



**UConn** | UNIVERSITY OF  
CONNECTICUT

**Campus Master Plan**

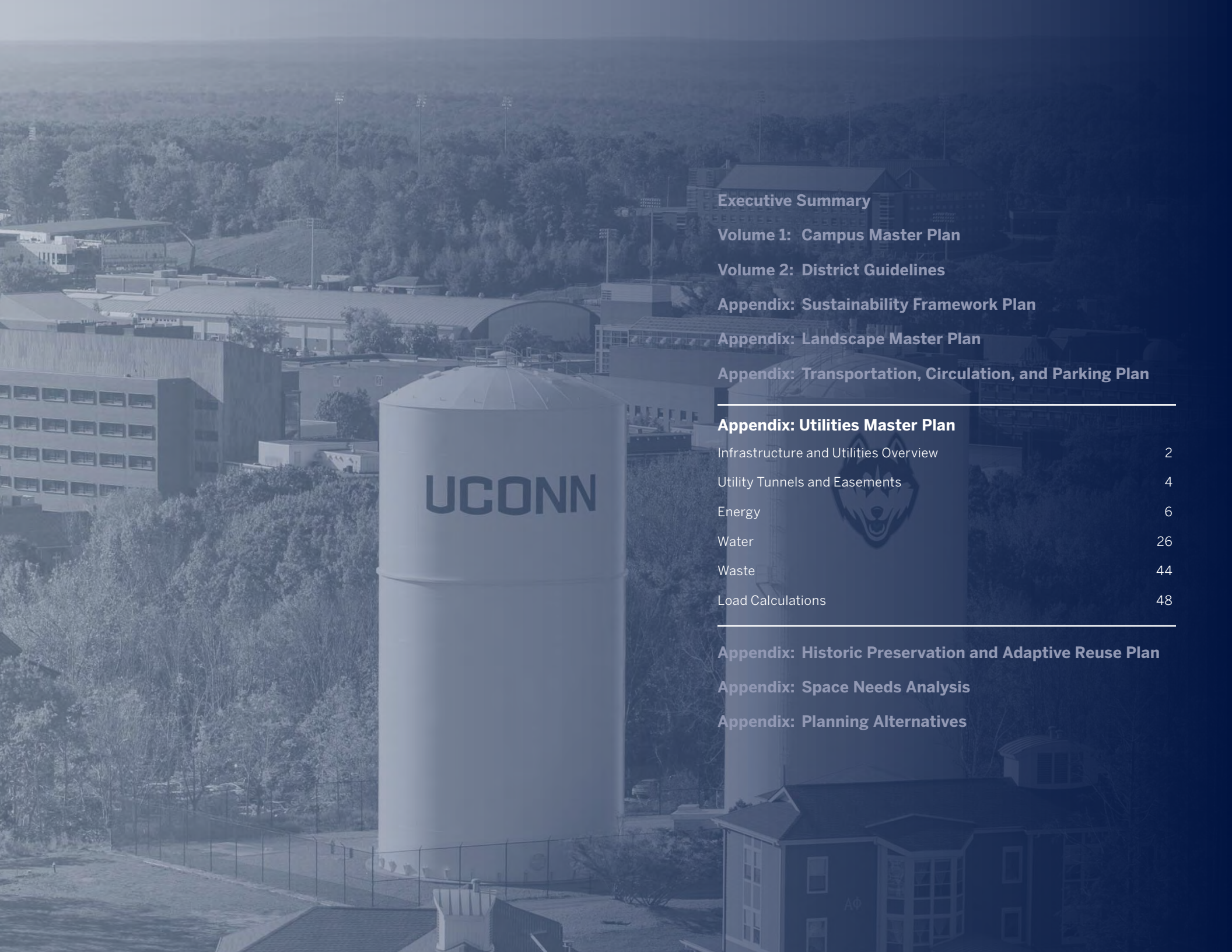
# **D Appendix: Utilities Master Plan**

SKIDMORE, OWINGS & MERRILL LLP  
MAY, 2015









**Executive Summary**

**Volume 1: Campus Master Plan**

**Volume 2: District Guidelines**

**Appendix: Sustainability Framework Plan**

**Appendix: Landscape Master Plan**

**Appendix: Transportation, Circulation, and Parking Plan**

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**Appendix: Utilities Master Plan**

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# Infrastructure and Utilities Overview

Campus utility infrastructure is the backbone supporting all buildings, services, and student and faculty needs. Existing systems represent a significant investment over decades of growth, requiring that future upgrades first look carefully at the infrastructure in place before recommending expansion or major changes. Layered onto each of the systems included in this plan is knowledge about their existing status and the impact of development which may require expansion or adjustment.

The overall approach to the Master Plan utility infrastructure is to provide the capacity for future development in conjunction with UConn's sustainability goals and commitment to climate neutrality by 2050. The proposed utility infrastructure will incorporate the following over-arching principles:

- Prioritize increases in efficiency, including energy, water consumption and reuse, and supplementing or replacing aging infrastructure, to reduce overall demand before investing in new supply or generation capacity.
- District-based supplemental utility plants that are interconnected via looped systems, providing redundancy and shared load distribution.
- New underground looped systems coupled with investments in roads and landscape improvements to provide resiliency.
- Increased utility supply and capacities to meet the full build-out program.
- Sustainable development that includes stormwater management in harmony with the landscape and renewable energy alternatives.

## Electrical Service

Electric power on campus is generated by a campus-owned Central Utility Plant (CUP), supplemented by Connecticut Light & Power (CLP) through UConn Substation 5P. Although the plant can generate a maximum of 26.75 MW, it is currently permitted for a maximum of 24.9 MW. The CUP and Substation 5P provide power to all buildings on campus through 5 main medium voltage feeders. Four of these feeders are connected to both the CUP and Substation 5P, to import power to the campus from CLP when campus demand exceeds CUP capacity and as a back-up, should one or more of the CUP generators be unavailable.

For the near-term plan, in a “business as usual” approach (no major energy efficiency improvements to existing buildings and new buildings designed using currently implemented energy saving measures, which could achieve a LEED Silver/Gold Certification), the campus could see an increase in demand of approximately 6.6 MW over the next 5 years, for a total demand of 34.6 MW. The additional power requirement would be supplied by an increase of imported power from CLP through Substation 5P; however, this demand exceeds both the CUP capacity and Substation 5P capacity, thus losing the redundancy needed to ensure power to all buildings at all times.

If UConn were to employ a campus-wide initiative to reduce demand in existing buildings by 30%, and increase the energy efficiency of new buildings by 30% over the “business as usual” approach, the overall demand on campus could be reduced to levels close to the existing CUP capacity in the near-term. At an overall decrease of 25%, there could be a net zero increase in demand.

## Steam Service

The existing high pressure steam (hPs) and pumped condensate (PC) infrastructure on campus is comprised of the Central Utility Plant (CUP) and the Heating Plant (HP) on Glenbrook

Road. These two plants are connected and operate in tandem to provide flexibility and redundancy from an hPs generation standpoint. The CUP and HP currently produce a maximum of 500,000 lbs/hr (N+1, redundant configuration), and peak demand on campus is 225,000 lbs/hr, less than half of capacity.

For the long-term plan, the campus could see an increase in demand of approximately 130,000 lbs/hr over the next 20 years. To support planned expansion, upgrades to the existing high pressure steam and pumped condensate systems must be addressed. Although increased capacity is not necessary during this time frame, significant upgrades to the steam and condensate distribution networks will be critical. Long-term, connection to each district loop will be required as new buildings are added. Existing boilers will be nearing the end of their useful life; in conjunction with the planned replacement of this capacity, more efficient and sustainable means of generating steam will need to be pursued. At the building level, this could include high-efficiency condensing boilers. At the CUP, this could include Biomass boilers.

## Chilled Water Service

The CUP currently produces a maximum of 10,000 tons of chilled water (N+1, redundant configuration), and the peak demand on campus is 8,300 tons, projected to increase to 10,000 tons in the near future. In 2013, RMF drafted an assessment of the existing chilled water system. As part of that report, some future cooling loads were identified. To satisfy this new demand, UConn is adding an additional 2,000 ton chiller, which aligns with RMF's recommendation, to bring the total capacity of the CUP to 12,000 tons (N+1, redundant configuration). Future expansion is limited, due to lack of real estate, to one additional 2,000 ton chiller. The South District supplemental Utility Plant (sUP) currently produces a



maximum of 500 tons (N+1, redundant configuration), and the peak demand is 275 tons. UConn is adding an additional 500 ton chiller to bring the total capacity of the South District sUP to 1,000 tons (N+1, redundant configuration).

For the long-term plan, the campus could see an increase in demand of approximately 12,000 tons over the next 20 years. To support the planned expansion of campus in the next 5 years, upgrades to the existing chilled water (ChW) system must be considered. Within the CUP, the two existing Tecogen, natural gas-fired chillers are beyond their anticipated useful life and due for replacement. In addition, one (1) sUP will be required to support the increase in demand over the next 5 years. Furthermore, as part of the long-term plan, the South District sUP will require modification and increased capacity, and upgrades to the headers and limited distribution network will be required. An additional sUP may also be required in the long-term. In conjunction with this increased capacity, more efficient means for generating chilled water will need to be pursued.

Chilled water is currently supplied to the campus via a radial piping network. As recommended within RMF's assessment, a distribution loop will be pursued to provide enhanced efficiency and redundancy.

### **Gas Service**

Connecticut Natural Gas (CNG) supplies gas to the University. Based upon UConn's Climate Action Plan and goals for reaching climate neutrality by 2050, over the long term new buildings are anticipated to be connected to the CUP and satellite plants for electric, heat, and hot water needs. Other sustainable strategies such as renewable energy are expected to further reduce gas demand as these are constructed. Therefore, long-term gas loads are not anticipated to increase over today's demand. However, as individual projects come on-line that require gas service,

including co-generation plants, and before these long-term strategies are implemented, peak loads will need to continue to be evaluated against the current main and distribution supply with CNG.

### **Stormwater**

Stormwater runoff from UConn's campus is collected through a series of inlets and conveyed through a pipe and manhole system, ultimately outletting to either the west and the Willimantic River or to the east and the Fenton River. The majority of stormwater runoff discharges directly to the storm drainage system with limited stormwater treatment measures. In November 2004, UConn established *Campus Sustainable Design Guidelines* that in part addressed the need to implement stormwater quality measures. Any State project that affects a floodplain, impacts storm drainage facilities, or increases peak runoff rates is subject to permit requirements and approval by CTDEEP under the Flood Management Certification permit. UConn will need to adhere to the agreed upon runoff reduction strategies with CTDEEP and also mitigate the impacts of new development within the Master Plan, particularly development on the western part of campus that lies in the Eagleville Brook watershed and is subject to Total Maximum Daily Load (TMDL) restrictions as further described herein.

### **Potable Water Service**

UConn serves as the potable water provider to its Storrs campus, as well as portions of the surrounding town of Mansfield. Water is supplied to the campus from wellfields at the Fenton and Willimantic Rivers. Much of the piping system is dated from the 1940s, and there are a significant number of dead-end systems without loops, which will need to be updated and rectified. Significant conservation efforts implemented on campus in recent years have helped to reduce the demand on the water system to 1990s levels

according to UConn's 2011 Water Supply Plan. Even with considerable development in the long-term, projected demand of 3.12 MGD is considerably below the proposed total supply of 4.95 MGD (safe yield of 4.17 MGD), which will be in place after a 1.85 MGD pipe supply connection through Connecticut Water Company is completed in approximately two years. This does not mean, however, that the University should not continue to pursue water conservation measures to serve its broader sustainability mission.

### **Wastewater / Sanitary Service**

The campus wastewater collection system is a combination of gravity and pumped sewers that are collected and treated at UConn's Water Pollution Control Facility (WPCF). The WPCF also receives flow from the Depot Campus. In general, the collection system is quite dated, with pipes from the 1940s or earlier. Previous assessments have identified improvements to the collection system and treatment facility which should be implemented within the early stages of this Master Plan time frame. Based upon the current projected programming and including the implementation of recommended sanitary system repairs and stormwater separation, the current design capacity of 3.0 MGD for the existing treatment plant has the potential to be exceeded following the Master Plan's long-term buildout, but can handle the increased flows in the near term. Should the existing plant need to be replaced or expanded, its current location is ideal. It offers potential reuse of existing gravity piping and pump station infrastructure; has adjacency to the newly constructed reclaimed water facility; and it is not a high priority for future development due to the limitations of the adjacent capped landfills.

