Cayuga Lake Modeling Project
http://cayugalakemodelingproject.cornell.edu
Frequently Asked Questions
05/21/13

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1. Project Overview

1.1. What is the Cayuga Lake Modeling Project (CLMP)?

The New York State Department of Environmental Conservation (NYSDEC) and Cornell University have agreed to conduct a detailed study of the sources and fate of phosphorus in Cayuga Lake. The primary goal of this project is to build a computational water quality model of Cayuga Lake and its watershed, providing a better understanding of where phosphorus comes from, and how it affects the lake ecosystem. Cornell will fund this initiative, and has consulted with NYSDEC to develop a team of independent experts to conduct the work.

The partnership between Cornell and the NYSDEC represents a unique application of an emerging approach to water resources management; this approach focuses on science-based decision making and sustainable resource use. The insights from this investigation will help NYSDEC as they manage other lakes in the state.

1.2. Why do this project now?

The CLMP is included as a condition of the final permit renewal and modification for Cornell’s Lake Source Cooling facility. Links to the final permit, the associated fact sheets, and the NYSDEC responses to comments on the draft permit can be reviewed at http://www.dec.ny.gov/lands/88250.html.

The prior permit for the LSC facility required Cornell to monitor eight sites in southern Cayuga Lake each summer for phosphorus, water clarity and chlorophyll-a. This program was designed to support a statistical evaluation of the potential impacts of the LSC return flow on lake water quality conditions. The extensive data set generated by this monitoring program failed to detect any impact of the LSC facility on Cayuga Lake. However, the water quality of southern Cayuga Lake did change over this period; chlorophyll-a concentrations increased slightly despite enhanced phosphorus removal at the two wastewater treatment plants discharging to the lake’s southern shelf. NYSDEC and Cornell concur that a water quality model of Cayuga Lake is needed to understand the factors affecting phosphorus dynamics in the lake.

Once completed, the mathematical model will enable NYSDEC to prepare a Total Maximum Daily Load (TMDL) allocation for phosphorus, or decide on other beneficial actions to improve water quality conditions. Since 2002, the southern basin of Cayuga Lake has been on state and federal lists of impaired waters, and a TMDL has been required. NYSDEC has not been able to complete the phosphorus TMDL for southern Cayuga Lake due to limited funding resources. The model will have a special focus on the impaired southern basin.

1.3. Who is involved?

The project will be led and directed by NYSDEC. Cornell University has consulted with NYSDEC to develop a team of scientific experts to assess water quality conditions throughout the entire lake,
compile information regarding the contribution of nutrients and sediment from the watershed, and develop the mathematical models linking the watershed inputs to the quality of the lake. Upstate Freshwater Institute (UFI) http://www.upstatefreshwater.org/ a not-for-profit research corporation located in Syracuse NY will be responsible for the lake water quality modeling. Cornell Professor Todd Walter http://www.hydrology.bee.cornell.edu/ will lead the watershed assessment and modeling. The Community Science Institute (CSI) http://www.communityscience.org/ will be a resource to the modeling groups. The project team will draw on other local experts in diverse areas, ranging from biological monitoring to detailed evaluations of water motion within the lake. EcoLogic LLC http://www.ecologicllc.com/ will support NYSDEC outreach efforts, and coordinate communication between the project scientists and the community.

1.4 How will the community be involved in the project?

NYSDEC and Cornell welcome active community participation. The Cornell project team will maintain a web page, with meeting announcements, meeting summaries, and draft materials for community review. NYSDEC and Cornell will continue to provide opportunities for community members to provide input.

The NYSDEC attended a public information session convened by the Tompkins County Environmental Management Council to discuss the draft permit in December, 2012. In late January, 2013, NYSDEC representatives returned to Ithaca to participate in a technical workshop on the draft Quality Assurance Project Plan (QAPP), which outlines details of the planned monitoring and modeling that comprise the first phase of the CLMP. The QAPP workshop was hosted by the Cayuga Lake Monitoring Partnership, a committee of the Tompkins County Water Resources Council. This organization has agreed to serve an ongoing role in coordinating local sources of data, information, and knowledge about the Cayuga Lake ecosystem. Chaired by Roxanna Johnston, City of Ithaca Watershed Coordinator, the Monitoring Partnership will meet regularly with members of the project team to discuss progress and findings throughout the multi-year project.

In addition to regular meetings with the technical stakeholders, NYSDEC and the Cornell team are committed to providing opportunities for the general public to learn more about the project and keep abreast of important findings. Specific events and schedules have not been finalized, but will be advertised widely using various media outlets. Some of the suggestions for community outreach include a “Meet the Scientists” event on the Cayuga Lake Floating Classroom, watershed walks and talks, tours of the LSC facility, newsletters and press releases, and periodic community briefings.

The web address: http://cayugalakemodelingproject.cornell.edu; will be used to announce meetings and events, report progress, and host links to related actions. The NYSDEC has created a list serve so that interested parties can be notified when new information is released. To join this mailing list, follow the link at https://public.govdelivery.com/accounts/NYSDEC/subscriber/new The NYSDEC has also developed a Cayuga Lake project web page on their site http://www.dec.ny.gov/lands/88250.html.
1.5 What is the Cayuga Lake Watershed Restoration and Protection Plan (RPP), and how does it relate to the CLMP?

