Campus-Wide System: A campus-wide central chilled water system has been developed in recent years and is being expanded to serve additional cooling loads as need arises and opportunity affords. This system is superior to other smaller cooling systems in that it provides highly reliable chilled water service on a continual year-round basis. It is the intent of long range planning to develop and extend this system to serve as many buildings as practical. The system is configured as a single networked distribution system served by five individual chiller plants in conjunction with a large stratified liquid thermal storage tank. A sixth plant, located remotely, is dedicated to the Veteran Medicine satellite campus. As of the time of this writing total chilled water production capacity at UIUC is on the order of 50,000 tons and thermal storage is nominal 50,000 ton-hours.

Chilled Water Production: Design and construction standards for the chilled water plants are distinct from distribution system standards and thus are not included herein. The five plants referenced and their relative locations on campus are as follows:

- Oak Street Chiller Plant (southwest)
- North Campus Chiller Plant (north central)
- Library Air Conditioning Center (central)
- Animal Sciences Air Conditioning Center (central)
- Chemistry & Life Sciences Chiller Plant (east central).

The thermal storage tank is located at the far southwest corner of campus. Due to the remote location of the veterinary medicine campus, the chiller plant and associated distribution system that currently serve it will continue to operate independently as a satellite system for the foreseeable future.

Plant Control: Each central chilled water plant is equipped with a *Delta-V* industrial control system. Each building served by the system is equipped with a direct digital control system. Plants and building control systems communicate via the campus Ethernet network. System fill pressure is controlled via static pressure feedback from connected buildings. Pump control within the operational "trim plant" is accomplished via pressure differential feedback from connected buildings. This configuration shall be maintained.

Interruptible Service: Although highly reliable, the central chilled water system shall be treated as "interruptible service". Chilled water service outages are planned in advance but rare unplanned outages have occurred. Thus, backup cooling shall be provided for critical equipment served by this system.

Chilled Water Distribution: Chilled water is distributed to campus buildings through a single networked system consisting of parallel supply and return piping laid out in a grid configuration. The system incorporates "closed loops" to allow feeding areas from two directions. Further development of closed loops is desirable and shall be included as a significant factor in future planning. In conjunction with development of closed loops optimized placement of valves is essential.

Distribution Piping: Existing distribution piping including mains and branches range in size from 4" to 54". Mains are typically 24" and larger and building run-outs are typically 6-10". Piping is direct buried, uninsulated. Installation of chilled water piping within steam tunnels shall be avoided. System test pressure is 200 PSIG, thus system components including valves shall be Class 250 minimum. Approved pipe types include ductile iron, pre-stressed concrete cylinder pipe and HDPE. All distribution piping shall be sized and configured as appropriate to serve the ultimate future cooling loads in the geographical area being served. Although the cooling systems within buildings are to be designed for a chilled water temperature differential of 16 degrees F minimum, distribution piping shall be conservatively sized for a temperature differential of 12 degrees F maximum. Buried piping shall have a typical earth cover of 5'. A minimum cover of 3' is allowed when circumstances dictate. Compacted sand or flowable-fill bedding and backfill shall be provided. Thus poly tube or sheet is not required to protect piping from direct contact with soil. Underground piping shall be kept clean throughout construction. Aggressive steps shall be taken to ensure a high level of

cleanliness. Tracer wire with terminal boxes and warning tape shall be provided for all buried piping (see *Section 33 05 26.23 Utility Identification Tracer Wire*).

Isolation Valves: Isolation valves shall be installed in central distribution mains adjacent to each major branch and in all branch piping. Branch valves shall be located as near associated mains as practical but shall not be located beneath streets. Valves shall be provided with valve boxes and associated surface-level stabilizing pads of substantial size to prevent movement. Manual air vents shall be provided at high points and shall be close-coupled to the pipe to minimize risk of damage. A manual blow-off/drain shall be installed at each regional low point in main distribution piping but is not required at each and every low point in main and branch piping. Valves shall be identified as to service at surface stabilizing pad.

Locating Buried Chilled Water Piping: After piping has been placed and prior to backfilling *F&S Facilities Information Resources* shall be contacted to perform on-site GPS data collection. Also, when existing utilities are uncovered the same requirement applies.

Temperature/Pressure: Building chilled water system design shall typically be based upon the delivery of 43 degree F supply water to the building service entrance at a supply/return differential pressure of 25 PSI minimum. As of this writing the summer-time CHW supply pressure typically does not exceed 120 PSIG at any point in the system. Differential pressure typically does not exceed 60 PSI.

System pressures can vary substantially based upon campus location, cooling load distribution, real-time production at each of the five chiller plants and TES tank operating mode.

Distribution System Feedback: Pressure and temperature sensors shall be provided at the service entrance at each building to facilitate monitoring of central distribution system pressure and temperature. These shall be connected to the digital communication network and shall provide data directly to the *eDNA* campus data historian.

Building System Compatibility: All chilled water cooling systems in new and remodeled buildings within the current and future geographical reach of the campus-wide system shall be designed such that they are compatible with this system.