# Utility Tunnels + Easements

Existing utility tunnel infrastructure is limited to short runs north and south of the Central Utility Plant (CUP) and between buildings in the science core. The vast majority of underground utilities throughout the main campus are either direct buried or in accessible trenches.

To support the planned expansion of the campus, however, upgrades to the distribution network must be considered in concert with capacity upgrades and efficiency initiatives. While a tunnel system presents a higher first cost than a direct buried or an accessible trench, the life cycle cost is lower than those two alternatives, and it allows for much more efficient operations, simpler maintenance, and longer service life.

The proposed utility tunnel distribution network would connect the CUP and Supplemental Utility Plants (sUPs) and establish a primary utility loop serving the campus core. In the near term, it would handle utility extensions required for early science and research growth in both the north and south parts of campus. In the long term, these branches would be extended and the loop system completed.

Proposed new tunnels would be paired with landscape and transportation improvements, such as the Academic Way and other major pathways, the woodland corridors, and reimagined Hillside and Glenbrook Roads. These should be reserved as future utility easements.

## Goals:

- Efficiently supply utilities between buildings and the CUP and sUPs
- Guarantee longevity: with proper design and maintenance, tunnels can remain in good condition for 60-80 years
- Simplify maintenance: piping, valves, and traps are easy to access, which results in more effective maintenance
- Provide protection for piping and components
- Minimize disruptions to campus due to campus distribution modifications
- Align tunnel construction with planned upgrades to roads, pedestrian paths, and landscape features

## Improvements:

- Route new piping within a utility tunnel
- Distribution piping shall be pipe-in-pipe with leak detection to minimize losses

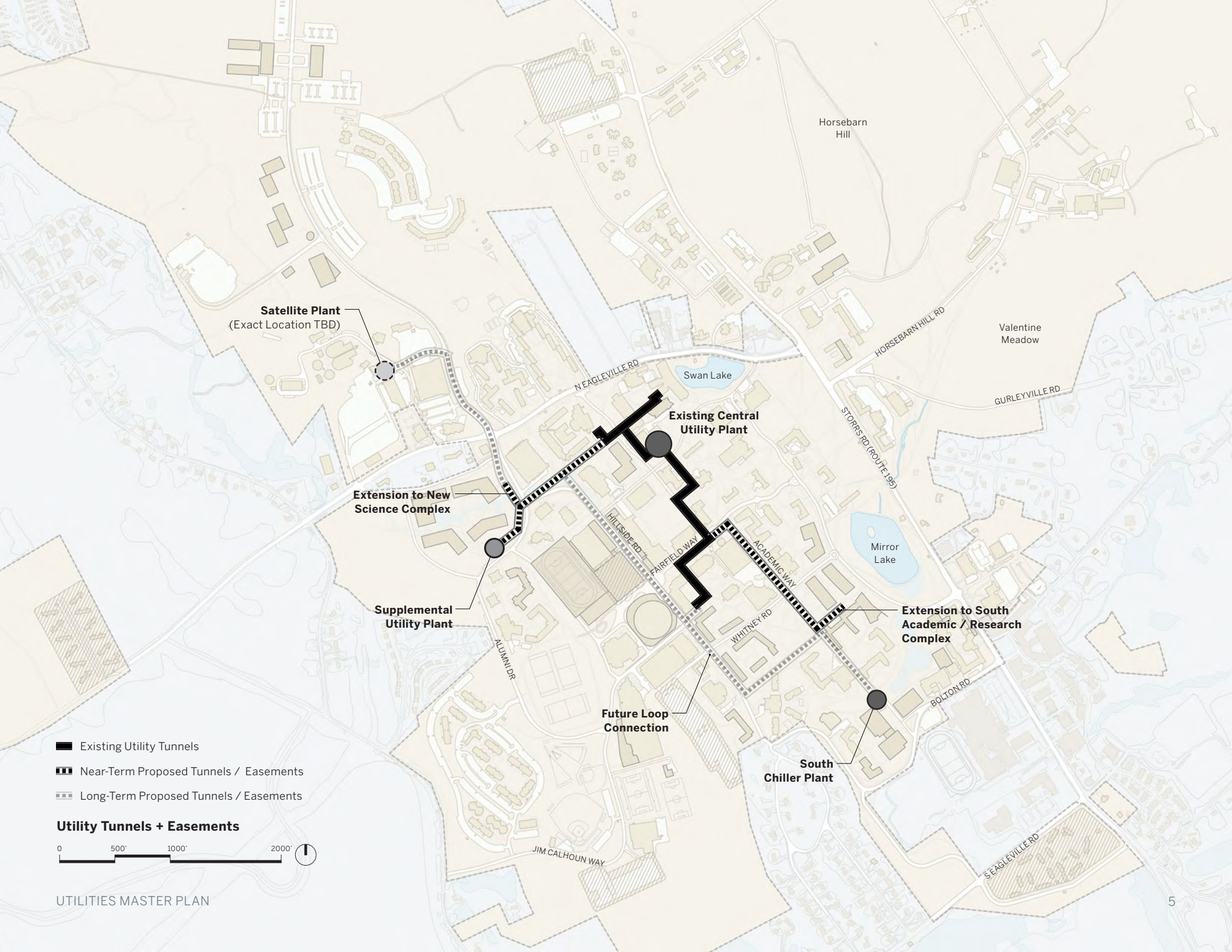


Traditional Approach: Direct Bury or Accessible trench



Preferred Approach: Steam Tunnels Near Central Utility Plant









# Energy

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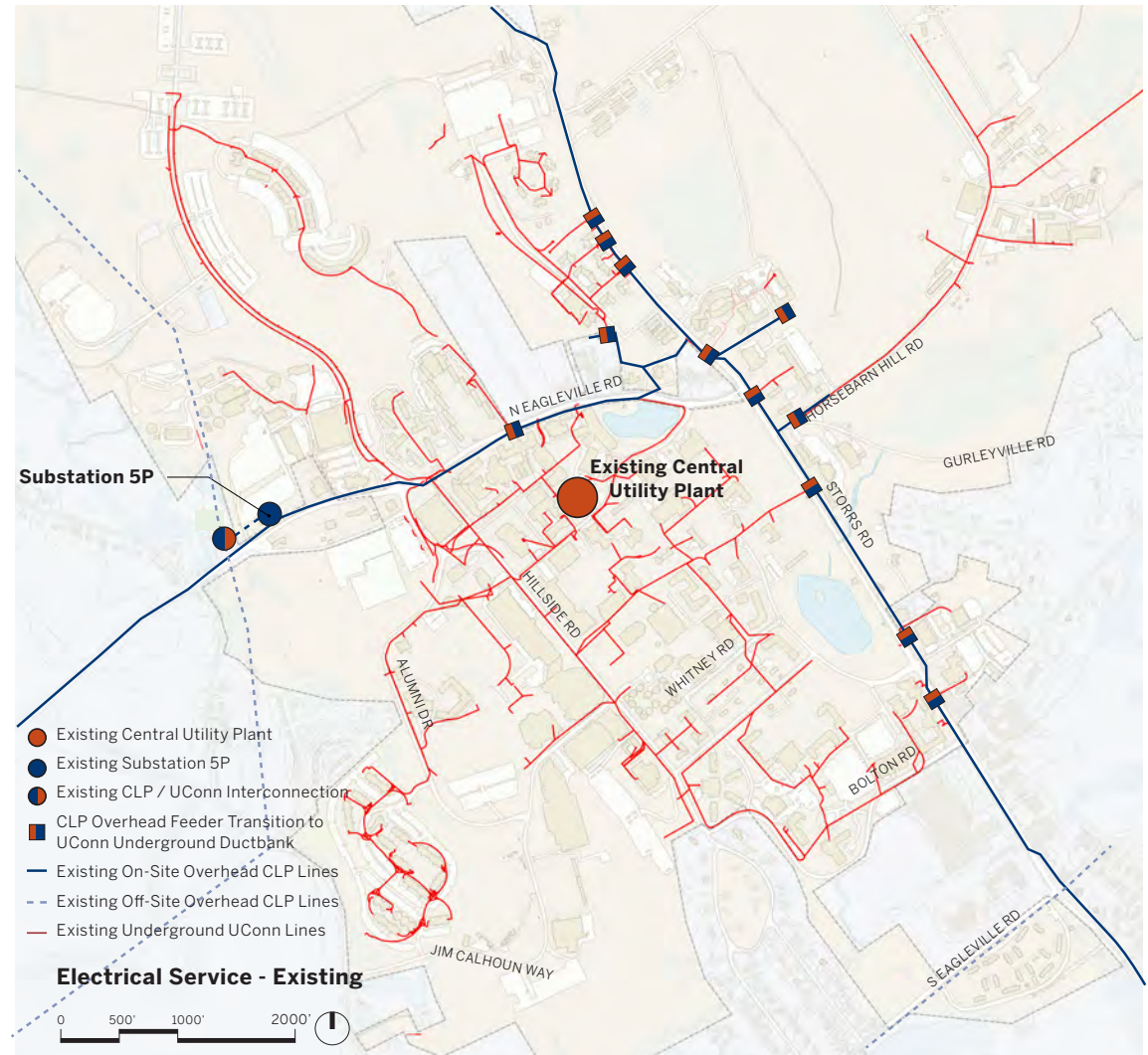
# Electrical Service

## Existing Conditions

The existing electric infrastructure on campus includes the Central Utility Plant (CUP) on Glenbrook Road, Substation 5P on North Eagleville Road, 5 overhead and underground 13.8 kV circuits, and distribution equipment throughout the campus. The CUP consists of three (3) 7.5 MW gas turbine generators and one (1) 5.0 MW steam generator. The plant capacity is 26.75 MW (19.5 MW should one generator be out of service (N+1)) but only has a permit for a maximum of 24.9 MW. The CUP directly supports 4 of the 5 main feeders that serve various locations on campus. For each of the 4 feeders there is a corresponding feeder at Substation 5P.

Peak demand on the entire campus has been reported to be approximately 28.0 MW, in September 2013. Although upgrades to the plant are inevitable, and equipment will require replacing, the plant is currently permitted for a maximum of 24.9 MW. It has also been reported that expanding the plant is not feasible for a number of reasons including regulatory approval to increase permitted capacity, electrical constraints (the switchgear that the generators are connected to is rated 1,200 amps and has a peak capacity of 28.6 MVA), as well as physical constraints at the CUP.

Substation 5P consists of a 69 kV tap at the Connecticut Light & Power (CLP) overhead transmission line on North Eagleville Road. The conductors run underground to Substation 5P and terminate at an exterior air switch and fuse. This switch serves a 69 kV – 13.8 kV, 3 phase, 4 wire transformer rated 18.0 / 20.2 / 26.9 / 33.6 MVA (55°C rise OA / 65°C rise OA / 55°C rise FA / 65°C rise FA) which serves the main 13.8 kV switchgear. The switchgear is rated 3,000 amps, which can support a maximum of 71 MVA. It has 5 circuits which serve the campus distribution system; four of the five circuits directly interface with the CUP to import power from CLP when demand exceeds capacity, and as a backup when one or more of the CUP generators is unavailable. The fifth circuit at Substation 5P is also supported by the CUP by back-feeding power through Substation 5P via one or more of the other 4 feeders.