The RPP is a collaborative management plan and planning process for the Cayuga Lake watershed developed in 2001 by the Intermunicipal Organization (IO), a voluntary partnership of 31 villages, towns, cities and counties. Water resource managers and stakeholders throughout the watershed are discussing collaborative approaches to updating the RPP. This project is independent of the CLMP; updating the RPP is not among the requirements placed on the permit renewal for Cornell’s Lake Source Cooling facility. If efforts to update the RPP move ahead, the project team from Facilities Services (Energy and Sustainability) will collaborate to provide input as possible, but will not take a leading role. Information gathered as part of the modeling project may help inform the RPP update, and strengthen the foundation for decision making. To read the RPP, link to http://www.cayugawatershed.org/Cayuga%20Lake/RPP/cayindex3.htm

1.6 Who are the spokespersons for the CLMP and how can I get in touch?

Diane Carlton, Citizen Participation Specialist
reg7info@gw.dec.state.ny.us
(315) 426-7403
NYSDEC Region 7
615 Erie Blvd. West
Syracuse NY 13204

Liz Moran, Project Consultant
LMoran@EcoLogicLLC.com
(315) 655-8305
EcoLogic LLC
5 Ledyard Ave., Suite 200
Cazenovia NY 13035

1.7 How much will the CLMP cost?

Cornell has committed to spending $2.1 million on the CLMP over a period of about four years; this is the estimated cost to monitor the lake and selected streams in 2013 and develop the water quality models of the lake and watershed. These funds are drawn from the university’s budget for facilities and energy management. The project cost includes monitoring the entire lake and selected tributaries during 2013, analyzing multiple samples, and developing and testing the water quality models. Costs for university project managers and outreach activities are also included in the budget.

1.8 What’s the timeline for the CLMP?

The final project schedule depends on NYSDEC approvals of the detailed workplans describing the data gathering and modeling tasks. The tentative schedule extends over a 45-month period.
2. Total Maximum Daily Load (TMDL)

2.1 What is TMDL?

Total Maximum Daily Load (TMDL) is the amount of a particular substance, such as phosphorus, that can be added to a body of water from all sources without causing meaningful environmental harm.

2.2 Why is NYSDEC completing a phosphorus TMDL for southern Cayuga Lake?

The TMDL is a regulatory approach to setting limits when water quality conditions are considered impaired. Southern Cayuga Lake has been on state and federal lists of impaired waters since 2002. NYSDEC has concluded that the impairment is due, in part, to elevated levels of phosphorus, a nutrient that encourages the growth of algae and other aquatic plants. Waters are considered impaired when water quality conditions do not fully support the designated uses. For southern Cayuga Lake, the designated uses include recreation, drinking water, and protection of the aquatic biota. If, after the modeling and TMDL are complete, there is no feasible set of actions that would restore water quality conditions to a level that fully supports the designated use, completing a Use Attainability Analysis (UAA) process may be the next step. The UAA is a structured, scientific evaluation of the factors affecting a designated use. For southern Cayuga Lake, a UAA would examine the extent to which natural sediment input from the tributaries affects water clarity, thus precluding swimming in this region of the lake.

2.3 Who else might be affected by a TMDL for southern Cayuga Lake?

Two wastewater treatment plants, serving the Ithaca area and Cayuga Heights, have permitted discharges to southern Cayuga Lake. In recent years, both of these facilities have focused on enhanced phosphorus removal. It is possible that NYSDEC will update the discharge permits for these facilities, to more accurately reflect their existing effluent quality. The TMDL will also consider other sources of phosphorus to the southern lake basin, including runoff from developed areas and agricultural lands.

2.4 What information does NYSDEC require to complete the phosphorus TMDL?

To complete the phosphorus TMDL for southern Cayuga Lake, NYSDEC needs a water quality model that quantifies the relationship between phosphorus inputs and lake water quality. Cornell is required to
fund the development of this tool on behalf of NYSDEC, and to use it with the Department’s oversight. Constructing the model will require significant additional monitoring of the entire lake and major tributary streams. Once the model is completed and accepted, NYSDEC will use this tool to determine the total amount of phosphorus that can be added to the lake while maintaining water quality standards, and then allocate the allowable loading among all the sources. The allocation will include significant watershed sources, wastewater treatment plants, and industrial users. There is an allowance for future growth in the TMDL allocation.

2.5 How will the phosphorus TMDL be implemented?

Each TMDL has an implementation plan, which is prepared by NYSDEC and approved by the Environmental Protection Agency. The implementation plan will include specific actions and milestones to bring the phosphorus input from all sources to the target level. The target level will be defined based on attainment of water quality conditions that support the designated uses of southern Cayuga Lake. A recent local example is the phosphorus TMDL for Onondaga Lake (Syracuse NY), finalized in June 2012. http://www.dec.ny.gov/docs/water_pdf/tmdlonfinal.pdf

3. Modeling project

3.1 Can you provide an overview of the modeling efforts?

Two models—a watershed model and a lake model—will be developed and linked together. The watershed model predicts the movement of water and phosphorus from the watershed to the lake. The lake model predicts how the phosphorus affects water quality and aquatic life such as plankton. Linkage between the two models occurs at the points where water and materials from the watershed reach the lake. The project team will use a phased approach, and build on well-established modeling approaches that have been approved by the federal Environmental Protection Agency (EPA) and NYSDEC in multiple applications.

3.2 Will the Cayuga Lake Modeling Project include monitoring of the lake and watershed?

The proposed modeling initiative is an integrated program that includes site-specific data collection (monitoring) in the lake and watershed. There are five major elements.

(1) Monitoring selected significant tributaries to characterize external loading of nutrients and sediment under a range of conditions.

