Cornell University Chilled Water Best Management Practices Program

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Facilities Services

Energy and Sustainability

Utilities

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Contents

1 Overview of Purpose:

In accordance with New York State Department of Environmental Conservation State Pollutant Discharge Elimination System (SPDES) Permit NY0244741, Cornell University is required to submit a Best Management Practices – Optimization Program. Per the Schedule of Compliance;

> *The permittee shall submit a program that, to the degree practical, will maximize the efficiency of the Lake Source Cooling system while minimizing the volume of water used. The program shall review all major campus facilities over the five-year permit cycle, including components or systems, to identify areas of cost-effective optimization, and shall implement identified practices. The program may include the implementation of practices such as minimization of the use of campus chilled cooling water in noncritical buildings during times of limited or no occupancy, optimization of building temperatures to reduce cooling needs, optimization of heat transfer equipment, and the use of automated valves and other equipment to minimize campus chilled water use. The program shall continuously seek to identify areas of greater efficiency in the use of campus chilled cooling water so that that additional use of the Lake Source Cooling system may proceed while increases in the volume of water taken from Cayuga Lake are minimized to the degree practical.*
>
> *The permittee shall submit an annual report summarizing any ongoing or additional practices identified and implemented and identify new buildings which use the Lake Source Cooling plant that have been placed online.*

The due date is February 1 of each year. This document is the annual report as required per the schedule of compliance.

2 Chilled Water System

2.1 Chilled Water System Description

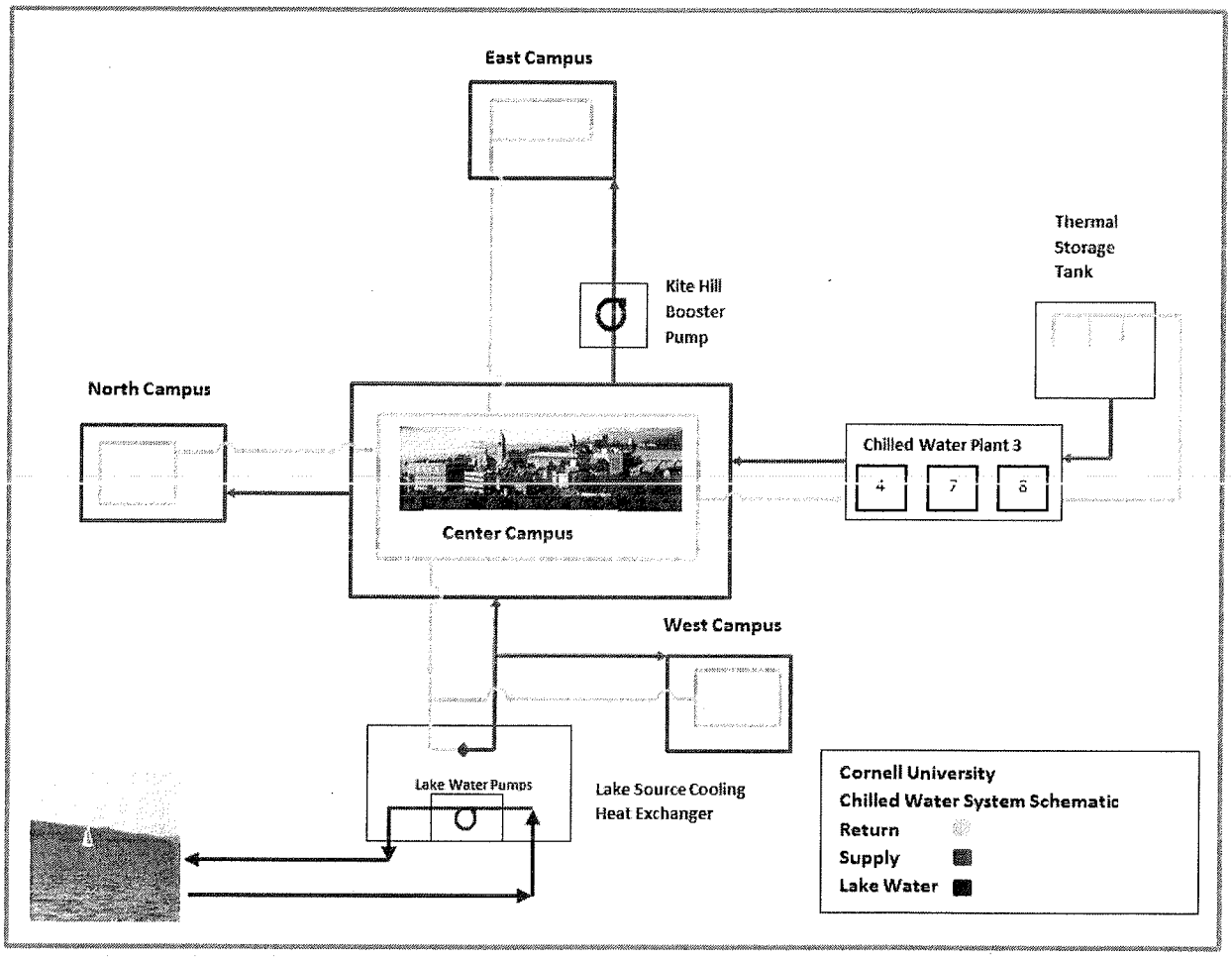
Figure 2.1 depicts the chilled water system. The system consists of chilled water production facilities that provide chilled water for campus cooling. Lake Source Cooling (LSC) provides approximately 98% of the annual chilled water needs with Chilled Water Plant 3 providing the remainder.