## Load Projections + Assumptions

		Electrical (MW)			
		Present	Near Term	Mid Term	Long Term
Business As Usual Approach	Demand	28.00	34.61	39.08	51.09
	Power Imported	3.10	9.71	14.18	26.19
10% Energy Reduction	Demand		31.15	35.17	45.98
	Power Imported		6.25	10.27	21.08
20% Energy Reduction	Demand		27.69	31.27	40.87
	Power Imported		2.79	6.37	15.97
30% Energy Reduction	Demand		24.23	27.36	35.76
	Power Imported		N/A	2.46	10.86

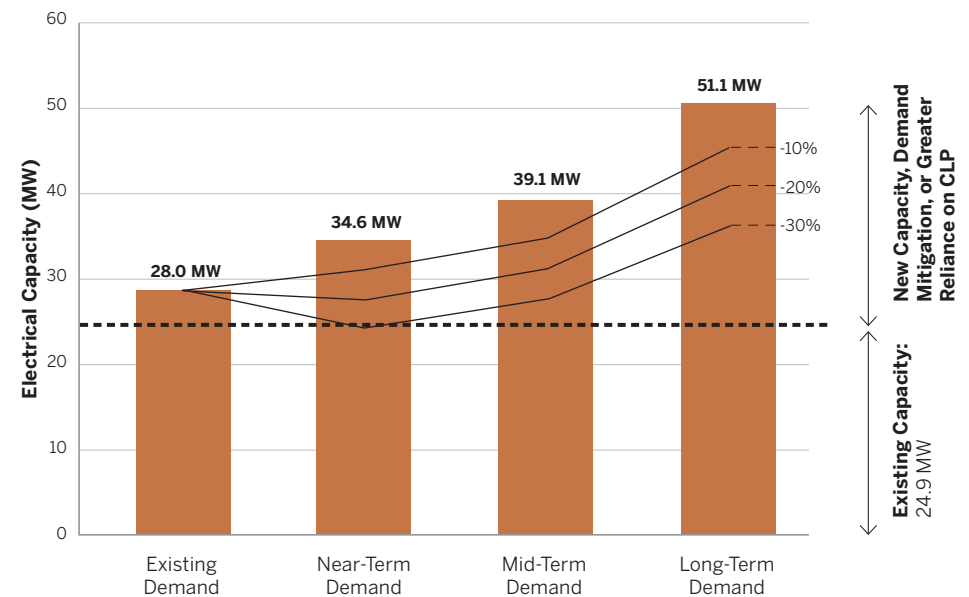
Assumptions: (W/SF)	New Buildings	Demolition	Renovation*
Parking structures:	1	1.3	-0.3
Residence Halls:	3.5	4.55	-1.05
Academic Buildings:	6.5	8.45	-1.95
Science Buildings:	9	11.7	-2.7

\*Renovated buildings are assumed to be approximately 30% more efficient following the renovation. Indicated value is relative energy savings.

\*\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.

## Impact on Utility Systems

The graph below shows that the existing demand on campus already exceeds the CUP's maximum capability. The near-, mid-, and long-term demand will expound on this problem, requiring significant new capacity or demand mitigation. However, retrofitting existing buildings and designing new buildings to be more energy efficient could ultimately reduce the demand to levels below the existing CUP capacity in the near-term and return back to present demand levels in the mid-term. Strategies to achieve these types of load reductions are outlined in the Sustainability Framework Plan.



# Electrical Service

## Near-Term Campus Plan (0-5 Years)

It is anticipated that the electrical demand increase on campus over the next 5 years could be approximately 6.6 MW, increasing the total demand on campus to 34.6 MW. In order to adequately provide power for this load, the following factors regarding energy use should be considered:

### Goals:

- Design all new buildings to be substantially more efficient than current Energy Code requirements.
- Renovate all existing buildings to be substantially more efficient than current Energy Code requirements.
- Provide energy efficiency upgrades of existing facilities that have no immediate plans for renovations to free up existing MW for use in new facilities.
- Electrical infrastructure continues to have the capability to generate and/or import enough power to satisfy the campus needs.
- Commission a study to determine means to improve the infrastructure capacity and redundancy so that load shedding may be avoided when one source becomes unavailable. The infrastructure should have N+1 capability, for fault tolerance, to support the entire campus. Options to be explored should include:
  - Expansion of Substation 5P from a single-ended configuration to a double-ended configuration with an additional CLP transmission line tap from a different CLP circuit, such that either substation can support the entire load during maintenance operations or loss of source.
  - Increase Substation 5P transformer size and/or increase on-site generation.
  - Substation transformers and equipment typically have a useful life well beyond 20 years, so the design of these systems should consider campus growth beyond the long term.
- Document / confirm sequence of operations for

load shedding at the CUP when Substation 5P is unavailable and demand exceeds capacity of the CUP.

- The electrical infrastructure does not have to rely on renewable power to meet capacity.

### Improvements:

- Upgrade existing cogen and distribution equipment as it nears end of useful life.
- Update and modify load shedding protocols as new buildings are brought onto the system, to ensure demand does not exceed plant and/or substation capacity should either source become unavailable.
- Replace existing overhead conductors with new underground conductors for increased reliability and future expansion.
- Complete a comprehensive computer model of the existing distribution system to better understand the dynamic nature of power distribution system on campus.

## Mid-Term Campus Plan (6-10 Years)

To support the next wave of new electrical loads as the campus expands in years 6-10, the framework that began in the near-term will be expanded. It is anticipated that the electrical demand increase on campus from years 6-10 could be an additional 4.5 MW, bringing the total increase in demand from Day 1 to 11.1 MW, and the total demand on campus to 39.08 MW.

### Goals:

- Continue to design new buildings to be substantially more efficient than current Energy Code requirements.
- Continue to renovate existing buildings to be substantially more efficient than current Energy Code requirements.
- Continue to provide energy efficiency upgrades of existing facilities that have no immediate plans for

renovations to free up existing MW for use in new facilities.

- Restore redundancy (fault tolerance) to the electrical infrastructure such that it has the ability to generate and/or import enough power to satisfy the campus needs at all times to avoid load shedding should one source become unavailable. The infrastructure should have N+1 capability to support the entire campus.
- The electrical infrastructure does not have to rely on renewable power to meet capacity.
- Commission a study to determine the possibility / feasibility to build additional on-site power cogeneration. Explore any and all opportunities to create new on-campus central utilities.

### Improvements:

- Implement the plan commissioned in the near-term to improve electrical infrastructure capacity and redundancy so that load shedding may be avoided when one source becomes unavailable.
- Continue to provide new power distribution with an emphasis on reliability, flexibility and ease of expansion into the long-term campus plan.
- Upgrade existing cogen and distribution equipment with new, more efficient technology as it becomes available and existing equipment nears end of useful life.
- Replace any remaining existing overhead conductors with new underground conductors for increased reliability and future expansion.
- Update the comprehensive computer model of the distribution system to include all new components.



### Long-Term Campus Plan (11-20 Years)

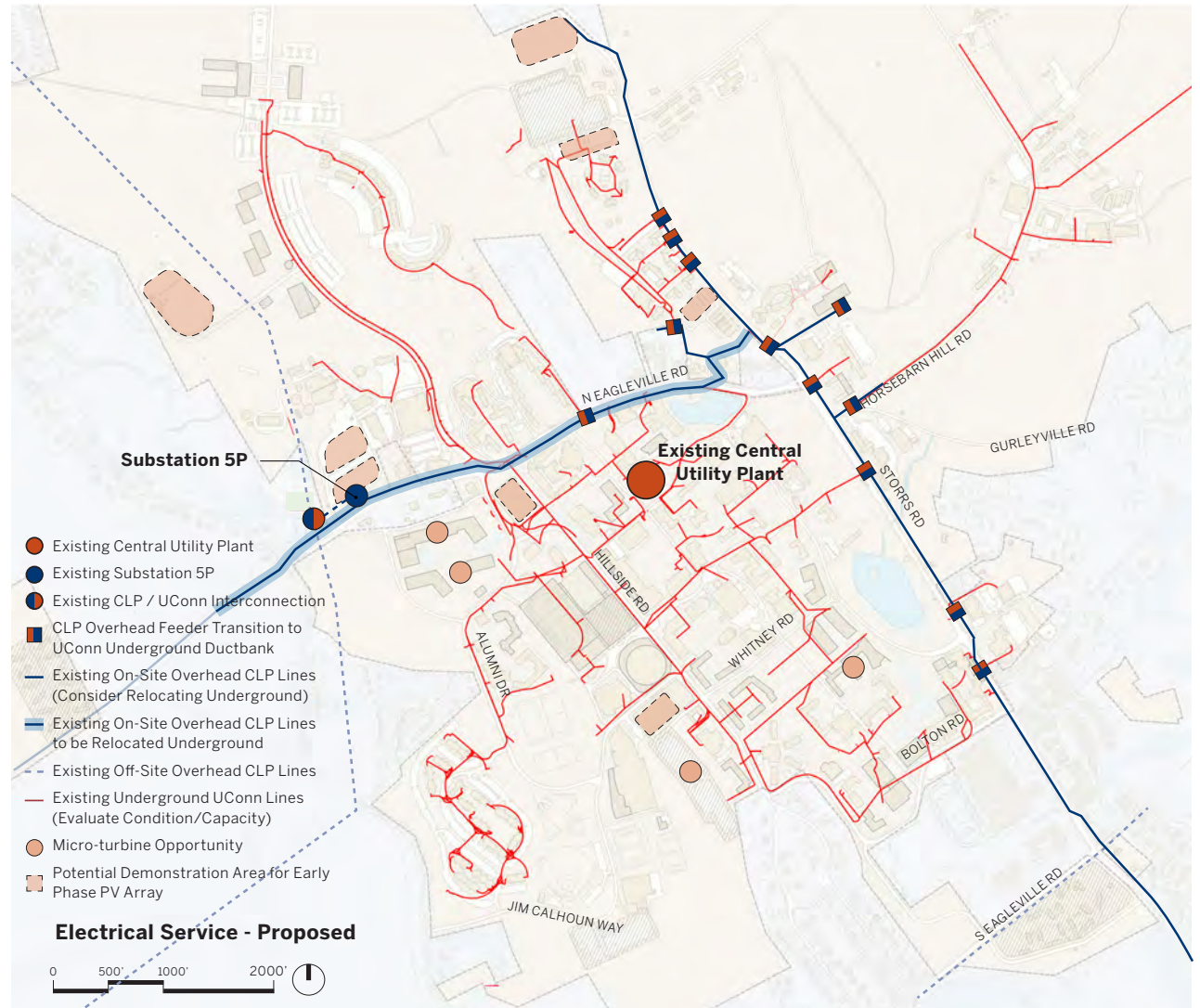
Finally, expansion from years 11-20 could result in additional estimated peak demand of 12.0 MW, bringing the entire campus to a peak demand of approximately 51.1 MW – more than double the capacity of the existing cogen plant.

#### Goals:

- Continue to maintain electrical infrastructure capacity that can support the campus electrical demand, in an N+1 configuration.
- Continue implementation of energy efficient measures in new and existing facilities to lower demand on campus.

#### Improvements:

- Implement the plan commissioned in the mid-term to increase on site co-generation in an area of concentrated loads.
- Continue with upgrades to the existing co-gen and distribution equipment with new, more efficient technology as it becomes available and existing equipment nears end of useful life.
- Replace any remaining existing overhead conductors with new underground conductors for increased reliability and future expansion.
- Update the comprehensive computer model of the distribution system to include all new components.



# Electrical Emergency Power

## Existing Conditions

The emergency system on campus comprises the 4,160 volt Central Emergency System located in the Central Utility Plant (CUP) and individual, stand-alone emergency generators at many individual buildings.

The Central Emergency System consists of one (1) 1.5 MW and two (2) 1.25 MW diesel engine generators with space for a future 1.5 MW unit that is planned to be installed soon, all operating in parallel.

Current capacity is 4.0 MW (2.5 MW in an N+1 configuration). When the fourth generator is installed, the system can support a maximum of 5.5 MW (4.5 MW in an N+1 configuration). The two (2) 1.25 MW units are at the end of their useful life and need to be replaced. Current peak demand load, as reported by recording equipment on 35 of the existing 42 automatic transfer switches, is 3.52 MW. Seven transfer switches have recording equipment but do not yet connect to the database.

The system generally serves buildings in the campus core, bounded by Storrs Road, North Eagleville Road, Hillside Road, and Gilbert Road. The system is distributed at 4,160 volts through a series of underground manholes and ductbanks, and at each building served, a 4,160 volt to 480 volt substation distributes to local transfer switches. The system is also used to “black start” the cogeneration equipment in the CUP.

Each of the following buildings has an emergency substation fed by the emergency system, and some substations serve multiple buildings:

- Central Utility Plant
- Pharmacy / Biology building
- New Chemistry
- Northwest Quad Building
- Building C5
- Building C6
- Building C7
- Biology / Physics Building
- Computer Center
- Torrey Life Sciences Building
- West Building
- UConn Coop
- Castleman Building, which serves:
  - Castleman Building
  - Student Union
  - Gentry Building
  - Rowe Center for Undergraduate Education
- School of Business
- Information Technologies Building
- Oak Hall
- Wilbur Cross Building, which serves:
  - Wilbur Cross Building
  - Storrs Hall
  - CLAS Academic Service Center

The stand-alone emergency systems in the remainder of buildings consist of varying configurations of generators, transfer switches, and battery systems. The following is a list of existing stand-alone units. As each of these systems is (generally) not expandable beyond the building(s) currently served, this report will not address these systems further.

