Status Report 2
Lake Source Cooling Outfall Redesign Study

SPDES Number NY0244741

8/24/2015

Department of Energy & Sustainability
Cornell University
Infrastructure, Properties & Planning

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1. Introduction

Cornell University's Lake Source Cooling (LSC) facility supplies chilled water to cool buildings and research equipment on the university's Ithaca campus. 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 cools a second closed loop of campus chilled water as it is pumped through the non-contact plate and frame heat exchangers. Slightly warmed lake water is returned to southern Cayuga Lake through an underwater diffuser. The lake water and campus chilled waters never mix.

The New York State Department of Environmental Conservation (NYSDEC) issued a State Pollutant Discharge Elimination System (SPDES) permit for the LSC facility in March 1998, after all the environmental reviews were completed. This permit, which governs the return of the lake water to Cayuga Lake, has been renewed periodically since the LSC facility came on line in July, 2000. The most recent SPDES permit, effective date May 1, 2013, included several modifications and new conditions. This status report #2 summarizes work accomplished to date on one of the May 1, 2013 permit requirements: to complete a preliminary redesign study for a modified outfall of the LSC facility. A modification to the outfall would be implemented in the event that Cornell determines that this action would be the most practical and cost-effective approach to comply with a future phosphorus limit, or to avoid the risk of adverse environmental impacts to Cayuga Lake.

The language from the SPDES permit requiring the LSC outfall redesign study is cited below.

"In compliance with Title 8 of Article 17 of the Environmental Conservation Law of New York State and in compliance with the Clean Water Act, as amended, (33 U.S.C. 1251 et. Seq.), per SPDES Permit Number NY 0244741 (http://www.dec.ny.gov/docs/water_pdf/cornelllscprmt.pdf), effective May 1, 2013, Cornell (permittee) shall comply with the following schedule for permit compliance:

> "The permittee shall develop and submit an approvable plan for an Outfall Redesign Study to evaluate potential alternative sites for relocating the discharge from Outfall 001 to a location within the Class AA segment of Cayuga Lake (as depicted by transect A-A' on the Monitoring Locations map and defined in 6 NYCRR Part 898.4, Table I, Item 227).
>
> "The requirement of this Study shall be to evaluate the current mixing zone of the discharge, identify one or more discharge locations in waters of sufficient depth to ensure that the discharge plume remains below the photic zone and to determine that the discharge will not contribute to an impairment of the designated uses of the Lake."

Cornell University developed a draft workplan for completion of the required outfall redesign study, and met with NYSDEC staff in Albany NY in December 2013 to discuss the technical elements of our approach. The draft workplan was modified in response to discussion during the December meeting; a

final version of the workplan was submitted to NYSDEC in January 2014. The workplan was approved, with one additional requirement, on April 30, 2014. This date (effective date of workplan approval, EDA) defines the schedule set forth in the May 1, 2013 SPDES permit for the required status reports and final report of the outfall redesign study.

The permittee shall submit Outfall Redesign Study status reports:	EDA + 8 months (December 30, 2014) EDA + 16 months (August 30, 2015) EDA + 24 months (April 30, 2016)
The permittee shall submit an approvable final report:	EDA + 30 months (October 30, 2016)

This document is Status Report 2, submitted EDA+16 months, on or before August 30, 2015.

2. Summary of Progress by Workplan Task

The approved workplan includes a table of objectives and tasks that will enable Cornell to meet the outfall redesign-related requirements of the May 1, 2013 SPDES permit for the LSC facility. The objectives and tasks are summarized in Table 2-1 along with a brief status update as of EDA + 16 months. One additional task requested by NYSDEC as part of the workplan approval is designated in blue text.