This system is a variable flow, “high delta T” system with distribution pumping located within the chiller plants. Distribution system design dictates that no pumps be located within individual buildings with the possible exception of a minimal number of booster pumps located within “high head” buildings. At the time of this writing no such pumps exist.

Service Entrance: Requirements for achieving compatibility with the campus-wide system include provision of the following at the service entrance for each building: (see *Drawing 23 09 13-3, Central Chilled Water System Metering Station Detail* and *Drawing 23 20 00-1, Central Chilled Water System Building Service Entrance Detail* for detailed requirements):

1. Installation of dedicated wall penetration pipe spools with building isolation valves and interior drains and vents. For buildings with below-grade basements, piping shall be brought into the building through penetrations in the basement wall. For buildings with slab-on-grade construction or with inadequate basement depth, a generously sized pit with a floor drain shall be provided to facilitate accessible pipe entrance. Extending piping vertically through the floor slab without provision of a pit may be considered, however Owner approval is required prior to design of such installation.
2. Provision of building strainer with isolation valves and bypass.
3. Installation of a BTU metering station. The meter shall be connected to the digital communication network and shall provide data directly to the *eDNA* campus data historian operated by *F&S*. The service entrance piping and metering station shall be sized with appropriate consideration given to the building’s potential future cooling load.

In the past, automation of the building chilled water return valve was required. This is no longer the case. Thus, isolation of the building from the campus distribution system is now strictly manual. This is viewed to be acceptable.

4. Provision of building differential pressure regulating valve(s) and associated pressure feedback controls for buildings that utilize standard pressure dependent control valves. Provision of a pressure regulating valve is not required for buildings that utilize pressure independent control valves.

Thermal Expansion: Provision for thermal expansion of system fluid occurs at a single point in the system. Oak Street Chiller Plant is the default location although any of the five plants are viable options. Expansion tanks shall not be provided within connected buildings.

Differential Pressure Feedback: As applicable, differential pressure feedback at the building level shall typically be accomplished as follows: A pressure differential transmitter shall be piped across the supply and return piping at a location near the most hydraulically remote coil (or other CHW cooling load) in each building and tied into the building EMS. Occasionally it may be necessary to provide multiple DP transmitters for large and/or complex building systems where it is difficult to identify the most hydraulically remote point in the system.

DP sensors shall be connected to "mains" in the building system rather than smaller branch lines. They shall not be located on the "coil side" of any coil isolation valve. The goal here is to minimize the impact that a single coil or grouping of coils has on the measured DP of the larger building system. Toward this end, consideration shall be given to converting a branch into a main (in effect) by increasing its size.

Static Pressure Feedback: As applicable, static pressure feedback at the building level shall typically be accomplished via connection of a pressure transmitter to a return main at or near the highest point in the building system and incorporating it into the building EMS. Where suitable the SP transmitter shall be connected to the system at the same location as the DP transmitter. As with the DP transmitter the SP transmitter shall be connected to a "main" rather than a branch.

Regulating Valve Sizing: Given varying pressures in the central system, it is difficult to properly size the pressure/flow regulating valve for a building given that system DP can vary substantially, especially during periods of thermal storage tank discharge. As stated below in the paragraph entitled *Utility Program Statement* the *F&S Utilities and Energy Services Division* shall be contacted to obtain specific system pressure data to be used for valve sizing at a given location.

Typical values provided for valve sizing are as follows: 30 PSID at building service entrance, 5-8 PSID across building regulating valve at design chilled water flow rate. To date, most of these valves are oversized. Virtually every building on campus now has a year round cooling load. In most cases the winter load is small relative to the maximum summer load. So in order to achieve adequate turn-down it may be necessary to provide multiple parallel valves. In such cases valve sizing shall be based upon actual turn-down requirements. The standard 1/3-2/3 approach shall not be applied.

Pressure Independent System: As stated previously, buildings with pressure independent control valves do not require building pressure regulating valves. The Owner shall be consulted in determining which system type is most appropriate for a given building. Installation of pressure independent control valves with no DP control at the building level is now default. In such case DP feedback from the most hydraulically remote location is used for monitoring purposes only.

Building System Conversion: In order for an existing building (or portion thereof) to be provided with cooling from the central system, its internal chilled water system(s) shall first be made fully compatible. In addition items addressed above in the paragraph entitled *Service Entrance*, conversion of an existing building's chilled water system(s) to achieve compatibility

shall also include the following as applicable:

1. Removal of any antifreeze solution from the system accompanied by a thorough system cleaning.
2. Resolution of any resulting freeze protection issues at cooling coils within air handling units, making modifications as required. These modifications will be substantial in many cases and may include the reconfiguring of air handling units and/or ductwork to improve air mixing, the upgrading of dampers and controls and the installation of air blending devices. In each case, special freeze protection controls developed by UIUC shall be provided at each cooling coil (see applicable specifications and drawings).
3. Elimination of any chilled water bypass in the system.
4. Replacement of any three-way control valves and/or inappropriate two-way control valves at cooling coils with appropriate two-way valves and modification of piping as appropriate.
5. Replacement of existing isolation and balancing valves as appropriate.
6. Cleaning or replacement of condensate drain traps and piping systems serving chilled water coil drain pans to ensure adequate condensate removal.
7. Upgrading of pipe/valve insulation as required.
8. Removal of abandoned chillers, cooling towers, pump(s), expansion tank(s) air separator(s), etc. along with any associated piping, electrical power and control wiring, conduit and devices, and pneumatic control tubing and devices as appropriate.