Unit Location	Manufacturer	Size (kW)	Fuel Type
Beach	Kohler	350	Diesel
Psychology	Kohler	600	Diesel
Bio 4 Annex	Kohler	150	Diesel
Gampel	Cummins	200	Diesel
Fenton Pumps	Kohler	400	Diesel
Pharmacy	Kohler	750	Diesel
Bio #4 Ng	Onan	170	NG
Ellsworth	Onan	30	NG
Hale	Onan	30	NG
Putnam	Onan	50	NG
New Atwater	Kohler	100	LPG
Babbidge	Waukesha	170	LPG
E- Project	Onan	15	LPG
Eng 3	Kohler	20	LPG
Facilities Ops	Marathon	100	LPG
Fire/Police Complex	Kohler	90	LPG
Infirmary Building	Onan	30	LPG
Hicks/Grange	Onan	15	LPG
Post Office Lift Stn	Onan	15	LPG
Market Place	Onan	5	NG
New Fine Arts (Nfa)	Onan	15	LPG
Rosebrooks House	Onan	45	LPG
Whitney Hall	Kohler	80	NG
Willi Well 3	Kohler	100	LPG
Bio #3	Caterpillar	43	Diesel1
Commissary Whse	Kohler	230	Diesel1



Unit Location	Manufacturer	Size (kW)	Fuel Type
Dodd Center	H.O Penn	500	Diesel4
Electrical Mobile	Cummins	250	Diesel1
IMS	Onan	250	Diesel1
Jorgensen Auditorium	Kohler	25	Diesel1
Gurleyville Lift Station	Onan	100	Diesel1
HI Head	Cummins	375	Diesel4
Sewage Plant	Onan	500	Diesel4
Willi Well 1	Kohler	125	Diesel1
Eastwood Lift Stn	Onan	35	Diesel1
Mans Apts Lift Stn	Onan	35	Diesel1
Northwood Lift Stn	Onan	35	Diesel1
North Pkg Garage	Spectrum	100	Diesel1
Bio Ag	New Age	325	NG
Field House	Kohler	30	LPG
Plains Rd Lift Station	Onan		Diesel1
Birch Rd Lift Station	Onan		Diesel1
Alumni Quad	Caterpillar	160	LPG
Buckley	Kohler	80	LPG
Shippee	Kohler	60	LPG
McMahon	Onan	55	LPG
Capstone Lift Station	Olympian	100	NG
Hilltop Suites	Kohler	17	NG
Poultry	Cummins	35	NGR
Pfeizer	Onan	80	LPG
Horse Barn Lift Station	Kohler	30	LPG
Towers	Onan	250	NG
Football Complex	Cummins	60	NG

### Near-Term Campus Plan (0-5 Years)

It is anticipated that the emergency (and optional Standby) electrical demand on campus could increase by approximately 2.1 MW over the next 5 years.\* However, this load could increase greatly as some buildings, such as residence halls, may want emergency generation for the entire facility to allow it to be used as an area of refuge. In addition, research users may require additional emergency power to protect the research and research storage. Depending on the location of the new buildings, they could be supported by one of the following methods:

- Connect to the existing Central Emergency System: New emergency loads will have to be determined and reviewed with existing demand and capacity. It may be necessary to increase the size of one of the existing, older generators to meet the new capacity.
- Create a new Emergency System in areas of concentrated emergency loads: It may be advantageous to create a new Central Emergency System in clusters of new and existing buildings. Central systems offer better redundancy and better use of resources, such as load diversities, that can allow more accurate "right sizing."
- Provide stand-alone emergency systems: A cost-benefit analysis may conclude that stand-alone emergency generation is the most efficient use of University funds to support emergency loads in some buildings. However, an investment in the expansion of the Central Emergency System in the near term may benefit overall funding in the long term.

### Goals:

- Provide new systems to meet the latest adopted Code for Emergency (Life Safety) system.
- Commission a study to review new emergency load requirements in all buildings – new, renovated and existing – which will determine new emergency loads, emissions implications, and emergency power priorities across the campus. The study should identify areas suitable for existing Central Emergency System expansion, areas suitable for new Central Emergency Systems, and areas suitable for stand-alone emergency systems.
- Review existing emergency systems for reuse in buildings to be renovated.

### Improvements:

- Review the emergency power study to determine the best method of providing emergency power to each new and renovated building and implement the recommendations, in phases if appropriate. This could include:
  - Modifications to the existing Central Emergency System.
  - New Central Emergency Systems in areas of concentrated buildings that can be expanded in the mid and long term.
  - Stand-alone systems in more remote areas of the campus.

\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.

# Electrical Emergency Power

## Mid-Term Campus Plan (6-10 Years)

It is anticipated that the next wave of new emergency electrical loads could be relatively insignificant (0.9 MW), as there are many buildings slated for demolition or renovation that will offset the emergency requirement. Again, depending on building location, condition of equipment in existing buildings, and campus plans to expand emergency power beyond “typical” requirements, means of providing emergency power will vary.

### *Goals:*

- Provide new systems to meet the latest adopted Code for Emergency (Life Safety) system.
- Review systems provided in the near term and determine means to expand these systems to additional buildings on campus.
- Revisit near-term emergency power study, and update based on the needs for the mid term.
- Review existing emergency systems for reuse in buildings to be renovated.

### *Improvements:*

- Review Master Plan to determine the best method of providing emergency power to each new and renovated building.
- Expand the existing and new Central Emergency Systems (if provided in the near term) to support additional building in the vicinity of the system.
- Review existing emergency systems for reuse in buildings to be renovated.

## Long-Term Campus Plan (11-20 Years)

Expansion from years 11-20 could result in additional estimated emergency peak demand of 3.6 MW, which may increase based on campus plans to expand emergency power beyond “typical” requirements.

### *Goals:*

- Provide new systems to meet the latest adopted Code for Emergency (Life Safety) system.
- Review systems provided in the mid term and determine means to expand these systems to additional buildings on campus.
- Revisit mid-term emergency power study, and update based on the needs for the long term.
- Review existing emergency systems for reuse in buildings to be renovated.

### *Improvements:*

- Review Master Plan to determine the best method of providing emergency power to each new and renovated building.
- Create new and expand existing Central Emergency Systems to support additional building in the vicinity of the system.
- Review existing emergency systems for reuse in buildings to be renovated.



## Gas Service

Connecticut Natural Gas (CNG) supplies gas to the University. The age and condition of the system varies, but all piping is owned by CNG. The Algonquin Gas Transmission (AGT) pipeline is not owned by CNG, and there is a separate feed to the cogen turbines with dedicated supply at 360 lbs which is maintained by CNG. The AGT main is at 700 lbs and the UConn campus supply is at 65 lbs. Most gas mains on campus are 6 to 8 inches, with some 4-inch and smaller service lines.

Based upon UConn's Climate Action Plan and goals for reaching climate neutrality by 2050, over the long term new buildings are anticipated to be connected to the CUP and satellite plants for electric, heat, and hot water needs. Other sustainable strategies such as renewable energy are expected to further reduce gas demand as they are constructed. Therefore, long-term gas loads are not anticipated to increase over today's demand. However, as individual projects come on-line that require gas service, including co-generation plants, and before these long-term strategies are implemented, evaluation of peak loads will need to continue to be evaluated against the current main and distribution supply with CNG.



Connecticut Natural Gas (CNG) Driller



Depot Campus Fuel Cell converts natural gas into electricity and heat

# Steam Service

## Existing Conditions

The existing high pressure steam (hPS) and pumped condensate (PC) infrastructure on campus is comprised of the Central Utility Plant (CUP) and the Heating Plant (HP) on Glenbrook Road and underground distribution piping throughout campus. These two plants are connected and operate in tandem to provide flexibility and redundancy from an hPS generation standpoint. The CUP and HP currently produce a maximum of 500,000 lbs/hr (N+1, redundant configuration), and peak demand on campus is 225,000 lbs/hr.

Existing distribution piping is in very poor condition and beyond its useful life; some piping is over 80 years old. In 2009, Fuss & O'Neill drafted an assessment of the existing steam distribution system and concluded that a comprehensive replacement and repair of the system was required. This work was to include, but not be limited to: replacement of all unreliable steam and condensate pipes (and associated vaults), adoption of current UConn design standards, metering at all buildings and condensate metering at critical junctions, and installation of isolation valves. At that time, capital expenditure of this work was estimated at \$100 million over the next 8 to 12 years. The UConn facility group reports that the amount of condensate returned represents approximately 40% of the total steam generated (i.e. make up water for steam generation is approximately 60%), making the system very inefficient. To that end, in 2013, URS drafted an aerial infrared leak and heat loss report which highlighted areas of heat loss within the heating system.





## Load Projections + Assumptions

		Steam (lbs/hr)			
Business As Usual Approach		Present	Near Term	Mid Term	Long Term
	Demand	225,000	275,520	302,600	357,454
	Excess Capacity	(275,000)	(224,480)	(197,400)	(142,546)
10% Energy Reduction	Demand		247,968	272,340	321,709
	Excess Capacity		(252,032)	(227,660)	(178,291)
20% Energy Reduction	Demand		220,416	242,080	285,963
	Excess Capacity		(279,584)	(257,920)	(214,037)
30% Energy Reduction	Demand		192,864	211,820	250,218
	Excess Capacity		(307,136)	(288,180)	(249,782)

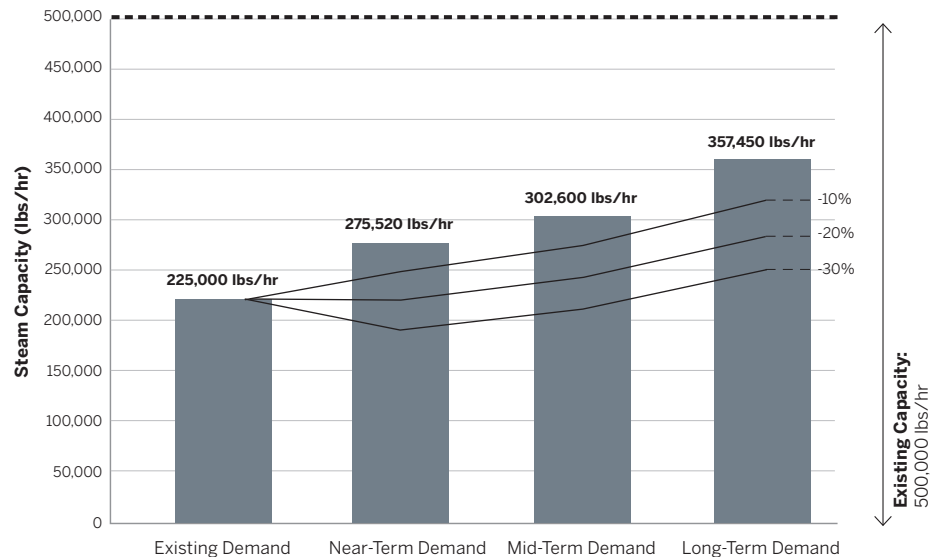
Assumptions: (BTU/SF)	New Buildings	Demolition	Renovation
Academic / Teaching	40	52	-12
Administration	40	52	-12
Arts / Culture	40	52	-12
Athletics + Recreation	50	65	-15
Misc	37	48	-11
Parking	0	0	0
Residence / Dining	60	78	-18
Science	42	55	-13
Student Services	45	59	-14
Support / Utility	37	48	-11

\*Renovated buildings are assumed to be approximately 30% more efficient following the renovation. Indicated value is relative energy savings.

\*\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.

## Impact on Utility Systems

The graph below shows that near-, mid-, and long-term demand are accommodated by existing capacity. However, efficiency improvements should still be explored, as excess steam can be readily converted to chilled water to make up for current capacity deficiencies.



# Steam Service

## Near-Term Campus Plan (0-5 Years)

To support the expansion of campus in the next 5 years, upgrades to the existing high pressure steam (hPs) and Pumped Condensate (PC) systems must be addressed. Current peak demand on the hPs system, located at the CUP, represents approximately 48% of peak capacity. As such, increased capacity is not necessary during this time frame. However, upgrades to the steam and condensate distribution networks will be critical to this near-term plan. It is anticipated that the hPs demand increase on campus over the next 5 years could be approximately 50,000 lbs/hr. In order to adequately provide hPs for this load, the following factors should be considered:

### Goals:

- Efficiently supply hPs to, and return PC from, buildings to the existing CUP.
- Revise distribution to eliminate a single point of failure.
- Provide accessibility to piping for improved inspection and service.
- Set groundwork for future flexible expansion.
- Monitor building level utilities.