(2) Lake-wide monitoring of water quality conditions and the lake biota.

(3) Process studies to specify key model inputs. For example, UFI associates will test the various inputs to Cayuga Lake—including the tributary streams, treated effluent from the wastewater treatment plants, and return flow from the LSC facility—for phosphorus bioavailability. These site-specific studies
will support the construction of a realistic model of the potential impact of various phosphorus sources on stimulating algal growth.

(4) Watershed modeling to examine how tributary loading varies based on land use and weather conditions.

(5) A lake phosphorus/eutrophication water quality model that will simulate lake response to external inputs and internal cycling.

The model will represent the entire lake, with a focus on the impaired southern end. The overall integrated product will be a management tool linking watershed activities to lake water quality. In addition, the model will demonstrate the impacts of natural variations in weather conditions and changes in lake biota on Cayuga Lake water quality conditions.

3.3 Is one year of monitoring data adequate to develop the model?

This is an important question, given the year-to-year variability in weather conditions affecting runoff and transport through the tributary streams. The engineers and scientists who will complete this project are reasonably confident that monitoring during 2013 will be sufficient, in light of the extensive existing data sets characterizing the lake and its watershed. However, the decision on the adequacy of the data sets for model testing purposes ultimately rests with the NYSDEC.

Calibration of the watershed model will rely primarily on historical data. The watershed modelers will use the extensive data collected throughout the Cayuga Lake watershed to select appropriate flux rates of water, sediment, and nutrients from subwatershed areas. These rates will vary based on site-specific conditions of soils, land use, road networks and surface hydrology. Excellent long-term data sets exist for Fall Creek and Sixmile Creek. In addition, other shorter term historical datasets from various tributaries exist, including recent monitoring by the Community Science Institute. These data capture a wide range of hydrologic conditions. Part of the watershed modeling effort will be to consolidate these data, effectively expanding on the one year of contemporary data planned for 2013.

In Cayuga Lake, year-to-year variability is modulated by the lake’s long water residence time (between 9 and 12 years). There is an extensive 15 year database of ambient water quality conditions in the southern lake, which is the focus of the TMDL. The 2013 Cayuga Lake monitoring program will collect additional samples along the entire 38-mile lake, including samples at multiple depths. These data will be used to construct the water-quality model for the lake.

3.4 Won’t the prominent role of Cornell scientists in collecting and analyzing data and developing the models tend to bias the results in Cornell’s favor?

The Cayuga Lake model will be developed by Upstate Freshwater Institute, an independent research organization that is not affiliated with Cornell. Some members of the Cornell faculty will work on this project, collecting data related to the lake’s biological community and completing a detailed computational description of water circulation. The employment of these Cornell scientists does not
depend on their finding results or analyzing data for Cornell’s benefit. As tenured scholars at a world-class university, they are widely recognized as authorities within their disciplines and are ethically bound to find, analyze and report facts in an unbiased manner. Their reputations depend on it. Partly, they accomplish this by applying the scientific method, which tests competing alternative hypotheses and selects those that best fit the facts. They don’t set out to prove hypotheses, but rather to test them. The scientists also have a local and professional interest in coming to a better understanding of Cayuga Lake and its watershed.

The project team developed a Quality Assurance Project Plan (QAPP) to document the details of the sampling and analytical program planned for the modeling project. The QAPP was developed by UFI scientists and reviewed with members of the technical stakeholder community at a workshop in late January, 2013. The QAPP was reviewed and approved by NYSDEC prior to the onset of monitoring. The final accepted QAPP document covering monitoring and watershed modeling is available on the project web site at http://energyandsustainability.fs.cornell.edu/file/20130311%20QAPP%20final.pdf. A separate QAPP will be developed and submitted for review and approval prior to initiating the lake modeling.

3.5 Is it acceptable for Cornell to collaborate on the modeling, since the outcome may ultimately affect the permit for Lake Source Cooling?

All phases of model development will be overseen by NYSDEC. Once NYSDEC accepts the model and uses it to complete the TMDL, the EPA has its own review and approval process. This collaborative approach to model development, bringing together expertise and funding from multiple sources including permit holders, has been used for many successful projects. A recent local example is the Onondaga Lake phosphorus TMDL, which was accepted by EPA in June 2012.

3.6 What happens if the study shows that the return flow from the Lake Source Cooling facility is having a significant adverse impact on Cayuga Lake?

If the model demonstrates that the LSC facility does have a significant adverse impact on the lake, the university will take the necessary steps to correct the situation. Cornell will continue to comply with all permit conditions. If future permits require a change in operations, Cornell will evaluate the costs and environmental benefits associated with several alternatives. These alternatives include: (1) reducing the volume of water circulated through the LSC facility, and replacing the cooling capacity with electrically-driven chillers (either new or existing); (2) modifying or relocating the LSC facility’s outfall out of the southern basin; or (3) other options that are not yet defined.

3.7 Sediment loading is a significant issue in southern Cayuga Lake. Will the water quality model also address sediment?

The water quality model to be developed for Cayuga Lake will focus on eutrophication, the response of algal growth to nutrient enrichment. The CLMP will not directly address the sediment impairment of southern Cayuga Lake. However, the UFI program will measure the bioavailability of sediment entering
the lake from the tributaries, which will further our understanding of the ecosystem impacts of the sediment loading. Among the water quality variables to be measured and modeled is turbidity (a measure of light scattering, directly related to the size and number of particles suspended in the water). The CLMP will track the relative contribution of algal cells and sediment particles to water column turbidity. Therefore, to the extent that sediment loading is reflected in water column turbidity, the CLMP will provide insights into the factors affecting water clarity in the lake. This information will further our understanding of the linkages between the watershed and the lake, particularly in association with storm events.