Table 2-1. Summary of progress with workplan tasks

Objective	Task	Status Update EDA+ 16 months
Evaluate current mixing zone of the LSC return flow	Complete a three-dimensional (3D) model of the LSC return flow under current conditions: flow rate and temperature of LSC return flow; meteorological forcing functions; diffuser configuration; flow rates from IAWWTP and VCHWWTP.	Alexandra King and Edwin Cowen continue to make substantial progress with setting up and testing the three-dimensional hydrodynamic model of the southern shelf of Cayuga Lake, Si3D. As reported in Status Report 1, current conditions of mixing and water residence time on the shelf have been analyzed under various conditions of stream flow and wind conditions. The existing LSC outfall diffuser has been analyzed using CORMIX to characterize the near-field mixing dynamics; this has enabled the researchers to modify the governing equations within Si3D to accommodate near-field mixing. A detailed gridding study was completed in August 2014. Gridding study data have now been compiled and will be used as the basis for calibration of the near field model. **(section 3)**
	Validate the 3D model using data from the RUSS, thermistor at the pile cluster, LSC intake temperature records, and other measurements specifically for this study.	
	Use the validated model to simulate the 3D velocity and temperature fields under current conditions, from which estimates of the spatio-temporal evolution of the LSC outfall plume will be determined.	
	Quantify the effects of the LSC return flow on residence time of Cayuga Lake water on the shelf.	

Objective	Task	Status Update EDA+ 16 months
Identify an alternative discharge location that meets criteria	Define the depth of photic zone in Cayuga Lake, based on statistical analysis of light profile data in Class AA segment collected 1999-2006, 2013.	**Complete**, reported in Status Report 1.
	Apply model to a new outfall located within the Class AA segment of Cayuga Lake in order to project the configuration of the discharge plume of LSC return flow during the critical period for phytoplankton growth (June 1-Sept 30).	**Complete**, reported in Status Report 1.
	Discuss the potential impact of return LSC flow through a new outfall during May and October (per NYSDEC request 4/30/14)	**Complete**, reported in Status Report 1.
	Investigate potential effects of a range of meteorological conditions on projected plume from relocated outfall.	**Complete**, reported in Status Report 1.
Compare environmental impacts of existing and alternative outfall	Apply the hydrodynamic and eutrophication models to project summer phosphorus and chlorophyll concentrations in 303(d) listed (Class A, southern shelf) segment and main lake (Class AA segment) of Cayuga Lake, under two scenarios: current outfall and redesigned outfall.	0% complete (pending completion of the eutrophication model)
Develop alternative outfall	Complete conceptual design of outfall extension/relocation	0% complete
	Develop (engineers opinion of) costs for permitting, design, survey, bidding, construction	0% complete
Prepare detailed implementation schedule	Identify potential suppliers and contractors; develop critical path timeline for acquisition of pipe and other materials.	0 % complete
	Identify required regulatory permits and approvals from NYSDEC, ACOE, and any local municipalities; including SEQRA compliance	0% complete
	Identify required easements from OGS	0% complete
Submit outfall redesign study to NYSDEC	Report to comply with SPDES special condition	0 % complete (due 11/1/2016)

3. Status of the Three-Dimensional Hydrodynamic Model Si3D

3.1 Previously Reported

In the January 2015 Status Report #1 (SR1), we reported the following:

1. Development of the numerical grid/mesh for the 3D model (refer to SR1, Section 3.1).

2. Field data collected in 2012, 2013, and 2014 (refer to SR1, Section 3.2).

3. Analysis of the LSC outfall operating parameters and ambient lake conditions. In this analysis, we classified the outfall according to the CORMIX II classification system (refer to SR1, Section 3.3).

4. Modifications to the 3D hydrodynamic model, Si3D, through which we have:

   a) incorporated the LSC outfall's input of mass, momentum, and buoyancy (and the intake's sink for these quantities) into the model equations, and

   b) modified horizontal eddy viscosity and diffusivity in the near field of the outfall plume to ensure linear spreading with an adjustable entrainment rate (refer to SR1, Section 3.4)

3.2 Current Focus

As reported in SR1, the Cornell research team conducted an intensive temperature monitoring field study (gridding study) in August 2014 to map the LSC outfall plume. Temperature profiles were measured at 170 points centered near the LSC outfall, and three continuous temperature records were collected at the edges of the sampling domain using thermistor strings. The location of the sampling points is shown in Figure 3-1. This intensive sampling effort was additional to the field sampling program employed to collect model driver data in 2012, 2013, and 2014, which included a long thermistor chain near the LSC intake, meteorological measurements at the piling cluster, and supporting stream flow and water surface elevation measurements from the USGS and NYSCC (see SR1 for details).