### Improvements:

- Remove existing hPs and PC radial piping network.
- Provide new piping bridge (via utility tunnel) between the CUP and new chilled water sUP serving development at X Lot. Provide piping bridge (via utility tunnel) under Whitney Road to create a southern loop by connecting the CUP with the South District.
- Provide connection from central loop to serve the gateway and Storrs Road developments.
- Start connection from central loop to existing buildings (for buildings not slated for demolition or significant renovation).
- Distribution piping to be pipe-in-pipe with leak detection to minimize losses.
- Provide building level hPs and PC meters at all existing to remain, renovated, and new building entries.

## Mid-Term Campus Plan (6-10 Years)

To support the next wave of new steam loads, the framework that began in the near term will be expanded. It is anticipated that the hPs demand increase on campus from years 6-10 could be an additional 27,000 lbs/hr, bringing the total increase in demand from Day 1 to approximately 77,000 lbs/hr. In order to adequately provide hPs for this load, the following factors regarding energy use should be considered:

### Goals:

- Continue implementation of the near-term campus plan goals.
- Minimize usage of fossil fuels.

### Improvements:

- Continue the North District distribution loop.
- Start connection from central loop to existing buildings (for buildings not slated for demolition or significant renovation).
- Provide distribution piping utilizing pipe-in-pipe (with leak detection) and locate piping within a utility tunnel or accessible trench.
- Provide building level hPs and PC meter installation at renovated and new buildings entries.

## Long-Term Campus Plan (11-20 Years)

Expansion in years 11-20 could result in additional estimated peak demand of approximately 55,000 lbs/hr, bringing the total increase in demand from Day 1 to approximately 132,000 lbs/hr and the entire campus to a peak demand of approximately 400,000 lbs/hr. Connection to each district loop will be required as new buildings are added.

During this phase, existing boilers will be nearing the end of their useful life. In conjunction with the planned replacement of this capacity, more sustainable means of generating steam will need to be pursued. In order to adequately provide hPs for this load, the following factors should be considered:

### Goals:

- Continue implementation of the mid-term plan goals.
- Minimize usage of fossil fuels.

### Improvements:

- Complete the North District distribution loop. Provide a piping bridge (via utility tunnel) under Hillside Road that connects the north and south portions of the South District to provide additional redundancy, flexibility, and reliability.
- Complete connection from central loop to existing buildings (for buildings not slated for demolition or significant renovation).
- Provide connection from central loop to serve the gateway, Agricultural Campus, and Storrs Road developments.
- Complete distribution piping utilizing pipe-in-pipe (with leak detection) and locate piping within a utility tunnel or accessible trench.
- Complete hPs and PC meter installation at renovated and new buildings.
- Replace existing boilers at the heating plant and heat recovery steam generators at the co-gen plant with Biomass boilers.

### Additional References:

1. Steam Distribution System Assessment. Fuss & O'Neill – Sep., 2009.
2. Aerial Infrared Steam, Liquid Leak & Heat Loss Report. URS – March 30, 2013.
3. North Eagleville Road Area Infrastructure Repair/Replacement and Upgrade. URS- September, 2013





- Existing Central Utility Plant
- Near-Term Local Utility Plant
- Long-Term Local Utility Plant
- ▬ Near-Term Proposed Steam Main
- ▬ Long-Term Proposed Steam Main
- Existing Steam Main

**Steam Service - Proposed**



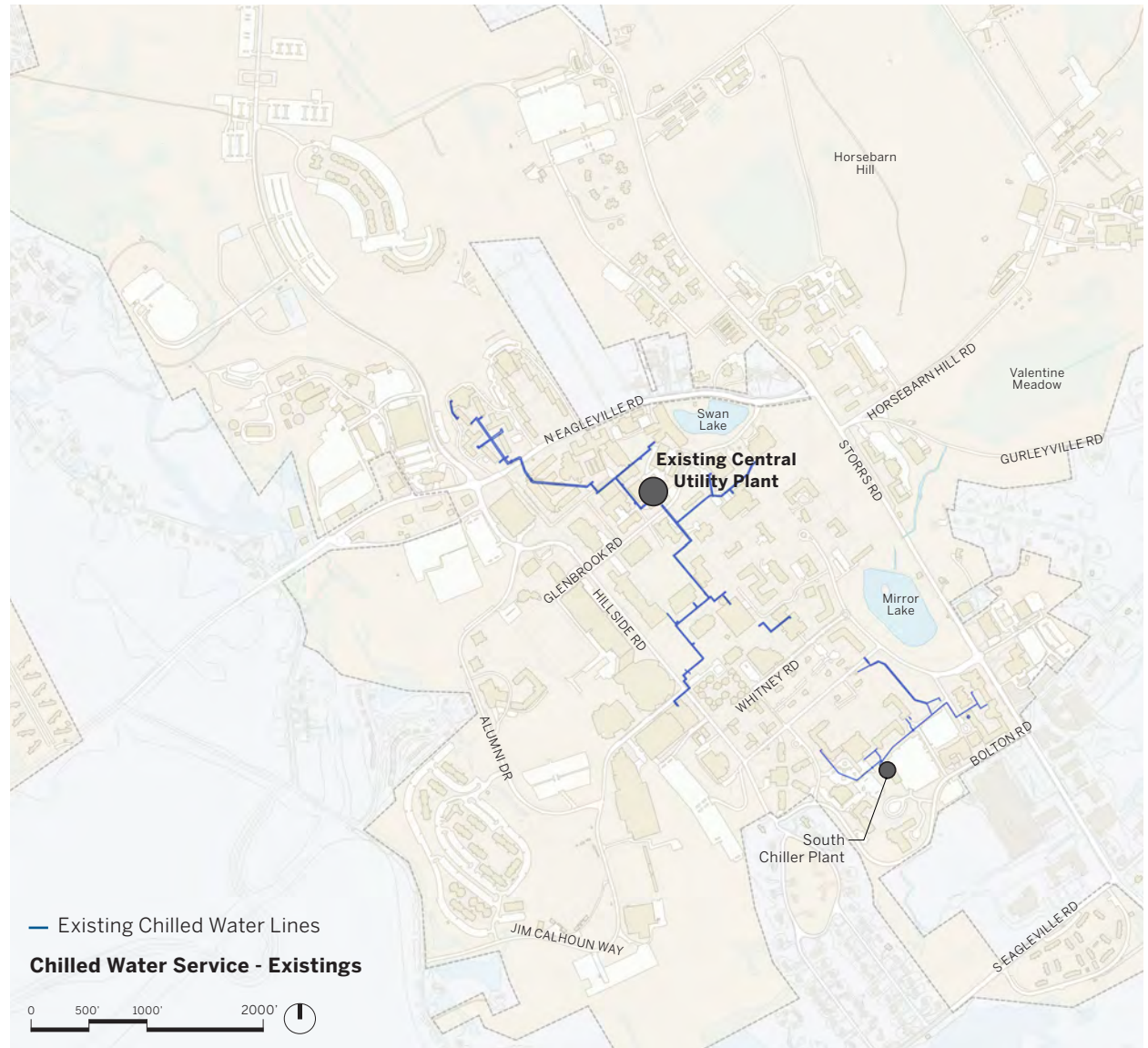


# Chilled Water Service

## Existing Conditions

The existing chilled water (ChW) infrastructure on campus is comprised of the Central Utility Plant (CUP) and underground distribution piping throughout campus. The South District is fed from the much smaller South Campus Chiller Plant. These two plants are independent from one another and do not connect. The CUP currently produces a maximum of 10,000 tons (N+1, redundant configuration), and the peak demand on campus is 8,300 tons. In 2013, RMF drafted an assessment of the existing chilled water system. As part of that report, some future cooling loads were identified. This new building construction will increase peak demand to 10,000 tons. To augment this additional demand, UConn will be adding an additional 2,000 ton chiller, which aligns with RMF's recommendation, to bring the total capacity of the CUP to 12,000 tons (N+1, redundant configuration). Future expansion is limited, due to lack of real estate, to one (1) additional 2,000 ton chiller.

The South District supplemental Utility Plant (sUP) currently produces a maximum of 500 tons (N+1, redundant configuration), and the peak demand is 275 tons. UConn is adding an additional 500 ton chiller to bring the total capacity of the South District sUP to 1,000 tons (N+1, redundant configuration). Chilled water is currently supplied to the campus via a radial piping network. As recommended within RMF's assessment, a distribution loop will be pursued to provide enhanced efficiency and redundancy.





## Load Projections + Assumptions

		Chilled Water (Tons)			
		Present	Near Term	Mid Term	Long Term
Business As Usual Approach	Demand	8,300	14,691	16,301	22,171
	New Capacity	(1,700)	2,691	4,301	10,171
10% Energy Reduction	Demand		13,222	14,671	19,954
	New Capacity		1,222	2,671	7,954
20% Energy Reduction	Demand		11,753	13,041	17,737
	New Capacity		(247)	1,041	5,737
30% Energy Reduction	Demand		10,284	11,411	15,520
	New Capacity		(1,716)	(589)	3,520

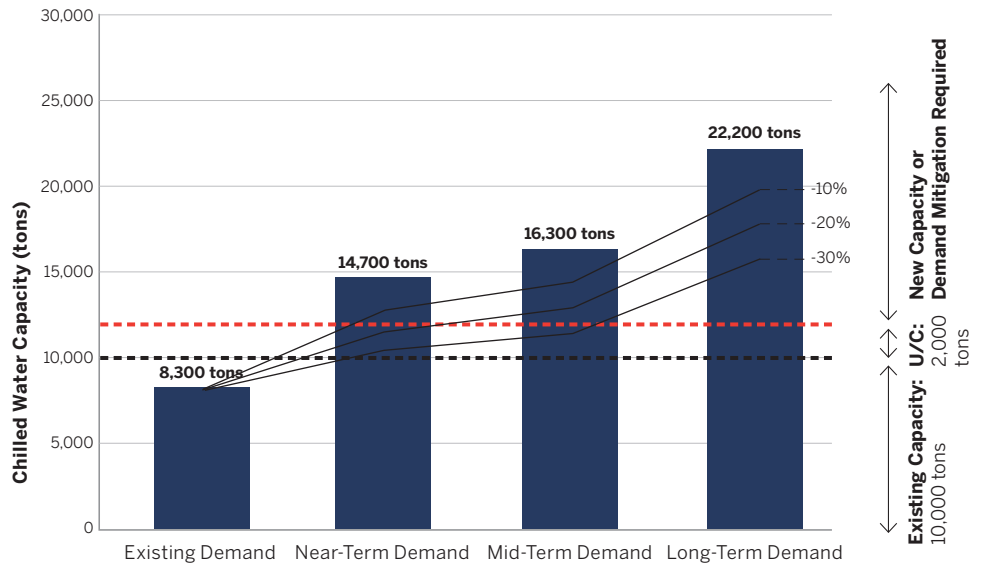
Assumptions: (SF/TON)	New Buildings	Demolition	Renovation
Academic / Teaching	200	154	-667
Administration	200	154	-667
Arts / Culture	225	173	-750
Athletics + Recreation	375	288	-1,250
Misc	400	308	-1,333
Parking	0	0	0
Residence / Dining	200	154	-667
Science	175	135	-583
Student Services	200	154	-667
Support / Utility	400	308	-1,333

\*Renovated buildings are assumed to be approximately 30% more efficient following the renovation. Indicated value is relative energy savings.

\*\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.

## Impact on Utility Systems

The graph below shows that near-term demand for chilled water will exceed the capacity of existing facilities. To rectify this, UConn is already expanding chilling capacity at the CUP to 12,000 tons. However, mid- and long-term growth of science and research programs will drive increasing chilled water demand, which must be accounted for either through expanded capacity (SUPs, building-level absorption chillers) or increased efficiency in both new and existing buildings.



# Chilled Water Service

## Near-Term Campus Plan (0-5 Years)

To support the planned expansion of campus in the next 5 years, upgrades to the existing chilled water (ChW) system must be considered. Within the CUP, the two (2) existing Tecogen, natural gas-fired chillers are beyond their anticipated useful life and due for replacement. It is anticipated that the ChW demand increase on campus over the next 5 years could be approximately 4,700 tons. As such, increased capacity, as well as one (1) new supplemental Utility Plant (sUP) will be pursued during this time frame. In addition, upgrades to the distribution network will be central to this near-term plan. In order to adequately provide ChW for this load, the following factors should be considered:

### Goals:

- Efficiently supply ChW to, and from, buildings to the existing CUP.
- Provide new sUP to serve new development / X Lot science complex.
- Replace fossil fuel chillers within the existing CUP.
- Revise distribution to eliminate a single point of failure.
- Provide accessibility to piping.
- Monitor building level utilities.