The water quality model could potentially serve as a framework for a sediment model at some future point, because a significant task of the CLMP is to develop the hydrodynamic framework (the equations predicting how lake water moves between the model grid cells). The hydrodynamic framework could be used to address other issues, such as sediment.

4. The Lake Source Cooling facility

4.1 What is the LSC facility?

Cornell’s Lake Source Cooling (LSC) facility supplies chilled water to air condition and dehumidify buildings on the university’s Ithaca campus, and cool research equipment and spaces. The LSC process uses the renewable resource, naturally cold water deep in Cayuga Lake, in a non-polluting heat exchange process. This process draws water from deep in Cayuga Lake, where temperatures remain cold year-round, and circulates lake water through a heat exchange facility, located on East Shore Drive in Ithaca. The lake water transfers its chill to a second closed loop of water that is connected to the campus cooling system. Slightly warmed water is returned to southern Cayuga Lake through an underwater diffuser. The lake water and campus chilled waters never mix. For more information, and photos of the LSC facility, visit

http://energyandsustainability.fs.cornell.edu/util/cooling/production/lsc/default.cfm

4.2 Why did Cornell build the LSC facility?

The LSC facility uses a renewable resource (the deep cold water of Cayuga Lake) and a non-polluting cooling technology (noncontact plate and frame heat exchangers) to cool buildings and equipment on Cornell’s Ithaca campus. By investing in the LSC facility, Cornell was able to decommission six electrically-driven chillers, and accelerate the phase out of ozone-depleting CFC chemicals used as refrigerants. Since the facility came on line in 2000, the urgency of reducing fossil fuel consumption has only become more pronounced, spurring discussion and debate at the national, state and local levels. This innovative approach to energy management is part of a sustainable future. The LSC facility is a successful and innovative project – the peak summer electric demand of the entire campus would be 50% higher with conventional chillers instead of the LSC system. That is, without the LSC facility, the electric peak would be 18 MW higher than the actual peak of about 36 MW. The facility reduces the need for electricity to run the campus chilled water system by 87%, with concurrent reductions in
carbon air emissions of about 7,500 tons CO\textsubscript{2} per year, and other air pollutants from fossil fuel-fired electric generation.

4.3 What is the history of the LSC facility?

Cornell uses a central chilled water cooling system to provide campus buildings with air conditioning and dehumidification. Until the LSC facility came on line in 2000, the university relied primarily on electrically-driven chillers to remove heat from the circulating chilled water. In the early 1990s, Cornell utilities engineers began planning to replace these chillers, which were reaching the end of their 35-year service life. At the time, several factors encouraged the university to examine alternative cooling technologies. The 1990 Clean Air Act Amendments legislated the phase-out of refrigerants (CFCs and HCFCs) known to deplete atmospheric ozone; these refrigerants were used in the university’s chillers. Cornell was also committed to reducing overall campus energy consumption and its associated carbon footprint; this commitment was challenged by the projected growth in demand for campus cooling. The use of Cayuga Lake’s deep, cold water as a renewable resource was considered, and the university decided to take on the detailed assessment and permitting required to make this innovative approach a reality.

Extensive monitoring and assessment began in late 1993, and culminated in a Final Environmental Impact Statement in 1997. The SPDES permit for the facility was issued in 1998. With this key permit in hand, construction commenced and the facility came on line in July, 2000. As a condition of its permit, Cornell was required to implement an extensive monitoring program in Cayuga Lake’s southern basin. Biweekly water quality monitoring at a network of lake sites was conducted from 1998 through 2012.

In 2002, NYSDEC placed southern Cayuga Lake on its list of impaired waters—as a category 1 waterbody, meaning that a TMDL approach was required to bring the lake into compliance with water quality standards. NYSDEC has long stated their intent to complete a TMDL allocation for southern Cayuga Lake.

4.4 Has the LSC facility been recognized for its “green” approach to campus cooling?

The LSC project has been recognized as an outstanding example of pollution prevention and environmental sustainability. In 2001, the LSC facility won the New York Governor’s Award for Pollution Prevention. The Governor's Award recognizes institutions and companies that voluntarily go beyond the requirements of compliance with anti-pollution legislation. NYSDEC also honored the LSC project because of its highly innovative nature, and because the technology can be transferred to other institutions. In addition to multiple awards from the engineering community, the project was honored in 2002 with an Award of Special Recognition and Merit from the Ecological Society of America. The Society cited the engineers in the Department of Utilities and Energy Management at Cornell for "extraordinary vision and effort in proposing and carrying through to realization a major contribution to the wise sustainable use of a renewable natural resource."

4.5 Are there other deep water cooling systems in operation?
The City of Toronto partnered with Enwave to construct a Deep Lake Water Cooling (DLWC) facility, drawing cold water from deep in Lake Ontario and using the chill to cool private and public buildings in downtown Toronto. This project came on line in 2004, and is the world’s largest lake source cooling system. Water is drawn from a depth of 83 m in Lake Ontario, pumped through a heat exchange facility connected to a closed loop chilled water distribution system, and then enters the City’s potable water supply system. District cooling in Toronto has allowed the City to reduce its electricity demand for cooling by 90%, decommission a coal-fired power plant, and provide higher quality potable water.  

http://www.enwave.com/district_cooling_system.html

The City of Stockholm has used the cold water from the Baltic Sea for district cooling since 1994, with great success, and is evaluating expansion of the system.