AHU/Coil Design: The design of each cooling coil connected to this system shall be based upon an entering water temperature of 43 degrees F and a minimum leaving water temperature of 59 degrees F. Each cooling unit shall maintain this 16 degree F minimum design temperature differential at all load/operating conditions. Each unit shall also be designed with all features needed for adequate freeze protection of its chilled water coil(s) without the use of antifreeze solution in the chilled water system or the necessity of isolating and draining coils. See Section entitled *Building Cooling Systems* within these *General Guidelines* for additional information regarding freeze protection controls.

Control Valves: Control valves serving building air handling equipment and various cooling units shall be of the two-way type. Operational close-off rating, as opposed to static close-off pressure rating, shall be 50 PSID minimum for this somewhat demanding application. As stated elsewhere within these *General Guidelines* the use of pressure independent control valves, which has been encouraged in the past, is now required as default design. Their use results in higher and more consistent chilled water "delta T" which benefits the larger system in multiple ways. See section entitled *Building Cooling Systems* within these *General Guidelines* for additional information

Glycol: No glycol antifreeze solution shall be added to the central chilled water system or connected components. Use of glycol solution presents risk of contamination of the central system which is to be avoided at all cost. No cooling coil or other device served by the central system shall at any time be flushed or filled with glycol solution. If adequate freeze protection cannot be assured by application of freeze protection controls freeze protection shall be accomplished in a "non-glycol" manner. One such approach involves draining and drying coils with ventilation system air or draining and blowing out with compressed air.

Heat Exchanger: A water-to-water (or fluid-to-water) heat exchanger shall be provided for separation of central system piping from equipment and/or associated piping deemed vulnerable to leakage or contamination of the central system. For additional information see section entitled *Building Cooling Systems* within these *General Guidelines*.

Heat Recovery Chillers: In recent years multiple heat recovery (HR) chillers (a.k.a. heat pump chillers) have been installed in campus buildings and connected to the central chilled water system. In such cases it is essential that HR chillers consistently

generate chilled water at a temperature of 42F maximum. This requirement shall be satisfied at all operation conditions. When HR chillers are employed, dedicated chilled water flow meters shall be provided such that flow into the building system and flow exiting the building system can be metered separately without input from the HR system. Pumps and piping shall be configured such that the HR system is the equivalent of a stand-alone central chiller plant. When possible, HR chillers shall be non-modular with robust compressors rather than modular type with numerous lower quality compressors. A heat recovery chiller shall not be the sole heat source for a building. An entirely redundant HR chiller or separate heat source shall be provided. As opportunity affords HR chillers shall be centralized to serve multiple buildings. Note: The winter cooling load served by the central system is limited. Thus, HR chiller installations connected to the central system and dependent upon a year-round load may be limited accordingly.

Veterinary Medicine Complex: It should be noted that some of the system description and requirements addressed above are not fully applicable to the central chilled water system at the Veterinary Medicine complex.
For example, this system does not currently provide year-round cooling and is filled with ethylene glycol solution rather than 100% water as is the case with the central campus system. The Owner shall be contacted to establish limits of applicability for each cooling system/component served by this unique system.

Chilled Water Capacity Charge: In order to receive central chilled water service a project or campus unit is required to pay a one-time "Capacity Charge" fee. This applies to the central system at the veterinary medicine complex as well as the campus-wide central chilled water system. A written policy has been prepared to formalize and clarify the assessment of this fee. A standardized form has also been prepared to facilitate fee assessment. These documents are available in electronic format upon request.

Incentive: The formula used for calculating the Capacity Charge fee incorporates a fee reduction or "credit" for projects with chilled water systems that exceed the 16 degrees F delta T minimum requirement. Conversely, it incorporates an up-charge or "penalty" for those that fall short of this minimum requirement. Thus, a financial incentive to increase chilled water delta T is provided.

Responsibility: It is the responsibility of the *F&S Utilities and Energy Services Division* to provide oversight of all activities related to construction, modification, operation and maintenance of chilled water distribution system(s). Thus, at a functional level said entity serves as the *Owner* of the system.

System Operation: Start-up, shut down or other operational activity related to the distribution system shall be under the direct supervision of the *F&S Utilities and Energy Services Division.* No valve in the distribution system shall be operated by any individual other than an assigned staff member of said entity.

Commissioning & Inspection: *F&S Utilities and Energy Services Division* shall be contacted prior to testing, commissioning and/or energizing system components.
This does not remove responsibility of following other project protocols including but not limited to contacting *F&S Commissioning and Inspection.*

Utility Program Statement: Information related to available plant and distribution system capacities, system pressures and confirmation of system temperature to be used for design purposes shall be obtained from the Owner via a *Utility Program Statement*. Other specific design information including placement and sizing of system extensions shall be obtained in like manner.