The LSC facility is considered a "passive" facility as its output is controlled by lake water and campus return temperature. It is not like a chiller plant where the chiller can actively control leaving water temperature. The entering lake water temperature is the largest determinant of system capacity and lake water pumping volume. The temperature of Cayuga Lake water entering the heat exchange facility varies, depending on the lake's thermal stratification regime. In most years, the hypolimnetic temperature is about 39°F. When spring weather conditions delay the onset of seasonal stratification, hypolimnetic temperature is higher than normal (41 ºF + versus 39 ºF). When this occurs, the LSC facility cannot provide the same level of cooling at equivalent flow, and the pumped lake water volume is higher.

Chilled water plants 1 and 2 do not currently contain cooling capacity and have been inactive since 2000 when the LSC facility came on line.

Cold water is supplied to campus facilities via an underground closed loop (supply and return) distribution system. The Cornell district cooling system operates year-round, with summer chilled water supply and return temperatures of approximately 43-45 ºF and 56-58 ºF respectively. Winter chilled water supply and return temperatures are typically 40–43 ºF and 50-55 ºF respectively. The chilled water system produces approximately 45 million ton-hours (1 ton-hour = 12,000 Btu) of cooling each year for research processes, general air conditioning of laboratory space, computer rooms, lecture/teaching areas, offices, dining and common spaces. Only a small percentage of campus residential space is air conditioned. The system serves over 100 facilities totaling over 8 million square feet.

Figure 2.1 Cornell Chilled Water System



2.2 Chilled Water Production Equipment

Current production facilities include the Lake Source Cooling facility and centrifugal chillers located at Chilled Water Plant #3 (CWP3). Also located at CWP3 is a thermal energy storage tank which shifts cooling load on the chillers to off-peak times by charging (i.e., cooling) the water in the tank for use during peak cooling demand. The current ***installed capacity*** of the system is 22,500 tons. Installed capacity is defined as capacity that is available at all times on a perpetual basis. Along with the installed system capacity, some "transient" capacity is available to supplement the system should the system experience an outage of the installed capacity. Transient capacity is defined as capacity that is available on a temporary, short-term basis. The following table summarizes the chilled water resources:

Cornell Firm Chilled Water Resources

Source	Capacity (Tons)
Chiller 4	1,500
Chiller 7	4,000
Chiller 8	2,000
LSC	15,000
Total All Chillers	22,500

Cornell Transient Chilled Water Resources

Source	Capacity (Tons)	Description
Thermal Storage	2,000 - 8,000	4 - 20 Hours depending on conditions

3 On-Going Practices to Reduce Chilled Water Consumption and Energy

3.1 Chilled Water Plant Operations

Chilled water plant operations implement a variety of design and operational strategies to deliver chilled water to campus buildings efficiently. These include the following:

Variable Flow Design

The system is designed and operated as a variable flow, nearly constant temperature rise design, which minimizes the flow of chilled water and lake water along with pumping energy. Variable speed pumping at the plant responds to load change, which adjusts the flow to what is needed to meet the load.

Lake water flow is controlled to meet chilled water delivery temperature requirements to the campus with variable speed drives and flow/temperature measurement. This helps minimize the volume pumped and energy used by lake water pumps. This system is automated to assure high efficiency.

Heat Exchanger Flushout

Periodically, debris from the closed campus chilled water system will accumulate in the LSC heat exchangers and reduce efficiency. A periodic maintenance "flush out" is used to maintain heat exchanger efficiency and minimize pumping flow rates.