A feasibility study for district cooling of the medical complex in the City of Syracuse, drawing cold water from Lake Ontario or Skaneateles Lake, was completed in 2011. The report includes a detailed comparison of the Cornell LSC system and Toronto’s Enwave DLWC system.  


5. The LSC Permit Renewal/Modification

5.1 What is a SPDES permit?

The State Pollution Discharge Elimination System (SPDES) permit process is used to regulate all discharges to NY waters. Permits set limits on the quantity of materials discharged from regulated facilities. SPDES permits are issued for a five year term. Other facilities discharging to Cayuga Lake, including the Ithaca Area and Cayuga Heights Wastewater Treatment Plants, and Cayuga Operating Company (formerly AES Cayuga), hold SPDES permits.

5.2 Is this a new permitting requirement for the LSC facility?

No, the LSC facility has always operated under the terms of a SPDES permit. Cornell was issued a SPDES permit for the LSC facility in 1998, once the State Environmental Quality Review Act requirements were completed. The facility came on line in 2000. In 2002, the southern basin of Cayuga Lake was placed on the state and federal list of impaired waters [the 303(d) list] in Category 1 – meaning that a TMDL approach was needed to bring water quality into compliance and meet the lake’s designated use. Note that the TMDL process is explained in question 2.

The LSC facility’s SPDES permit was renewed in 2003, with no modifications. Cornell applied for permit renewal in the fall of 2007, and in 2008 the existing permit was extended until final terms of a permit renewal could be finalized. The LSC facility continued to operate under the terms of the 2003 permit, which remained valid because Cornell met all the required deadlines associated with the renewals, and the submittals have been accepted by NYSDEC. The NYSDEC issued a draft permit renewal and modification on October 16, 2012, and set a 60 day period for public comment. The Tompkins County
Environmental Management Council convened a public information session on the draft permit in December, 2012. Representatives of NYSDEC and the project modeling team discussed their approach and responded to community questions. There were 21 comments submitted to NYSDEC on the draft permit renewal.

The final SPDES permit for operation of the LSC facility was issued on March 27, 2013. NYSDEC also released updated Fact Sheets for the permit, and a responsiveness summary detailing how each of the comments on the draft permit was addressed. These documents are available on the NYSDEC web site http://www.dec.ny.gov/lands/88250.html

5.3 What are the conditions of the SPDES permit renewal and modification issued for the LSC facility?

The March 2013 SPDES permit for the LSC facility includes several important modifications and new conditions, as summarized below.

• A phosphorus limit on the return flow of Cayuga Lake water.
• A requirement for Cornell to fund development of a water quality model of the lake and watershed that will enable NYSDEC to complete a TMDL allocation for phosphorus inputs to the lake’s southern shelf (the impaired segment), or identify other effective measures to improve water quality conditions.
• A requirement for Cornell to complete a preliminary design study for a modified outfall (in the event that modifications to the LSC outfall are a cost-effective means to comply with a future phosphorus TMDL allocation).
• A requirement for additional biological monitoring to evaluate whether fish eggs and larvae are being drawn into the LSC system, and whether additional mitigation technologies are warranted. This condition was included to comply with new NYSDEC requirements for cooling waters.
• A requirement for Cornell to investigate and document Best Management Practices for managing their campus cooling load, with an objective of minimizing the need to draw water from Cayuga Lake.

One condition that was part of the 1998 SPDES permit was discontinued. Once the data gathering for the lake and watershed model is completed, water quality monitoring of southern Cayuga Lake will no longer be required of Cornell as part of the SPDES permit. However, the water temperature, flow rate, pH and concentrations of total and soluble phosphorus in the LSC return flow will continue to be measured and reported to NYSDEC as part of the 2013 permit requirements.

5.4 Why is in-lake monitoring being discontinued?

Lake monitoring will continue during the model development phase, and will include the entire lake. However, the intensive monitoring of the southern shelf conducted from 1998 to 2012 is no longer required. Cornell conducted annual biweekly monitoring at a network of eight stations in southern
Cayuga Lake, April – October over this 15-year period. The monitoring program was designed to support a statistical analysis of the lake water quality conditions, which is now completed. This resulted in an extensive data set, concentrated in a small segment of the lake. Annual reports of this lake monitoring are available at http://energyandsustainability.fs.cornell.edu/util/cooling/production/lsc/annualreports.cfm

The question of why the intensive monitoring is no longer required was raised during the public comment period on the draft SPDES permit. The NYSDEC response is available at http://www.dec.ny.gov/docs/water_pdf/cornelllscresp.pdf

5.5 Where can I review the permit?

The NYSDEC has developed a web page http://www.dec.ny.gov/lands/88250.html to share information regarding the many Cayuga Lake initiatives underway. The SPDES permit, associated fact sheets, and summary of responses to comments on the draft permit are available at this site.

5.6 The permit requires Cornell to do a lot of studies. How will these efforts be overseen?

NYSDEC engineers and scientists with expertise in lake water quality and modeling will provide technical review and oversight throughout the entire effort. The CLMP scientists submitted a Quality Assurance Project Plan (QAPP) to NYSDEC in early 2013 to provide details of planned data collection, data analysis and interpretation, and watershed modeling. This document was reviewed and approved before sampling began in late March, 2013. A second QAPP document that addresses the details of the lake model will be required as well.

