlain. Establishing an AM information “center” in a committee that is well connected to stakeholders in each jurisdiction and that understands how AM can be transformed from a theory into a site-specific solution for Lake Champlain will reduce confusion surrounding AM, and offer additional support for key stakeholders already involved in AM implementation.
**AM Principle:** Inclusivity  
**AM Tools:** Learning Feedback Loop, Monitoring System, Policy Review Process, Venue for all Stakeholders

Within an adaptive management framework, it is also important that the process of a learning feedback loop does not end with the creation of a phosphorus standard or management policy. Rather, the policies need to be implemented, monitored and consequently reviewed. To ensure that this occurs for Lake Champlain, there must be increased communication and transparency between jurisdictions. While also informing the invested stakeholders about AM’s fundamental application, the LCBP TAC can also address issues of transparency and miscommunication by creating an online database. The database would include an outline of all water quality monitoring efforts for the lake, and can ultimately help the TAC centralize the information on phosphorus loading in Lake Champlain that agencies and CACs have collected. The collective information on this database can inform the NYSDEC, VT DEC, and MDDEFP’s WQS development and review processes; as a result, the respective regulatory agencies will not only understand water quality issues in the lake more holistically, but will also be aware of how such issues are being addressed throughout the basin. Furthermore, by documenting their adherence to monitoring policies on the database, stakeholders in each jurisdiction may feel more accountable and more responsible to help manage the lake.

**AM Principles:** Flexibility, Inclusivity  
**AM Tools:** Learning Feedback Loop, Policy Review Process, Venue for all Stakeholders

Adaptive management also stresses that despite conflicts that may arise, it is important to understand the underlying interests of each of the parties. In the Lake Champlain Basin, the stakeholders all share an interest in reducing in-lake phosphorus concentrations, and more generally, improving the lake’s water quality. Yet because the in-lake and effluent water quality standards in Vermont, New York, and Québec differ, it is unclear whether these jurisdictions share the same goal. As mentioned in the “Current Regulatory Framework” section, New York monitors phosphorus with a narrative standard, while Vermont and Québec use numerical standards. So while Vermont is focused on reducing the in-lake phosphorus concentrations below a specific number, New York may be content when no more ‘slime’ is visible on the lake (see New York Water Quality Standards).

The potential for different expectations and different goals among the jurisdictions may become a source of conflict among stakeholders. Adaptive management may help to verify that the jurisdictions have consistent goals and thus minimize risk of conflict. An AM framework emphasizes the need to have all stakeholders involved in the policy-making and consequent review process so that goals are clearly defined and well understood. Although each jurisdiction is interested in minimizing in-lake phosphorus concentrations, this underlying mission is not represented clearly given differing WQS. Thus, the WQS themselves should not be the focal point of the management policy. Instead, each jurisdiction’s management policy should incorporate input from as many stakeholders as possible—not just those directly connected to the TAC—and should describe the need to reduce phosphorus loading into the lake. It is possible that a narrative water quality standard may be more suitable for the basin, for it allows for greater flexibility and emphasizes an overarching goal that all parties can work towards.
**AM Principle: Inclusivity**  
**AM Tools: Monitoring System, Established Timeline, Venue for all Stakeholders**

We also recommend that improvements in the Lake Champlain Basin be presented to the public through a narrative emphasizing short-term goals. LCBP mentions that “one of the biggest challenges [resource managers and lake advocates] face is helping the average public stakeholder understand the concept of response time, particularly in the context of phosphorus loading, and subsequent loading reduction, to the lake” (Howe 5/10/13). It is hard to measure the success of reducing in-lake phosphorus concentrations because it will take decades for Lake Champlain to recover. Yet the science behind this fact is complex and not easily accessible to the public. As a result, public stakeholders in New York, Vermont, and Québec, may become discouraged as the regulatory agencies struggle to reduce phosphorus concentrations in the lake. However, if the agencies advertise the short-term successes, such as fewer beach closings or toxic cyanobacteria blooms, the public may show a renewed interest in improving the lake’s water quality.