Thermal Storage Tank Capacity

The 4.4 million gallon thermal storage tank is dispatched to provide additional cooling resources to meet the peak summer load. This is accomplished by charging the tank with chillers at night using off-peak power and cooler night time temperatures which improve cooling plant efficiency. The tank cooling effect is then dispatched during the day, which supplements LSC when campus load exceeds LSC capacity. The net result is to operate the chillers at night and reduce or eliminate their use during the day. This is a cost-effective tool to control the electrical demand profile of the campus and thus reduce overall demand on the electrical grid. The thermal storage tank can also provide transient capacity for short term outages of firm chiller and LSC assets. The availability for back-up capacity is short term depending on how much capacity is being delivered and the corresponding charge level of the tank. Utilizing this system allows Cornell to meet peak summer loads without adding additional LSC pumping capacity.

Kite Hill Booster Pump

The Kite Hill booster pump increases the pressure of the water in the distribution system on a long connection to just the east campus buildings so all of the pumping from LSC does not need to include this extra energy. The end result is a reduction in total pumping energy needed at LSC. Without the Kite Hill Booster Pump total system efficiency would be lower.

3.2 Building Systems

Proper design of building controls, system heat exchangers, variable flow control valves, and variable speed pumps all contribute to reducing building cooling energy usage and the associated flow of water.

Campus digital controls are used to control temperature in spaces. Occupancy sensors and/or programmed occupancy schedules are used to relax the cooling set point when the space is not occupied. Relaxing cooling set points minimizes the use of fan energy, pump energy and lake water.

The major objective of the building's cooling system is to remove heat from inside the buildings and transfer it to the chilled water loop. The components and controls are designed to minimize the flow of chilled water, adding as much heat/temperature rise to each gallon pumped as possible, which reduces the volume of lake water needed. In general the following is used to accomplish this:

- Cooling loads utilize variable flow coils and pumping, and modulating control valves.
- Buildings utilize a recirculating loop interface that provides a controlled chilled water supply temperature to all loads in the building.
- The controlled temperature is reset based on outdoor air conditions to a warmer temperature when outdoor air does not require dehumidification and when mixed air systems are using outdoor air for direct cooling.

New buildings are required by university standards and policy to meet LEED Silver certification and include energy use intensity targets to emphasize the goal of energy efficient building design. The targets result in 30 to 50% less energy usage than energy code and typical existing "best in class" Cornell buildings.

3.3 Energy Conservation Initiative (ECI)

The purpose of the ECI program is to reduce overall building energy consumption combined from all sources by 15% compared to a 2010 pre-ECI baseline. This includes electricity, heating and chilled water usage. The current ECI effort began in 2010 and will conclude in FY 2015. It builds on a continuously funded and comprehensive program in existence since the 1970's. The ECI project process consists of

- performing a building study that develops facility improvement measures (FIMs) which will reduce building energy consumption,
- defining the project scope incorporating pay-back analysis along with other financial evaluations, and
- designing and implementing the project based on available funding. Numerous studies have been performed. Cornell University has committed over $32 million dollars for the ECI effort.

For fiscal year 2013, ECI projects are estimated to have saved approximately 1.3 million ton-hrs, approximately 2.5% of total campus chilled water usage. Table 3.1 provides a list of the affected facilities.

Table 3.1: ECI Projects with Chilled Water

List of Facilities with ECI CHW Projects Affecting FY13 Chilled Water Usage
Statler Hall
ST-Olin Chemistry Lab
Uris Hall
Comstock
Kinselberg
Bradfield Hall
Uris Library
Corson Mudd
Kroch Library
Carpenter Hall
Schurman Complex
Veterinary Education Center

3.4 Commissioning and Preventive Maintenance

Another strategy for reducing chilled water consumption is making sure existing systems are operating as designed and as efficiently as possible. This is done via commissioning and preventive maintenance.

New building systems, (either new construction or as part of a building renovation) go through a commissioning process, to make sure the systems are performing as designed, before the buildings are placed into operation.

Central equipment, which includes all air handlers, chilled water system and process cooling in the central mechanical rooms are re-commissioned and optimized on an 18-24 month basis.

Key building space controls are also periodically re-commissioned and optimized. The emphasis is on high energy use buildings which use significant amounts of energy. These buildings are typically laboratory research buildings requiring regular, high level air exchange.

The continuous commissioning, preventive maintenance, and optimization program was initiated in 2001 and currently consists of ten full-time technicians covering buildings that are served with district chilled water cooling. The continuous program is designed to maintain the operational efficiency and find further savings over time.