Cornell and NYSDEC are fully committed to conducting this work in an open and transparent manner, and will provide regular opportunities for stakeholders to review and comment on progress. A technical workshop on the monitoring QAPP was held in January 2013. One outcome of this workshop was a revision to the overall Project Organization chart, to formally recognize the role of community stakeholders in providing input to NYSDEC. The community will continue to have opportunities to review and comment on the project, including the key assumptions regarding model structure.

5.7 How does the LSC facility affect phosphorus in Cayuga Lake?

The LSC facility does not add phosphorus to Cayuga Lake. The transfer of water by the LSC facility brings deep water- which contains low concentrations of phosphorus- to the shallow, sunlit region of the lake where plants and algae can grow. Fortunately, the LSC return flow is clearer, cooler, and lower in phosphorus than the shallow southern basin. In essence, the return flow helps dilute and replace water affected by the wastewater treatment plants and major streams discharging to the southern basin. The LSC return flow can be considered a source of phosphorus to the southern shelf during the summer, when the lake’s deep and shallow waters do not naturally mix.
The issue of whether this phosphorus transfer is ecologically significant has been under review since the LSC facility was first conceived. As a condition of their permit to operate the LSC facility, Cornell was required to measure water quality conditions at a network of eight (8) monitoring stations on the lake’s southern shelf. The monitoring program has been in place since 1998, and has produced an extensive data set. The data have been reviewed and analyzed by experts in lake ecology, statistics, and hydrodynamics (water movement), in order to assess whether the return of water drawn from deep in Cayuga Lake to the lake’s southern shelf has affected water quality conditions. Cornell and its consultants used a statistical evaluation called the Before-After-Control-Impact (BACI) analysis to determine whether observed changes in water quality were related to the LSC return flow. This analysis concluded that there is no scientifically credible evidence that the LSC facility’s water circulation has harmed the lake.

5.8 What about soluble phosphorus? Is this a problem?

Phosphorus is present in several chemical forms in lake water, and these chemical forms differ in their ability to stimulate algal growth. The current NYSDEC guidance value for phosphorus in lakes, which was selected to protect recreational uses and water supplies, is set at 20 parts per billion (ppb) of total phosphorus. Total phosphorus includes all chemical forms of this nutrient. Whether dissolved in water, incorporated in algal cells, or bound to sediment particles suspended in the water, all forms of phosphorus are included in the measurement of total phosphorus.

Under the right conditions, phosphorus will cycle quickly between these various chemical forms. Water deep in Cayuga Lake tends to be higher in dissolved forms of phosphorus—since the water is too deep for light to penetrate, no algae are actively incorporating soluble phosphorus into their cells. The return flow from the LSC facility brings deep water, and its phosphorus, into Cayuga Lake’s southern basin. Years of monitoring data confirm that total phosphorus in the return flow is consistently below the guidance value.

5.9 Does phosphorus in the LSC return flow make the weeds worse in the southern basin?

Most of the rooted aquatic plants (weeds) that are in the southern basin of Cayuga Lake draw phosphorus from the lake sediments. There is no evidence that the LSC return flow has had any impact on the density or types of weeds found in Cayuga Lake. Sediment is carried into the lake from the tributary streams, Cayuga Inlet, Sixmile Creek and Fall Creek. As the streams enter the lake, water velocity slows and the sediment falls to the lake bottom. Aquatic plants will grow where sunlight reaches the sediment surface.

5.10 Why does the SPDES permit for the LSC facility include a phosphorus limit?

The LSC facility returns water to the lake’s southern basin, which is listed as impaired by excessive phosphorus. NYSDEC considers the transfer of water, and its associated phosphorus content, from an unimpaired region of the lake into the southern basin as a source, and thus subject to a regulatory limit.
5.11 How did NYSDEC set the phosphorus limit in the SPDES permit for the LSC facility?

The interim limit, 6.4 pounds per day (ppd) is intended to insure that the phosphorus cycled into southern Cayuga Lake by the LSC facility does not increase while the lake-wide monitoring and model development are underway. This limit was based on current conditions of the volume and quality of water circulated by the LSC facility. As described in the Fact Sheet issued with the permit, http://www.dec.ny.gov/docs/water_pdf/cornelllscprmt.pdf the interim limit of 6.4 ppd was calculated using a flow rate equal to 95% of the current flow and a phosphorus concentration set at 0.020 mg/l, which is the NYSDEC current phosphorus guidance value. The cited final limit, 4.8 ppd or as modified by the TMDL, was calculated using the 95th percentile of the measured loading (from July 2000-December 2009). NYSDEC selected this date range.

A final limit will be determined based on the outcome of the TMDL process. However, if there is delay in completing the TMDL that is attributed to the Cornell project team (not caused by NYSDEC or public review), then a phosphorus limit of 4.8 ppd will be imposed. As described in the fact sheet and noted above, this limit was determined based on a statistical calculation of the amount of phosphorus actually cycled by the LSC facility.

5.12 Does the permit renewal allow Cornell to increase phosphorus loading from the LSC facility?

The mass of phosphorus transferred by the LSC facility from one segment of Cayuga Lake to another is governed by two factors: (1) the volume of water circulated, and (2) the concentration of phosphorus in the lake water flowing through the facility. The LSC facility has control over only one of these factors, the flow rate through the facility. The system does not add phosphorus to the lake water. Flow rate remains capped at 2 cubic meters per second (m$^3$/sec); NYSDEC did not propose any changes to the current flow limit in the draft permit renewal.