### Improvements:

- Remove existing ChW radial piping network.
- Replace the two (2) existing gas fired chillers within the existing CUP with high efficiency electric driven or steam absorption during this time frame. Replace all steam absorption chillers with electric chillers.
- Provide new ChW sUP serving development at X Lot; phase capacity in concert with construction of new buildings, ultimate capacity of 6,000 tons.
- Provide new piping bridge (via utility tunnel) between the CUP and new ChW sUP. In addition, backfeed buildings previously served by the South

Chiller Plant.

- Route new piping within a utility tunnel or accessible trench.
- Distribution piping shall be pipe-in-pipe (with leak detection) to minimize losses.
- Provide building level ChW meters at all existing, renovated and new building entries.

## Mid-Term Campus Plan (6-10 Years)

To support the next wave of new ChW loads, the framework that began in the near term will be expanded. It is anticipated that the ChW demand increase on campus in years 6-10 could be an additional 1,600 tons, bringing the total increase in demand from Day 1 to approximately 6,300 tons. As such, increased capacity, as well as one (1) new sUP will be pursued during this time frame. In order to adequately provide ChW for this load, the following factors regarding energy use should be considered:

### Goals:

- Continue implementation of the near-term campus plan goals.
- Provide more efficient means of ChW generation.

### Improvements:

- Modify ChW sUP in the South District; ultimate capacity to match the new X Lot plant.
- For modified SUP, augment capacity utilizing ground source/air source heat pump.
- Continue (3) piping distribution loops: north, south, and east.
- Continue piping distribution network utilizing pipe-in-pipe (with leak detection) and locate piping within a utility tunnel or accessible trench.
- Continue ChW meter installation at renovated and new buildings.

## Long-Term Campus Plan (11-20 Years)

Building upon the mid-term plan, the subsequent 10-year phase will include expansion within all districts. Connection to each district loop will be required as new buildings are added. This expansion could result in additional estimated peak demand of 5,900 tons, bringing the total increase in demand from Day 1 to approximately 12,000 tons and the entire campus to a peak demand of approximately 22,000 tons. During this phase, expansion of the existing CUP will continue and modification of the existing South District sUP will be required. In conjunction with this increased capacity, more efficient means for generating chilled water will need to be pursued. In order to adequately provide ChW for this load, the following factors regarding energy use should be considered:

### Goals:

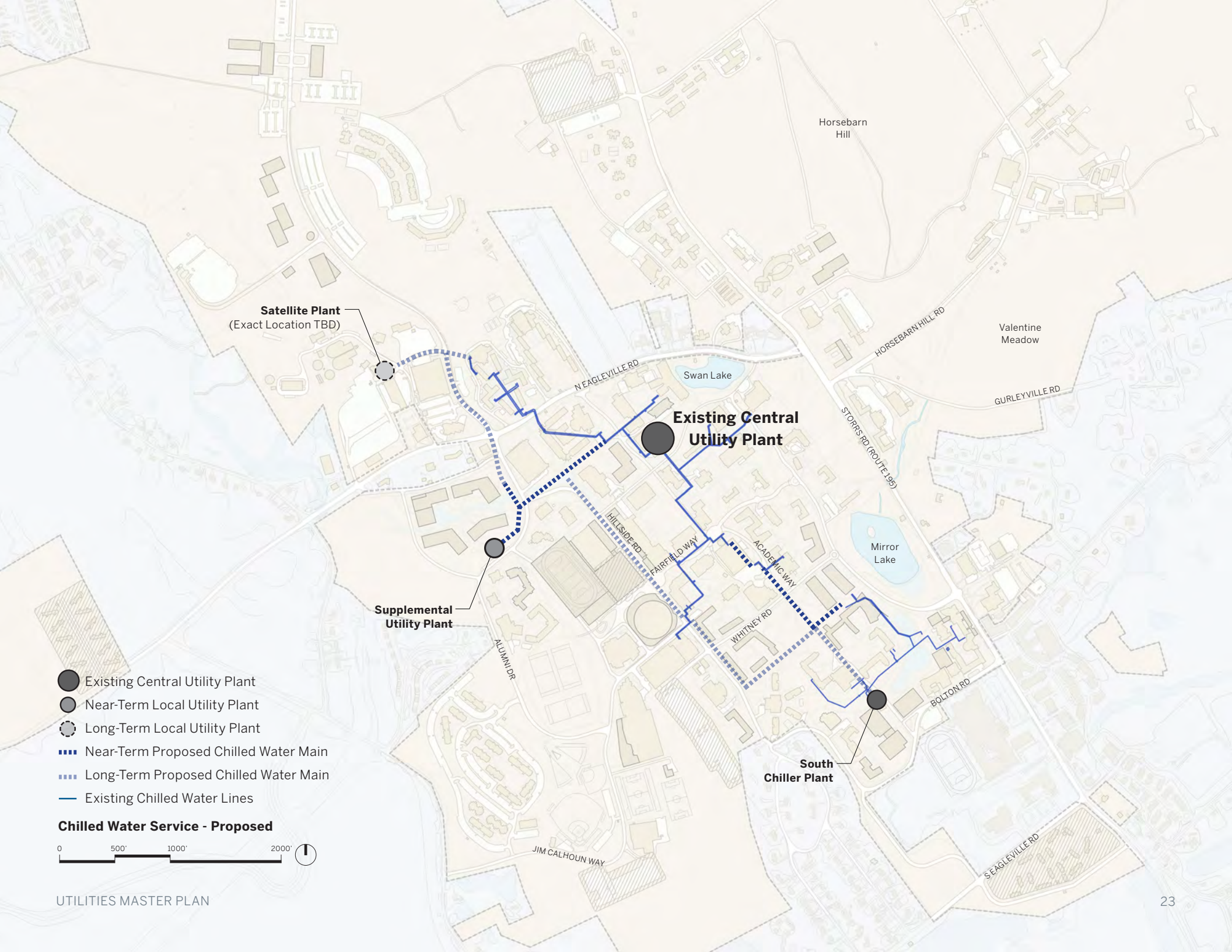
- Continue implementation of the near-term plan goals.
- Provide more efficient means of ChW generation.

### Improvements:

- Increase the capacity of the existing CUP with one new high-efficiency, electric driven chiller.
- Complete (3) piping distribution loops: north, south, and east. Add a piping bridge (via utility tunnel) under Hillside Road, providing additional redundancy, flexibility and reliability.
- Complete piping distribution network utilizing pipe-in-pipe (with leak detection) and locate piping within a utility tunnel or accessible trench.
- Complete ChW meter installation at renovated and new buildings.
- Provide new ChW sUP in the North District, ultimate capacity to match the new X Lot sUP.
- For new SUP, augment capacity utilizing ground source/air source heat pump.

### Additional References:

1. Chilled Water System Improvements Central Utility Plan. RMF – April, 2013.



- Existing Central Utility Plant
- Near-Term Local Utility Plant
- Long-Term Local Utility Plant
- Near-Term Proposed Chilled Water Main
- Long-Term Proposed Chilled Water Main
- Existing Chilled Water Lines

**Chilled Water Service - Proposed**





# Renewable Energy

The integration of renewable energy technologies will be essential for meeting carbon neutrality goals. Near-term opportunities for scalable, adaptable, and meaningful alternative energy production range from building-integrated photovoltaics and solar thermal systems to large-scale solar or wind farms on open tracts. Other alternative sources and renewable energy strategies including co-generation, fuel cells, methane harvesting, and trash-to-energy will need to be studied carefully to understand if the technology will serve larger goals.

A number of these strategies have already been studied as part of the University's 2012 *Preliminary Feasibility Study and Strategic Deployment Plan for Renewable and Sustainable Energy Projects*. This study addressed the deployment of six renewable and sustainable energy technologies: solar thermal, solar photovoltaics, wind, geothermal, fuel cell, and biogas. It outlined demonstration projects at eleven locations on the Main and Depot Campuses, which together accounted for a potential reduction of approximately 1,570,000 to 2,370,000 lbs/year of greenhouse gas emissions; 1,400 MMBtus of renewable thermal energy production; 3.22 to 5.05 million kWh/year in renewable electricity production; and 50,000 to 75,000 gallons per year of diesel fuel consumption<sup>1</sup>. These demonstration projects are the starting point for a longer-term strategy.

Over the next 20 years, these systems will improve and new technologies will emerge. UConn will need to actively consider integrating these new technologies into its NextGenCT plans to demonstrate viability and exhibit leadership in renewable energy development.

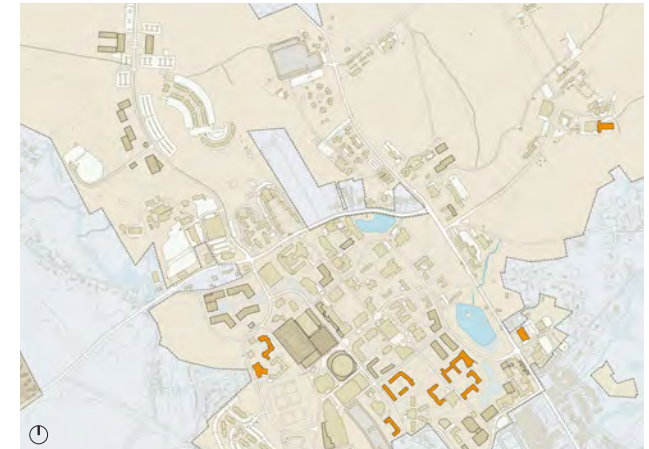


## Solar Photovoltaic Array

Photovoltaic arrays (either building or site installed) are particularly viable in this climate. Parking facilities offer the clearest potential for large-scale, canopy-mounted photovoltaic systems. These can be installed on new decks or on large surface parking lots, such as C Lot and F Lot, which cannot be developed into buildings as they sit atop capped landfills. Major new science buildings on the eastern half of campus – where runoff restrictions for Eagleville Brook are not a constraint – could also have roof-mounted PV arrays.

Other solar PV demonstration projects identified by the University and meriting further study include: <sup>1</sup>

- Homer Babbidge Library (south roof)
- ITE Building (roof)
- Horsebarn Hill Sciences Complex Building #4 Annex (south facing roof)
- Center for Clean Energy Engineering (Depot)



## Solar Hot Water

Solar hot water systems are particularly useful for residence halls, where domestic hot water demand can be significant for most of the year. UConn should consider installing these systems on all new residence halls, as well as retrofitting existing buildings when targeted for renovation.

Other solar hot water demonstration projects identified by the University and meriting further study include: <sup>1</sup>

- Putnam Refectory (roof)
- Shippee Hall (roof)
- Dairy Bar (roof)
- Horsebarn Hill Sciences Complex Building #4 Annex (south facing roof)

<sup>1</sup>Source: *Preliminary Feasibility Study and Strategic Deployment Plan for Renewable and Sustainable Energy Projects* (2012)



## Wind

Wind energy can contribute to overall energy reduction; however, wind as a resource at UConn must be analyzed and sited. Typically in the Northeast, the most cost-effective wind power strategy is at a large scale, such as an array of wind turbines on a ridge with reliable wind. Smaller building-mounted wind power systems should be studied for project-specific potential.

Demonstration wind projects identified by the University and meriting further study include: <sup>1</sup>

- Homer Babbidge Library (roof)
- North campus site between Busby Suites and the Marching Band practice field



## Geothermal / Ground Source Heat Pump

Ground-source heat pumps are potentially viable but require evaluation on a building-specific basis to confirm appropriate geotechnical and geothermal characteristics. The Storrs Campus sits atop a number of different subsurface conditions, which will each need to be evaluated for geothermal potential as new buildings are designed and developed.

Demonstration geothermal projects identified by the University and meriting further study include: <sup>1</sup>

- Horsebarn Hill Sciences Complex Building #4 Annex
- Thompson Hall (Depot)



## Other Opportunities

District utility plants also may be viable options for the University. The consideration of fuel cells or microturbines can provide efficient, localized power generation but would lock in dependence on natural gas. The carbon impact of other alternative sources and renewable energy strategies including cogeneration, fuel cell, and trash-to-energy will need to be studied carefully to understand if the technology will serve larger carbon goals.