3.5 Holiday and Calendar Break Scheduling Program

Operating equipment only when needed is another strategy to reduce chilled water consumption. During holiday and academic calendar breaks, building occupancy schedules are set to "unoccupied mode" and equipment is shut off to the extent possible. The energy management team works with facility managers to develop approaches for each building. A current focus is on dining halls and residential facilities to minimize outdoor air use and cooling.

3.6 Fume Hood Hibernation Program

A typical lab hood in a building uses as much energy as a home on an annual basis due to conditioning, delivering and exhausting the air passing through the hood. Facility managers can ask for a hood to be hibernated for a short period or long period to reduce energy use which will reduce the amount of cooling needed for the outdoor air. While hibernating, the hood must be sealed off and is no longer available for education or research.

3.7 Performance versus Forecast

The annual chilled water consumption forecast is used by the Energy and Sustainability Department to regularly check the performance of the buildings to the forecast. Because the forecast is based on a model that uses actual weather data, the forecast can be corrected to the actual weather in any billing month and then compared to the actual usage. Usages that are beyond an expected variance are then marked for follow up by the conservation focused controls technicians.

4 Additional Practices to Reduce Chilled Water Consumption

4.1 Campus Engagement Program

Cornell University has created an engagement program to promote user awareness of their energy usage and reducing the usage. Components of the program include the following:

- **Building Energy Dashboard:** Approximately 50 buildings are now available with real-time and archived energy use http://buildingdashboard.cornell.edu. Real time data can be downloaded through a link provided from the Dashboard http://portal.emcs.cornell.edu. Comparisons can be made to other buildings and competitions between buildings are now possible. The first college wide competition was run with the College of Engineering in Fall, 2013. Education and commitment tools inform users on how to reduce the amount of cooling energy. The Energy Dashboard is fully integrated with social media.

- **Green Offices:** A new program, started Fall, 2013 seeks to educate, certify, and promote energy saving and sustainable behaviors and practices for offices on campus.

- **Green Labs Program:** A new program, started Fall, 2013 aims to educate, certify and promote energy saving and sustainable behaviors and practices for laboratories on campus.

- **Engineering College Pilot Program:** The first college-wide engagement program started Fall, 2013. The purpose of the program is to reduce the college's environmental footprint.

- **Significant web content about these programs can be found at:**

  http://www.news.cornell.edu/stories/2013/09/engineering-launches-think-big-live-green-campaign

  http://thinkbiglivegreen.cornell.edu

4.2 Direct Billing

Colleges and units are now responsible for allocating a budget and paying for their respective energy usage. The intent via the new budget model is to provide greater transparency of each building's energy footprint and encourage the respective colleges and units to support initiatives that reduce energy consumption, which includes chilled water consumption.

4.3 Monthly Building Reviews

In fiscal 2014, a monthly review of building efficiency for all central utility connected buildings was added. Each month the continuous commissioning, preventive maintenance, optimization controls technicians review the control loop operations for major buildings. These reviews help find any controls issues and opportunities for improvement that will minimize building energy usage. Follow up is made by the technician directly. The technician can issue a corrective work order to make changes and repairs if necessary.

Each month the metered use of cooling is compared to the previous year. Any significant differences are flagged and followed up for corrective action.

5 New Loads that Use Lake Source Cooling

New buildings or new space added to the chilled water system are estimated for the coming fiscal year. The estimated usage is based on a combination of modeling from the design team on the project and metered data from existing campus buildings. The estimated new usage is then added to the total system load. The new loads expected to be added to the chilled water system in 2013 that will add load in fiscal year 2014 (July 1, 2013 through June 30, 2014) are summarized in Table 5.1. The total additional annual cooling expected in FY 2014 is estimated at 860,000 ton-hrs.

Table 5.1: New Cooling Loads

Project Name	FY 2014 Estimated Chilled Water ton-hrs	Comments
1041A: Stocking Hall Addition	340,000	Stocking Addition 1041A was substantially complete in April 2013 with occupancy in June 2013.
1063A: Food Science Addition	134,000	FSL-Addition 1063A was substantially complete in April 2013 with occupancy in June 2013.
1026: Warren Hall Renovation	64,000	2/3 of building occupied by 7/2013 and 1/3 of building will be unoccupied for gut/renovation and re-occupied 18 months later
2044: Gates Hall	209,000	Completion estimated at Spring 2014
1029: Fernow Hall	113,000	Completed Feb 2013, fully occupied May 2013
TOTALS	**860,000**	

6 Review of Major Campus Facilities

The permit requires the review of all major campus facilities over the five-year permit cycle. Table 6.1 lists the major chilled water campus facilities which are defined as academic buildings whose cumulative chilled water usage equals 50% of the total campus usage. It also lists what year the facility was reviewed. Text below the table describes the extent of the review and changes made as a result of that review.