However, the permit renewal places a phosphorus limit on the LSC return flow for the first time. The interim limit—during the period of monitoring, modeling and TMDL development—is 6.4 pounds per day. NYSDEC will enforce this limit as a monthly average.

The limit was calculated using LSC facility performance data from 2000 to 2009. The upper 95% of the statistical distribution around the facility’s discharge rate was calculated to be 1.6 m$^3$/sec (37.5 million gallons per day). The maximum allowable phosphorus concentration was set at the NYSDEC guidance value, 20 mg/m$^3$ (parts per billion).

The nature of the LSC facility and the demand for cooling on the Ithaca campus are such that the monthly phosphorus limit may affect the facility’s operations during the warm summer months. The volume of water circulated by the LSC facility varies in direct response to the demand for cooling on campus. Flow rates are highest on warm summer days, and decrease to low levels (less than 20% capacity) during the winter. Moreover, between November and late May, Cayuga Lake is completely
mixed, and the LSC facility does only what the winds and water currents are doing naturally—moving water from one segment of the lake to another.

The facility operates to meet current demand for campus cooling; increased circulation rate above the campus cooling demand would be additional energy consumption for no benefit. Therefore, it is not meaningful to project the potential impacts of operating the LSC facility at peak year-round.

6.Has the water quality of Cayuga Lake changed since the LSC facility started up in 2000?

6.1 Phosphorus and chlorophyll-a

There has been a change in Cayuga Lake. The summer (July through August) chlorophyll-a concentrations (an indicator of algal abundance) have increased about 60%, from 5.2 μg/L (micrograms
per liter, a unit of measurement equivalent to a part per billion, ppb) over the 2000 to 2005 period, to 8.5 μg/L over the 2006 to 2011 period. The total phosphorus (TP) concentration in Cayuga Lake’s deep waters (hypolimnion) increased as well over a similar time period. The average deep water TP increased from 12.3 μg/L during 2000—2003, to 15.6 μg/L during 2004—2009 while average soluble reactive phosphorus (SRP) increased nearly 80% over the same period, from 4.8 μg/L to 8.6 μg/L. Similar trends have been observed in Seneca Lake. Powerful statistics show that the LSC return flow is not the cause of the change in Cayuga Lake; water quality changes began to be measured more than four years after startup.

One of the most important observations is that the increasing chlorophyll and deep water phosphorus occurred despite the massive reduction in phosphorus input (some 80%) brought about by improvements to the two wastewater treatment plants discharging to southern Cayuga Lake (illustrated in the figure below). We note that the magnitude of reduction in this single source is equivalent to more than six LSC facilities. This finding illustrates the complexity of the water quality dynamics in the lake’s southern basin. Moreover, it has led Cornell and NYSDEC to work together to improve our collective understanding of factors influencing phosphorus dynamics in the lake. The CLMP will enable NYSDEC to use a scientifically-defensible approach to setting a phosphorus limit on the LSC facility.

![Graph showing chlorophyll-a and TP discharge](image)

LSC- Cornell Lake Source Cooling  
CHWWTP- Cayuga Heights Wastewater Treatment Plant  
IAWWTP- Ithaca Area Wastewater Treatment Plant  
Chlor- chlorophyll-a (plant pigment, indicating algal abundance)
Data Source: Cornell University, March 2013. Cayuga Lake Water Quality Monitoring, Related to the LSC Facility: 2012

Monthly average total phosphorus load (May – October) of three point source discharges to southern Cayuga Lake, and the summer average (June-Sept) chlorophyll-a concentration in the lake’s southern basin.

7. Opportunities for Collaboration

7.1 How does the CLMP relate to the other work underway in southern Cayuga Lake—dredging and hydrilla control?

Part of this project will be to fully understand the other efforts underway and how they may affect the development of the watershed and lake models. There certainly will be opportunities for collaboration, but specific areas have not yet been identified. The participation of the Monitoring Partnership will help coordinate the many initiatives underway on Cayuga Lake and its watershed. NYSDEC involvement in all of these activities will also help ensure proper coordination. The Cayuga Lake web page that NYSDEC has developed [http://www.dec.ny.gov/lands/88250.html](http://www.dec.ny.gov/lands/88250.html) includes links to various initiatives underway.

7.2 How will local knowledge be incorporated into the integrated management model of Cayuga Lake and its watershed?

There is a wealth of information on Cayuga Lake and its watershed, developed over years of monitoring and research. The project team is actively coordinating with local technical stakeholders to capture local data, information and knowledge so that the lake and watershed models can reflect the best available science. The Cayuga Lake Monitoring Partnership, a committee of the Tompkins County Water Resources Council, has agreed to serve an ongoing role in coordinating local sources of data, information, and knowledge about the Cayuga Lake ecosystem. Chaired by Roxanna Johnston, City of Ithaca Watershed Coordinator, the Monitoring Partnership will meet regularly with members of the project team to discuss progress and findings throughout the multi-year project.

8. Sedimentation and Use Attainment

8.1 Can a regulatory action such as a TMDL reduce sediments going into Cayuga Lake and the resulting turbidity (cloudiness) and growth of aquatic plants and algae?

There is substantial evidence that Cayuga Lake’s large southern tributaries (Cayuga Inlet, Sixmile Creek, and Fall Creek) are the major sources of nutrient and sediment loading to the lake’s southern shelf. The Cayuga Lake watershed was cleared of its forests in the 19th and early 20th centuries for agriculture and settlements. Much of the sediment eroded from the cleared landscape during this period is still stored in
the streambeds of the lake tributaries. Presently, much of the watershed has been reforested and the sediment loss from the landscape has decreased.