**AM Principles: Efforts of Predictability, Flexibility**  
**AM Tools: Learning Feedback Loop, Establishing Hypotheses and Assumptions, Monitoring System**

To be able to promote a decrease in toxic cyanobacteria blooms, other factors of the blooms need to be explored. Although, high phosphorus runoff is associated with cyanobacteria, it is not the only factor in cyanobacteria blooms. Other nutrients that may contribute to cyanobacteria are nitrogen and trace metals. But there is still a lack of knowledge on the conditions needed to cause such blooms; blooms have been documented in instances where there are no nutrient concerns. AM lends itself to the uncertainty at play in regards to the cause of the cyanobacteria blooms. By adopting the adaptive management tool of a learning feedback loop, the appropriate committee could form hypotheses to investigate different factors that lead to the blooms, and therefore minimize their growth.
5. CONCLUSION

Unsustainable phosphorus concentrations and an abundance of algae blooms in Lake Champlain suggest that the ecosystem’s health is currently at risk. New York, Vermont, and Québec all share regulatory authority over this trans-boundary resource and have all acknowledged the severity of the lake’s deterioration. Under the current regulatory framework, however, regulating agencies in these jurisdictions—such as NYSDEC, VT DEC, and MDDEFP—have been unsuccessful in developing and reviewing WQS and TMDLs that effectively address the issue. In the United States, states are permitted to establish their own WQS to be approved by the U.S. EPA. In Canada, provinces are granted similar responsibilities with respect to their water quality standards. Yet this power delegation does not enable states or provinces to engage in international binding agreements, nor does it specify the type of standard that must be developed. As a result, New York has developed a narrative water quality standard for phosphorus, while Vermont and Québec rely on numerical standards, and the three jurisdictions are unable to commit to a binding treating regarding phosphorus regulation in Lake Champlain. Thus, impediments within the current regulatory framework hinder flexible, coordinated, and consistent phosphorus regulation in the lake.

Furthermore, the framework fails to effectively prepare stakeholders for uncertain threats to the lake that may extend beyond phosphorus pollution. In order to address these impediments and to generally improve the conventional regulatory frameworks’ effectiveness, this paper recommends that adaptive management be implemented. Adaptive management (AM) emphasizes an iterative process through which feedback loops allow for greater efforts of predictability, flexibility, and inclusivity within the regulatory framework. The LCBP and other stakeholders in the Lake Champlain Basin have expressed interest in AM. In fact, the LCBP OFA plan describes a plan to pursue the management approach. Yet despite this preliminary interest, stakeholders have not proven that they can convert adaptive management from a theoretical ideal to an scheme that can actually be implemented to help address Lake Champlain’s water quality. This gap between AM theory and its implementation is quite common and is largely due to the following reasons: A system’s natural response timeline does not help the promotion of AM, the focus on individual issues confuses management due to spatial discontinuity, the need for an incredible amount of resources and the associated opportunity costs, and misunderstandings about the foundation of adaptive management.

The fact that phosphorus continues to threaten Lake Champlain, even after LCBP and other stakeholders in the basin have demonstrated an interest in AM, indicates that among other factors, these organizations have not been able to bridge the theory to implementation gap. Thus, this paper suggests that interested stakeholders return to the most fundamental tools in AM theory in order to shape a definition of adaptive management that is most appropriate for the trans-boundary ecosystem. Some of these key tools include a learning feedback loop, a monitoring system, a policy review process, a venue for all stakeholders, and commitment to enacting adaptive management. Our recommendations include the application of these tools to Lake Champlain and phosphorus pollution in the lake, specifically, in order to demonstrate how adaptive management can actually be implemented in the basin. While LCBP and regulatory agencies in each jurisdiction have considered how to best implement adaptive management within existing
financial, temporal, spatial, and political constraints, close adherence to adaptive management principles and tools will undoubtedly lead to more adaptive water quality standards for Lake Champlain, not only with respect to phosphorus, but also for potential future pollutants.
6. APPENDICES

6.1. Appendix 1
Case Study: 15-mile Reach and the Upper Colorado River Basin

This case study revolves around the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado Basin (the recovery program) established by water users throughout the Upper Colorado River Basin and the U.S. Fish and Wildlife Service (FWS). The recovery program is defined by its goals to “[recover] four species of endangered fish in the Colorado River and its tributaries in Colorado, Utah, and Wyoming while water use and development [continue] to meet human needs in compliance with interstate compacts and applicable federal and state laws” (Upper Colorado River Endangered Fish Program). This can be considered the “conventional management.” It was established to mutually benefit both the users of the river and the FWS in its attempt to protect the ecosystem. FWS realized in 1994 that the recovery program established in 1988 had failed to satisfactorily meet the reasonable and prudent alternative (RPA) standards to offset the environmental degradation caused by projects and activities along the river. The FWS suddenly wanted to tighten up the regulations along the river, causing panic to the users of the basin.