Additional demonstration projects identified by the University and meriting further study include: <sup>1</sup>

- Stationary Fuel Cells at Homer Babbidge Library, the ITE Building, and Horsebarn Hill Sciences Complex Building #4 Annex
- Biodiesel production system at the Longley Building (Depot)
- Small-scale gasification system at the Center for Clean Energy Engineering (Depot)





# Water

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# Stormwater

## Background

The UConn campus straddles two subregional drainage basins, the Willimantic River to the west of campus and the Fenton River to the east. Within these watersheds, stormwater runoff from the campus is collected through a typical inlet and pipe system with limited stormwater treatment practices being incorporated prior to discharging into tributaries of the two rivers. In November 2004, UConn established *Campus Sustainable Design Guidelines* that in part addressed the need to implement stormwater quality measures. Stormwater quantity, including flow and volume, is governed by the University's Flood Management Certification (FMC) with the Connecticut Department of Energy and Environmental Protection (CTDEEP). Any State project that affects a floodplain, impacts storm drainage facilities, or increases peak runoff rates is subject to permit requirements and approval by CTDEEP under the FMC permit.

Eagleville Brook is a tributary to the Willimantic River, a portion of which runs through the UConn campus. The CTDEEP has classified the brook as a Class A stream that is included on the *2004 List of Connecticut Waterbodies Not Meeting Water Quality Standards*. Based on this, Eagleville Brook is subject to regulations consistent with waterbodies of its quality. In order to comply with the Federal Clean Water Act [section 303(d)], the CTDEEP issued a Total Maximum Daily Load (TMDL) Analysis for the brook on February 8, 2007. The analysis determined there was no single pollutant or generator that could be identified as the primary source for water degradation and the subsequent decrease in fish population; therefore, a maximum impervious coverage target was established. The 2007 analysis goes on to cite several studies which link the percentage of impervious cover within a watershed and the quality of downstream runoff. The Eagleville Brook TMDL is the first in the nation to be based on impervious coverage and not on a particular pollutant.

## Initial Strategy

Chapter 2 of the Connecticut Stormwater Quality Manual provides a comprehensive review of the impacts of impervious surfaces and urbanization on the quality of downstream waterbodies. Additionally, the Center for Watershed Protection has documented that, as stream quality indicators decrease, impervious coverage levels increase. When impervious coverage is as low as 10%, water quality is impacted and at 25% water quality is impaired. In 2009, the approximate impervious coverage of the Eagleville Brook Watershed was 27% per Table 4 of the TMDL analysis. The CTDEEP determined that, in order to help the Eagleville Brook meet the required water quality criteria, the impervious coverage should be reduced to 11% within the watershed. This target value was calculated from a comprehensive analysis of nine Connecticut towns with known impervious coverage values. A review was conducted to correlate impervious coverage with aquatic life indicators in downstream waterbodies. Based on this review the CTDEEP identified 12% as the impervious coverage threshold with a 1% margin of safety.

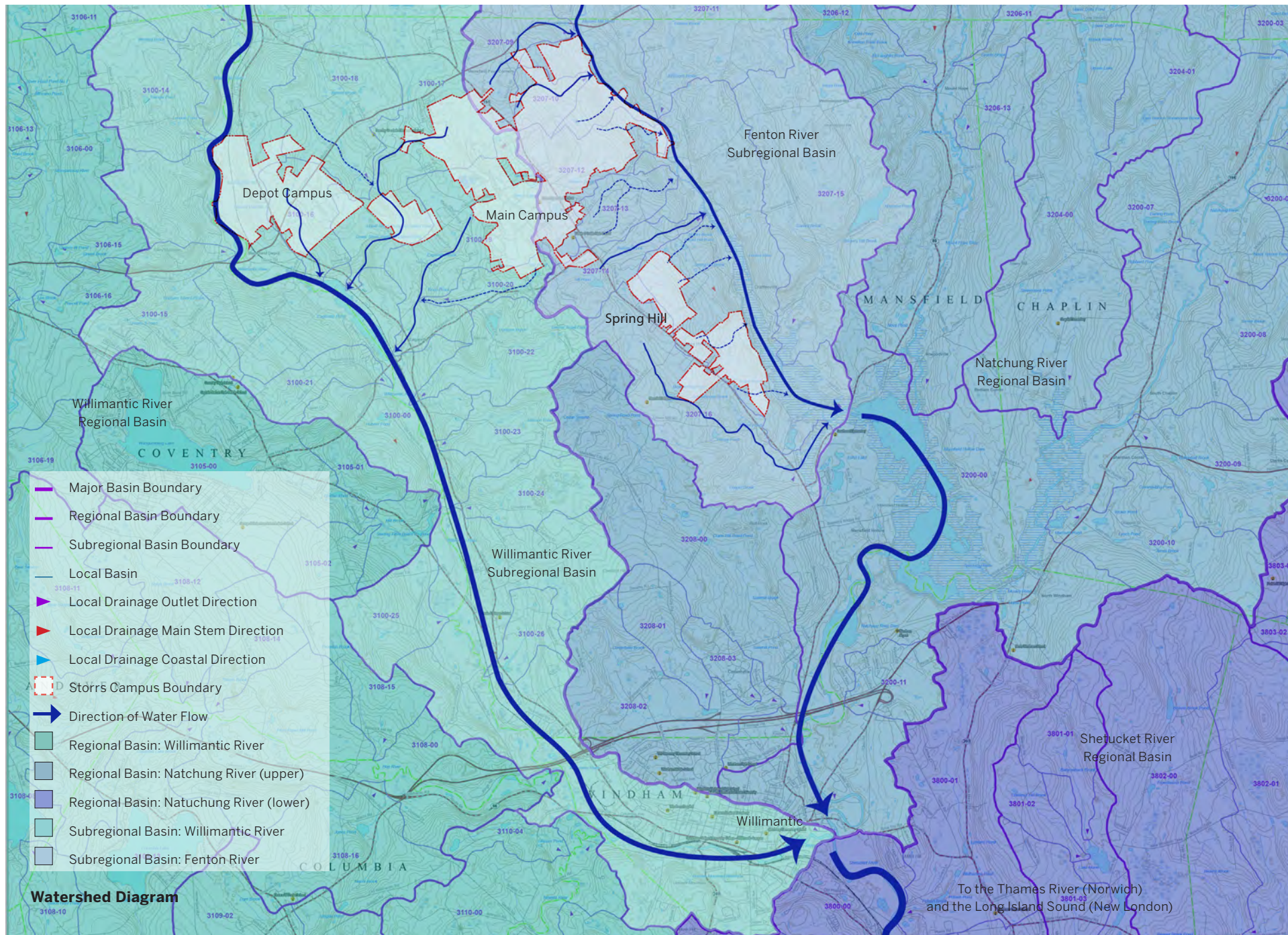
In order to meet CTDEEP's goal, UConn signed a Memorandum of Agreement (MOA) in 2009. The MOA outlined various flood and water quality enhancement projects across the campus, as well as an 11% impervious coverage threshold for the Eagleville Brook watershed. It is important to note that this agreement did not address the mitigation of future development within the watershed. Additionally, the MOA does not quantify how much of the impervious coverage within the watershed is part of the UConn campus, nor does it provide water quality benchmarks or sampling requirements to confirm the results of the impervious reduction.

The Eagleville Brook TMDL document from February 2007 recommends incorporating low impact development (LID) strategies such as disconnecting impervious surfaces from downstream water bodies, installing engineering best management practices (BMPs), and reducing impervious surfaces where practical. The *Connecticut Stormwater Quality Manual* provides design guidelines for the implementation of these practices. The TMDL report goes on to state that impervious coverage reductions should only be used as an interim measure of performance, and that meeting the TMDL requirement will ultimately be assessed by measuring the aquatic life indicators directly.

## Current Strategy

In 2013, UConn and the CTDEEP drafted a Memorandum of Understanding (MOU) which, once finalized, will replace the 2009 MOA. The 2013 MOU outlines an LID approach to the water quantity reduction and water quality enhancement goals of the CTDEEP. This approach more closely follows the recommendations of the 2007 TMDL document. The goals established in the MOU are based in large part on the findings of the March 4, 2010 "Impervious Cover TMDL Field Survey and Analysis Report," prepared by the Center for Watershed Protection and the Horsley Witten Group. The report was sponsored by the CTDEEP, UConn, and the Town of Mansfield in order to assess the Eagleville Brook watershed and identify appropriate measures for the enhancement of water quality. The report identifies a series of high priority projects on the UConn campus, which when implemented, would result in a 797,600 ft<sup>3</sup> annual reduction in stormwater runoff. UConn is committed to this annual runoff reduction goal, which will need to be attained on or before December 31, 2021. The current MOU is to be amended to reflect this volume reduction.







# Stormwater

## Future Development Goals

Water quality improvement strategies should not be limited to development within the Eagleville Brook watershed. While the Eagleville Brook is the primary concern of the CTDEEP and its watershed encompasses a significant portion of the UConn campus, development within the Fenton and Willimantic River watersheds should also be included in any future runoff and water quality enhancement strategies developed by UConn. All future development projects should be designed to contribute to the benefits of impervious reduction from a combination of surface conversion and stormwater quality measures. The current long-term development plan for the UConn campus embraces this strategy and will result in significant impervious surface coverage reductions campus wide.

Impervious Surfaces of Future Development	Eagleville Brook Watershed (acres)	Other Watersheds (acres)
Parking Lots Removed	16.4	11.9
Buildings Removed	6.0	4.8
Roads Removed	1.0	1.1
<b>Subtotal</b>	<b>23.4</b>	<b>17.8</b>
Buildings Added	20.1	10.3
Roads Added	1.2	0.8
<b>Subtotal</b>	<b>21.3</b>	<b>11.1</b>
Net Change in Impervious Surface	-2.1	-6.7

**Total Reduction in Impervious Area = 8.8 acres**

The previous table illustrates a programmatic summary of impervious surface modifications both within the Eagleville Brook watershed and outside this watershed, which includes both the Fenton and Willimantic River watersheds. This is a direct comparison of impervious coverage for future development identified within the long-term purview of the Master Plan. It does not account for the potential use of vegetated roofs, which would further reduce the net impervious surface coverage across the UConn campus.

In addition to impervious surface reduction, future development should also continue UConn's ongoing LID stormwater quality approach to reduce the quantity as well as improve the quality of runoff. In order to maintain consistency with the goals and objectives outlined in the 2013 Draft MOU, each development project, or the aggregate of all future development, should be designed to fully treat the water quality volume (WQV) as defined by the *Connecticut Stormwater Quality Manual* where feasible.

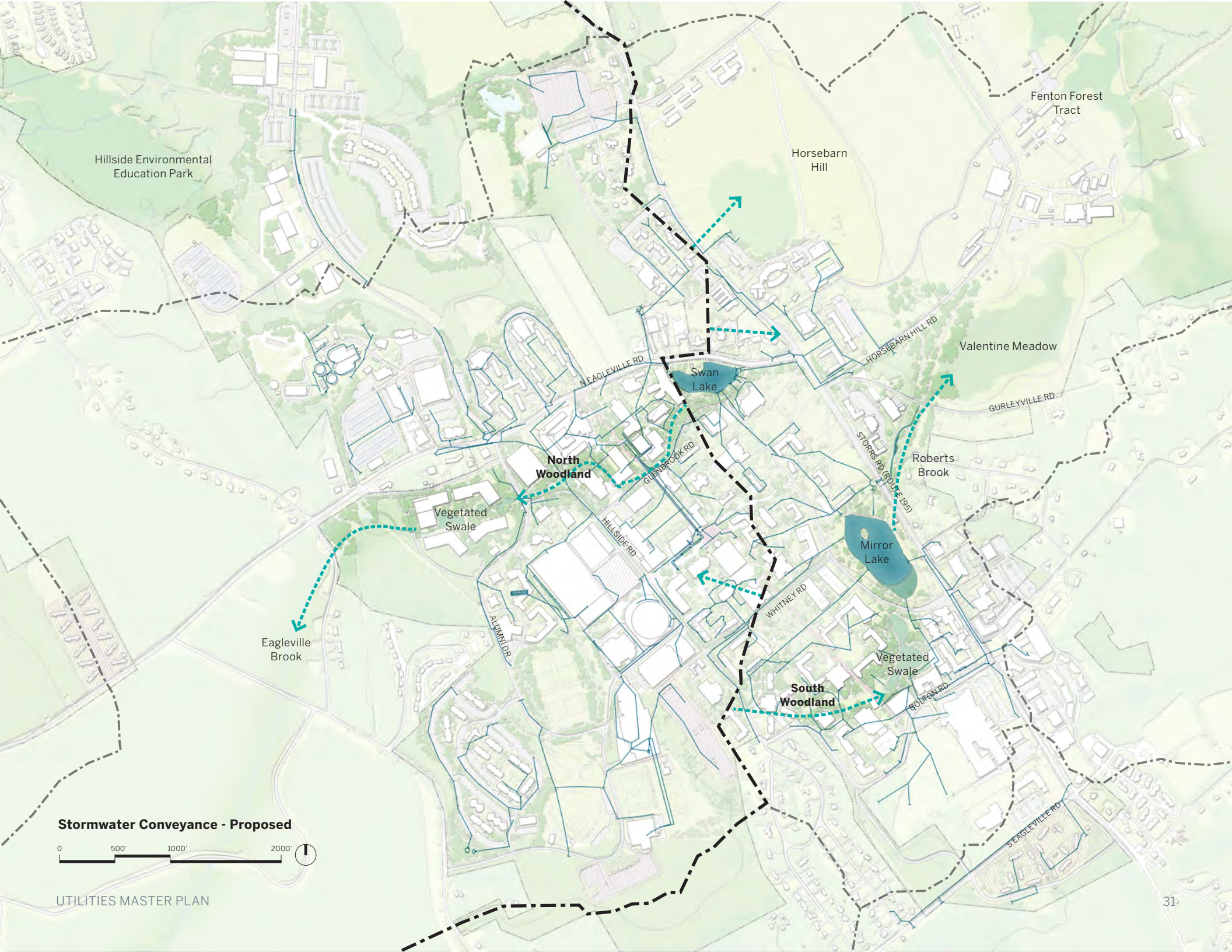
In order for UConn to track its progress towards its water quality enhancement goals, the Center for Watershed Protection has developed The Runoff Reduction Method (RRM) to estimate the amount of runoff being reduced from various BMP practices implemented throughout a watershed. Depending on the method selected and the hydrologic soil group in which the watershed is located, a runoff reduction rate is assigned; typical runoff reduction rates can be obtained from the Center for Watershed Protection. The runoff reduction rates are applied to the WQV treated in order to estimate the total reduction in runoff from the watershed for each practice. This metric will enable the University to track its stormwater runoff reduction performance and subsequent pollutant renovation on an annual basis.