Table 6.1: Major Campus Chilled Water Academic Buildings

Facility Code and Name	Year of Facility Review
1164_VET MEDICAL CENTER	2013
2051_FRANK H T RHODES HALL	
2085_WILSON SYNCHROTRON LAB & RING	
2000_DUFFIELD HALL	2013
1027_MANN LIBRARY	2013
1014_WEILL HALL	2013
2082_CLARK HALL	
1018_BIOTECHNOLOGY	2013
2019_BAKER LABORATORY	2013
2076_PHYSICAL SCIENCES BUILDING	
1166_NYS Veterinary Diagnostic Lab	
1165_EAST CAMPUS RESEARCH FACILITY	
1028B_BRADFIELD HALL	
2086_JOHNSON MUSEUM OF ART	2013
1019_CORSON_MUDD_COMPLEX	2013
1076_BOYCE THOMPSON INSTITUTE	2013

Vet Medical Center

During 2013, an Energy Conservation Initiative project was started to completely replace all of the heating, ventilating, and air conditioning system (HVAC) system controls. The project will be completed in 2014. The new controls will allow occupancy based logic to change air flow and temperatures in all spaces and accurately modulate supply air and central heating and cooling systems to match the varying loads in the space. New logic will minimize the use of cooling when outdoor air dewpoint temperatures are below 55 F to reduce cooling and reheat energy normally used in dehumidification. All new controls will be fully commissioned by third party commissioning consultants.

Duffield Hall

During 2013, an Energy Conservation Initiative project was completed to replace inefficient occupied space heating, ventilating, and air conditioning system (HVAC) system controls. The new controls allow occupancy based logic to change air flow and temperatures in all spaces. Central heating and cooling systems accurately modulate supply air to match the varying loads in the space. All new controls were fully commissioned by third party commissioning consultants

Mann Library

During 2013, an Energy Conservation Initiative project was started to replace the heating, ventilating, and air conditioning system (HVAC) system controls. The project will be completed in early 2014. The new controls will allow occupancy based logic to change air flow and temperatures in all spaces and accurately modulate supply air and central heating and cooling systems to match the varying loads in the space. All new controls will be fully commissioned by third party commissioning consultants.

Weill Hall

This new laboratory facility built in 2008 is a significant user of energy and since its construction university standards for minimum air ventilation rates have been updated allowing "right sizing" of air flows in laboratory spaces based on current and expected activities. During 2013, a review of all spaces was conducted to characterize the laboratory spaces and allow assignment of new minimum air flows where possible while still protecting lab occupants. The new airflows were put in place by Cornell's Energy Management team.

Biotechnology Building

This laboratory facility built in 1987 has undergone significant improvements to reduce energy usage since 2000. The controls and commissioning work reduced its energy usage 30-40%. During 2013, the building systems were re-commissioned and all controls were reviewed to ensure that the energy used is minimized.

Baker Laboratory

During 2013, an Energy Conservation Initiative project was started to completely replace all of the heating, ventilating, and air conditioning system (HVAC) system controls. The project will be completed in 2014. The new controls will allow occupancy-based logic to change air flow and temperatures in all spaces and accurately modulate supply air and central heating and cooling systems to match the varying loads in the space. New logic will minimize the use of cooling when outdoor air dewpoint temperatures are below 55° F to reduce cooling and reheat energy normally used in dehumidification. All new controls will be fully commissioned by third party commissioning consultants.

Johnson Museum of Art

During 2013, a thorough energy study was completed that identified a number of facility improvement measures to accurately control both temperature and humidity. The project is now in design and is scheduled for construction in 2014.

Corson Mudd Complex

During 2013, and energy study was completed that identified facility improvement measures that could be completed in the building. At this time, the capital available for Energy Conservation Initiative projects is limited and the project in this building will await future capital funding authorizations. The continuous commissioning, preventive maintenance, and optimization process will continue to minimize usage with the existing control system's capabilities.

Boyce Thompson Institute

During 2013, an energy study was completed and an Energy Conservation Initiative project was started in design. The project will reduce energy use including cooling by changing and updating heating, ventilation, and air conditioning system controls. The project is scheduled for construction in 2014.

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