At the advent of losing support for the recovery program, the water users, environmentalists, the FWS, and other federal and state agencies came together for a community-based initiative (Coe-Juell, 47). Based on a series of meetings, FWS came up with the Programmatic Biological Opinion (PBO) that secured agreement among the stakeholders involved in the negotiations. The PBO outlined new target goals and various management actions that emphasize adaptive management.

The PBO agreed to monitor the response of the fish population to the management interventions to “let the fish tell us” (Coe-Juell, 49). This reduced the uncertainty about the sufficiency of these management actions to meet their goal, and allowed the PBO to start its management practices without wasting time. Also, the PBO differed from previous management strategies in that it had specific interim goals and target indicators. Thus, effects of the management practices could be properly monitored and the progress of the project effectively measured.

The PBO effectively solved the problem of having unspecified goals due to uncertainties from insufficient information. Also, the PBO was able to solve the uncertainty regarding the members’ responsibility that used to be so thinly spread throughout the large basin. By inviting open discussion and embracing expertise and practical local knowledge, they were able to make subgroups that solved sub-problems. Such participation had the additional effect of creating solidarity amongst the members, as their increased participation lead to clarification and reinforcement of their initial interests. By pooling their knowledge and resources, they could couple management projects that could be integrated and mobilize their resources for effective management outcomes.
6.2. Appendix 2
Case Study: Florida Everglades

The subtropical wetland, also known as a “river of grass,” has faced extensive ecological changes due to human-induced alterations. Through the creation of the Everglades Drainage District in 1907 to promote agriculture and settlement, the ecological degradation in the Everglades started to gain some attention. Soon afterwards with the Central and Southern Florida Project for Flood Control and Other Purposes, the Everglades was subject to levees, water storage, improvements of conveyance channels, and large-scale pumping. These activities have led to massive hydrological change, causing flora and fauna in the Everglades to become federally threatened or endangered.

Due to the significant and blatant damage to the environment, the Comprehensive Everglades Restoration Plan was federally approved under the Water Resources Development Act of 2000. It is in this plan that adaptive management was officially recognized as a water management approach for the first time. The plan included a conventional definition of adaptive management, noting that adaptive management must 1) assess responses of the system to implementation of the plan, 2) determine whether or not these responses match expectations, 3) determine if the plan should be modified to achieve the goals, and 4) seek continuous improvements based upon new information.

Yet upon review after few years, the adaptive management approach had been deemed a failing venture due to the lack of a comprehensive monitoring plan for key indicators in the field. The committee responsible has reported that 1) the monitoring needs must be better prioritized and 2) system-wide indicators of ecosystem status are needed for clarity and narrower definitions (Panel on Adaptive Management for Resource Stewardship 56). In essence, the plan's restoration goals were too broad/general, where specific targets and measures were needed. Moreover, upon review, adaptive management within this plan was “more of a concept than a fully-executed management strategy”(Panel on Adaptive Management for Resource Stewardship 58). Lastly, some of the uncertainties were considered “beyond the ability of managers to immediately prepare for” (Panel on Adaptive Management for Resource Stewardship 58). Adaptive management in the Comprehensive Everglades Restoration Plan was an ambitious goal.
6.3. Appendix 3
Case Study: Missouri River Dam and Reservoir System

The Pick-Sloan Plan, passed through the 1944 Flood Control Act, was designed to aid in navigation and flood control of the Missouri River through creation of numerous dams. The dam and reservoir system of the Missouri River Basin serves to reduce flood damage, create water supply and irrigation, aid in navigation, generate hydropower, and support fish, wildlife, and recreation. The multiple use of the river created two problems. One, it changed the ecosystem significantly. Two, the competing uses created friction between interest groups.

The Corps has decided to implement adaptive management strategies on restoration projects along the river, adjusting river flows to represent pre-settlement hydrologic patterns as much as possible (Panel on Adaptive Management for Resource Stewardship 59). Yet this posed a new venue for disagreement between different interest groups along the river. While those in the lower river basin wanted flood control measures to prevent loss of agriculture due to the rush of spring waters, those in the upper river basin wanted to protect the high levels of water for recreational industry.