As a consequence, best management practices within the tributary subwatersheds can reduce, but not eliminate, sediment deposition. The Tompkins County Soil and Water Conservation District and other agencies continue to implement projects within the subwatersheds to help reduce soil loss.

8.2 Why is there no swimming at Stewart Park?

Sediment washing into the lake from the main tributary streams- Cayuga Inlet, Sixmile Creek, Fall Creek and Cascadilla Creek, reduces water clarity and makes swimming unsafe. State guidelines for swimming beaches call for a minimum water clarity of four feet. There has been no designated swimming beach at Stewart Park since 1967 (46 years ago).

The article that Professor Nelson Hairston published as an op-ed in the Ithaca Journal in 1999 provides the best answer- here it is again:

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The Ithaca Journal
April 12, 1999
Guest Columnist Nelson Hairston, Jr.
Frank H. T. Rhodes Professor of Environmental Science
College of Arts and Sciences Cornell University

The origins of Cayuga Lake's problems

The New York State Department of Environmental Conservation has added southern Cayuga Lake to the, now famous, 303d list. Although the legal and environmental significance of this listing that has been debated at length in this newspaper and elsewhere, the reasons for the designation are well known and relate to levels of nutrients and sediments present in the lake water.

While nutrients have received considerable discussion, the turbidity caused by sediments (particles of silt and clay suspended in the lake water) has received much less attention. It is the sediment that creates such unattractive murky brown water after storms and runoff from spring snowmelt.

It is also sediment accumulation in the near-shore region at Stewart Park that has long-time residents lamenting what they perceive as the worsening conditions in the lake. What are the origins of this problem? The south end of Cayuga Lake, the area now occupied by Stewart, Treman and Cass Parks, was originally and naturally a large marsh. The shallow, muddy sediments that formed the substrate upon which marsh vegetation grew came from the silt and clay particles carried by the tributaries that flowed across the land surrounding the Ithaca area and into the lake: Fall Creek, Cascadilla Creek, and Sixmile Creek.
These particles came from a naturally eroding landscape and were trapped in the marsh where they accumulated. This process led very slowly to an addition of dry land at the shore - much of it now supporting the homes and business of Ithaca. At the same time the deposited sediments extended the marsh edge out into the lake.

The southern Cayuga Lake marsh was filled in by Ithacans early in this century, first to make land for industrial development, and then later converted into the parks that we who live in the Ithaca area enjoy so much. But, the filling of the marsh did not stop the sediment from flowing down the creeks to the lake. Indeed, farming and land development in the watershed no doubt substantially increased the rate of erosion. With no marsh remaining to trap the sediments, the particles now flow largely uninhibited into the lake. When the velocity of the creek water is slowed by mixing with lake water, the sediments fall to the lake bottom, building up near the shores of Stewart and Treman Parks, and creating a large shallow shelf of mud.

Many long-time residents of the Ithaca area recall a wonderful period in the past when swimming was possible at Stewart Park. There is an understandable tendency for these residents to think that swimming at this site was somehow the natural state, that the current condition is unnatural, and that this change must be someone's fault.

In reality, all that is occurring is the inexorable action of natural processes that began when the glaciers receded from the region some ten millennia ago: a marsh is being deposited at the south end of Cayuga Lake - by an accumulation of shallow sediments that will eventually, without our intervention, be occupied by aquatic vegetation such as sedges, rushes and cattails.

The erosion that is depositing these sediments is an accelerated version of the process that formed our beautiful gorges and waterfalls. Those who enjoyed swimming at Stewart Park were lucky. They lived during the period of a few decades between the filling of the natural marsh and the point at which sediment accumulation at the edge of the park became so great that swimming was no longer possible.

The marsh is the natural condition. If the residents of Ithaca and Tompkins County don't like the marsh that is building off the shore at Stewart Park, then it will be necessary to fight back the forces of nature. It is a decision that should be considered only with the knowledge that this really is the action that is being proposed: to keep the lake shoreline in an unnatural state that we as users of the resource prefer.

There is no question that unnaturally high erosion in and along the tributaries should be curtailed by good land-management practices. This will reduce but not stop the rate at which the marsh is being built. We cannot, however, and I assume do not wish to halt farming, building new homes, schools and recreation sites in Tompkins County; some human accelerated erosion will always occur.

Natural erosion can be reduced by better watershed and channel management practices. Whatever our decision as a community, gravity will continue to make water flow downhill, natural erosion will continue, and sediments will continue to enter the lake and accumulate along the shore. We can influence the rates, but at some level we have no choice but to accept the process.
9. **What would it take to convert the LSC system over from the "once-through, non-contact" cooling water discharge to a "closed-loop" system?**

A closed-loop system with heat exchangers placed in the lake’s deep, cold waters was evaluated during the LSC project design, and was dismissed as impractical in the Final Environmental Impact Statement. Significant unknowns—such as the heat exchange efficiency, the potential for fouling by sediment, mussels, and other forms of aquatic life, and the methods required to build, maintain and clean such a system—precluded serious consideration of this option. Any leaks that might occur in the piping or heat exchangers would be very difficult to detect or repair, and could result in discharge of treated water to the lake. There would have been no comparable means of spill or leak detection and containment as is currently provided at the Heat Exchange Facility.