The near-field submodel for the LSC outfall plume within Si3D has only a single parameter that can be calibrated; this parameter is denoted **alpha** (refer to SR1, Section 3.4.2) and sets the near-field entrainment rate. Dr. Alexandra King and Professor Todd Cowen report that the gridding study data set is being used to calibrate this parameter.

As of the date of Status Report 2, the Cowen group reports substantial progress in compiling the input files in preparation for setting up the model simulations. Once the simulations are initiated, the researchers will be able to compare predicted and measured water temperatures and complete the calibration of **alpha**. In order to complete the calibration, the Cowen team will run simulations to predict 2014 water temperatures measured on the shelf during the August 14-15, 2014 field gridding study. They will run a series of simulations employing different values of **alpha**, and the calibrated value

of **alpha** will be selected to provide the "best fit" as defined by minimization of least square difference between predicted and observed temperatures.

Once the calibration is complete, the Si3D model will be validated by comparison to other data sets. The validated model will then be used in a predictive manner, to simulate the velocity and water temperature conditions under current conditions and alternative scenarios of the LSC outfall location and configuration. The impacts of the LSC return flow on residence time of water on the shelf will then be assessed.

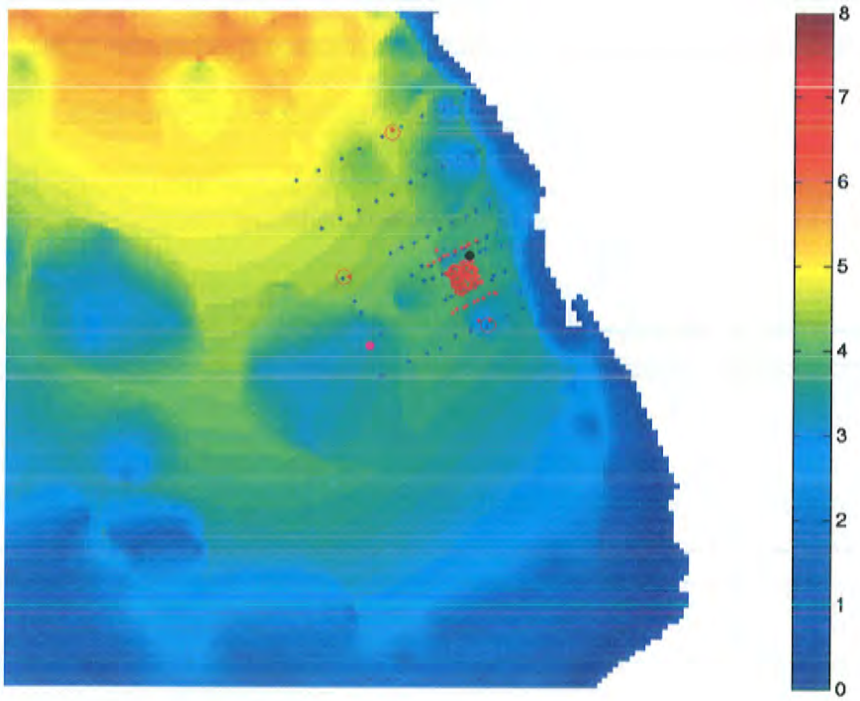

Figure 3-1. Profile locations for August 15, 2014 gridding study.

Color plot in background shows water depth (referenced to mean summer lake level) in meters. Large black dot marks location of LSC outfall, large magenta dot marks location of CHWWTP outfall, small blue and red dots mark location of temperature profile measurements from two different boats, and red open circles mark locations of moored thermistor strings. Gridded region is 400m x 400m.

4. Problems Encountered and Impact on Schedule

None. We remain on schedule to complete the outfall redesign study within the permit-required 30 month period. The Cornell project team will continue to commit the time and resources required to comply with this permit condition.

5. Upcoming Tasks

- Complete the calibration and validation of Si3D model.
- Complete the following work plan tasks related to the outfall relocation and redesign:
    - Develop (engineers opinion of) costs for permitting, design, survey, bidding, construction
    - Identify potential suppliers and contractors; develop critical path timeline for acquisition of pipe and other materials.
    - Identify required regulatory permits and approvals from NYSDEC, ACOE, and any local municipalities; including SEQRA compliance
    - Identify required easements from Office of General Services