Therefore, implementing adaptive management was difficult in this case due to the lack of stakeholder cooperation and difficult management protocols. There were a plethora of legal responsibilities in the form of federal laws, and the numerous stakeholders in the area with different—and sometimes competing—interests all wanted a part in the management of the river. “Successful implementation of the concept, however, [was] constrained by the conflicts embodied within an array of federal laws, congressional authorizations, administration guidance, the Corps’ own internal guidance, and differences of stakeholder opinion... Conflicts and inconsistencies among statutory responsibilities, court orders, agency opinions, and stakeholder preferences continue to confound adaptive management actions on the Missouri River” (Panel on Adaptive Management for Resource Stewardship 64). Therefore, even if a flawless ecological adaptive management strategy is conceived, the sociopolitical complications may render the whole project moot.
6.4. Appendix 4
Case Study: El Camino Real de Tierra Adentro

Boasting some of the finest mountain scenery in the Southwest, the Carson National Forest is one of five national forests of New Mexico (“Carson National Forest-Home”). It consists of 86,193 acres of wilderness. In the forest, there are areas that are both undisturbed to preserve the natural environment and areas that are used as resources. These resources include high quality water, outdoor recreation, wood, foraging for both wildlife and livestock, and a source of mineral extraction (“Carson National Forest-About the Forest”).

The Camino Real Ranger District (CRRD) is responsible under the USDA Forest Service (USFS) to ensure that the forest has a commitment to the agency's mission: “Caring for the Land and Serving People.” But this has become increasingly difficult because CRRD was expected to juggle and integrate multiple public demands that wanted differing amenities from the district (Steelman and Tucker). Throughout history, CRRD faced various troubles from interest groups, such as lawsuits and appeals from environmentalists and hostility from local residents. The stakeholders who held often-contrasting views with one another, against the CRRD, or both, made it difficult for effective management of the forest.

In response, CRRD has adapted new policies that were more flexible and pragmatic. While the policies were firmly grounded in the foundational mission of the USFS, they remained loose enough to adhere to the changing opinions and wants of the dynamic community it served. New permits and procedures were assigned depending on the circumstances.

The success of adaptive management is grounded in the mutual respect, trust and support the CRRD and the stakeholders shared. CRRD trusted the good nature of the stakeholders and allowed for the flexibility to meet the desires of the interest groups. In response, the stakeholders were onboard to collectively work towards the greater good of the forest. They provided solid political support and trusted that the CRRD had their best interests in mind.
6.5. Interview Appendix

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Halteman, Philip. 9 May 2013. Email Correspondence
Howe, Eric. 10 May 2013. Email Correspondence
Winslow, Mike. 13 May 2013. Email Correspondence
7. Notes

I State involvement in setting and enforcing water quality standards for Lake Champlain can be traced back to the 1972 Clean Water Act (CWA) Amendments, which establish state authority to set water quality standards for interstate waters. According to the CWA,

*It is the policy of the Congress to recognize, preserve, and protect the primary responsibilities and rights of States to prevent, reduce, and eliminate pollution, to plan the development and use (including restoration, preservation, and enhancement) of land and water resources, and to consult with the Administrator in the exercise of his authority under this Act.*

After passing the CWA, large point sources became the main target of regulatory agencies because they were easier to identify. The 1972 amendments to the CWA clearly directed efforts towards point source pollution by making it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions, by giving the EPA the power to implement pollution control programs such as setting wastewater standards for industry, and by funding the construction of sewage treatment plants under the construction grants program.

II The Natural Resources Board (NRB) was created by Act 115 of the Vermont General Assembly to succeed the Environmental and Water Resources Board in 2005. The NRB is a five member board which is divided into two panels, the Land Use Panel and the Water Resources Panel. Each panel has five members including the NRB Chair.

III Water quality standards consist of four basic elements: 1) Designated uses; 2) Water quality criteria; 3) Antidegradation policy and 4) General policies. Anti-degradation procedures identify steps and questions that need to be addressed when specific activities affect water quality. Tier 1 is applicable to all surface waters. It maintains and protects current uses and water quality conditions to support existing uses. Tier 2 maintains and protects water bodies with existing conditions that are better to support CWA 101(a)(2) "fishable/swimmable" uses. Tier 3 maintains and protects water quality in outstanding national resource waters (ONRWs), which are the highest quality waters in the U.S. with ecological significance. So, when states develop rules and implementation procedures to protect existing water uses and to prevent clean waters from being unnecessarily degraded, they provide the most stringent protection to the highest quality waters in the state.


V LCBP Mission Statement: "The Lake Champlain Basin Program (LCBP) works in partnership with government agencies from New York, Vermont, and Québec, private organizations, local communities, and individuals to coordinate and fund efforts that benefit the Lake Champlain Basin’s water quality, fisheries, wetlands, wildlife, recreation, and cultural resources."

VI For further reference, see tools section in Analysis and Recommendations, as well as Appendices 1-4.
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