When possible, projects should attempt to utilize multiple LID measures in series to further enhance the quality of runoff. An example of this might be providing a rooftop disconnection leading to a grass swale which discharges to a bio-retention pond. Below are a few approaches which could be utilized to enhance stormwater quality on campus:

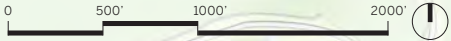
- Rain gardens
- Porous pavements/pavers
- Bio-retention facilities
- Vegetated swales
- Disconnected impervious surfaces
- Vegetated roofs
- Subsurface infiltration
- Rainwater harvesting
- Evaluate existing ponds and detention facilities for sediment deposition and loss of effective storage capacity

The CTDEEP plans to designate various state facilities as Municipal Separate Storm Sewer Systems (MS4); this would include universities such as UConn. This designation could add another regulatory layer to the future management of stormwater systems on campus.





**Stormwater Conveyance - Proposed**





# Potable Water Service

## Existing Conditions

### *Supply:*

UConn serves as the potable water provider to its Storrs campus, as well as portions of the surrounding town of Mansfield. While UConn is not considered a “water company” per the Connecticut General Statutes, the University chooses to comply with the relevant state statutes and Department of Public Health regulations. The contract operator for the water system is the Connecticut Water Company through its subsidiary, New England Water Utility Services, which provides the day-to-day operation of the system and the compliance with state and federal water quality standards. Their contract was recently renewed in 2010.

Presently, water is supplied to the system from two wellfields, which combined are permitted to withdraw 3.15 millions of gallons per day (MGD), although the safe yield of 2.32 MGD is lower, as described below:

- Willimantic River Wellfield – Wells were installed between 1958 and 1998. This wellfield contains four active wells that are permitted to withdraw 2.31 MGD and have a safe yield rate of 1.48 MGD
- Fenton River Wellfield – Wells were installed between 1928 and 1958. This wellfield contains four active wells that are permitted to withdraw 0.84 MGD, which is equivalent to the safe yield rate.

UConn has entered into an agreement with the Connecticut Water Company to extend five miles of water main to the campus from its reservoir in Vernon. This additional supply will provide another 1.85 MGD to the University’s water supply system from three different additional wellfields and the Lake Shenipsit Reservoir located in Tolland, Ellington, and Vernon.

Two of these wellfields are currently in operation and will be expanded; the third wellfield will be reactivated. In September 2013, the Office of Policy and Management approved the Environmental Impact Evaluation and Record of Decision for this extension.

### *Distribution:*

Much of the distribution piping system is dated from the 1940s, and there are a significant number of dead end systems without loops. In addition, previous studies have indicated there are deficiencies with system inventories, lack of a data management system, metering, valving, and security measures. Emergency power supply is provided to only two of the Willimantic wellfields. Although the Main and Depot Campus systems are interconnected, UConn’s water system is not interconnected with any other public water supply systems.

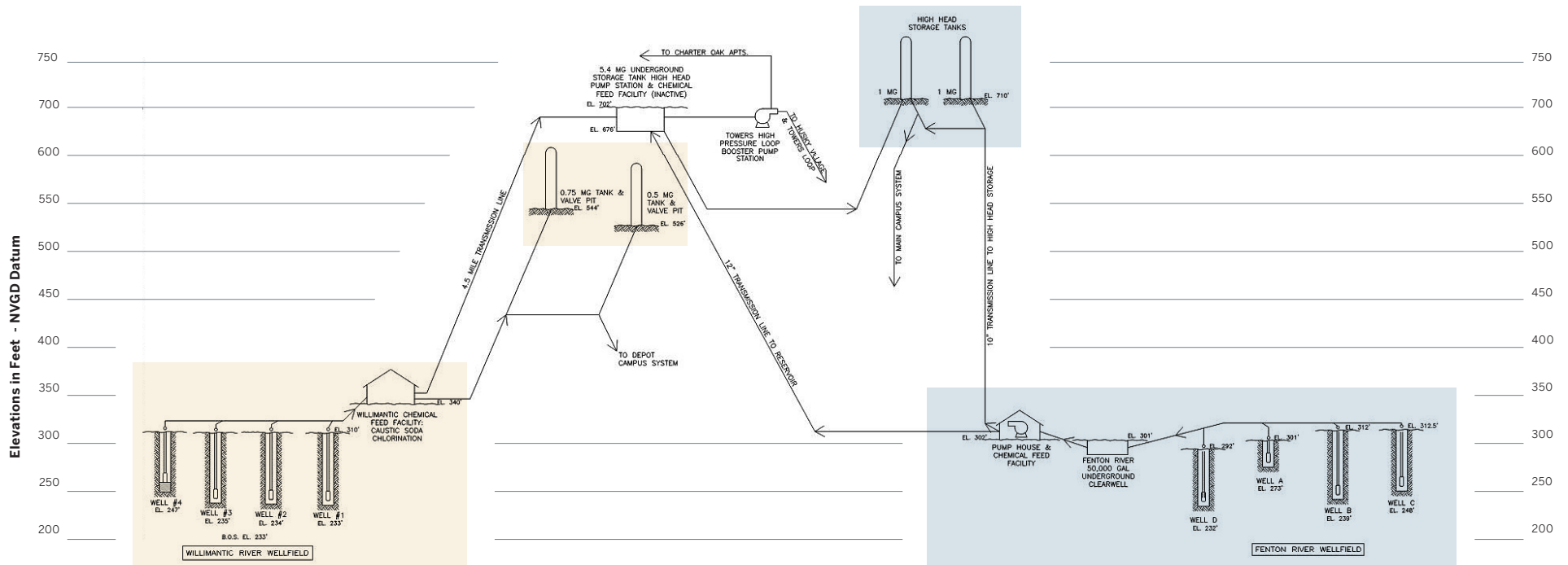
Treatment is provided at each wellfield with storage and distribution infrastructure located at various locations throughout the main campus. Approximately 8 MG of storage is available from six storage tanks. The age of the water distribution system ranges from 1914 to the present.

Water withdrawn from the Willimantic Wellfield is treated at a chemical facility located at the wellfield. From there, it is conveyed through four and a half miles of 16-inch ductile iron pipe to the 5.4 MG storage tank located at the Main Campus. Water withdrawn from the Fenton River wellfield is treated at a chemical facility located at the wellfield and then pumped to the 2 MG storage tanks near the Towers Booster Pump Station through two miles of 12-inch ductile iron pipe. An underground 50,000 gallon clearwell basin, to temporarily store treated drinking water, is also located at the Fenton River wellfield.

### *Demand:*

Significant conservation efforts implemented on campus in recent years have helped to reduce the demand on the water system to 1990s levels according to UConn’s 2011 *Water Supply Plan*, especially in September which is considered to be a critical time with the return of the students and the historically low water levels at the wellfields.

The Master Plan calls for significant new development and significant student enrollment over the next 20 years, which will have a major impact on this water system. The projected demands for the near-, mid-, and long-term campus plans are shown on the following page.



Water Supply Plan (By Milone & Macbroom, Dec. 2010)

- Depot Campus
- Agricultural/Main Campus

*Note:*  
 Diagram is for schematic purposes only. Buildings, tanks, pumps and distance between structures not to scale.

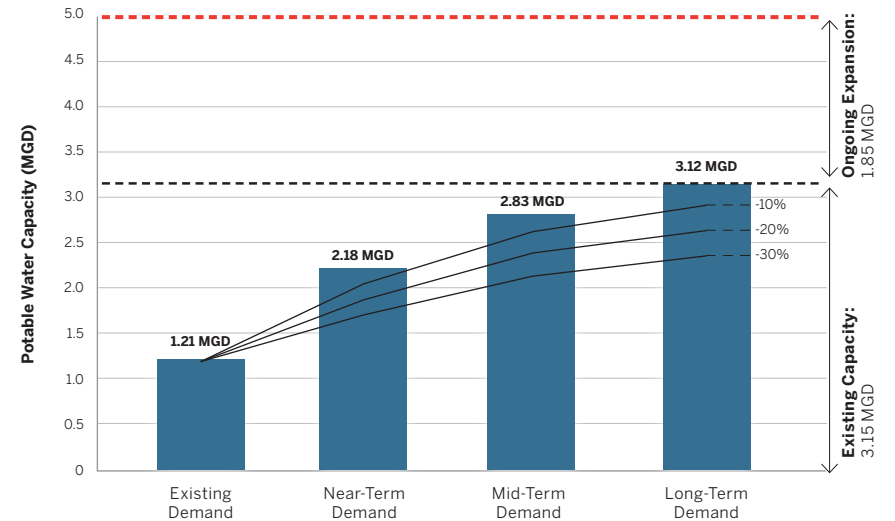
# Potable Water Service

## Load Projections + Assumptions

		Potable Water (Gallons-Per-Day)			
		Present	Near Term	Mid Term	Long Term
Business As Usual Approach	Demand	1,210,000	2,180,000	2,830,000	3,120,000
	Required Supply	(1,940,000)	(2,770,000)	(2,120,000)	(1,830,000)
10% Conservation	Demand		2,020,000	2,610,000	2,890,000
	Required Supply		(2,930,000)	(2,340,000)	(2,060,000)
20% Conservation	Demand		1,860,000	2,380,000	2,640,000
	Required Supply		(3,090,000)	(2,570,000)	(2,310,000)
30% Conservation	Demand		1,690,000	2,150,000	2,340,000
	Required Supply		(3,260,000)	(2,800,000)	(2,610,000)

Assumptions: (GPD/SF)	New Buildings	Demolition	Renovation
Academic / Teaching	0.083	0.108	-0.025
Administration	0.083	0.108	-0.025
Arts / Culture	0.054	0.070	-0.016
Athletics + Recreation	0.136	0.177	-0.041
Misc	0.000	0.000	0.000
Parking	0.000	0.000	0.000
Residence / Dining	0.110	0.143	-0.033
Science	0.137	0.178	-0.041
Student Services	0.083	0.108	-0.025
Support / Utility	0.000	0.000	0.000

## Impact on Utility Systems



Even with considerable development in the long-term, projected demand is considerably below the proposed total supply of 4.95 MGD, which will be in place after the pipe supply connection through Connecticut Water Company is completed in 2016. This does not mean, however, that the University should not continue to pursue water conservation measures to serve its broader sustainability mission. Measures to increase water efficiency by as much as 30% are attainable in the long term; strategies to achieve these types of load reductions are outlined in the Sustainability Framework Plan.

- \*Renovated buildings are assumed to be approximately 30% more efficient following the renovation. Indicated value is relative energy savings.
- \*\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.



### Near-Term Campus Plan (0-5 Years)

Within the next 5 years, expansion on campus will include growth focused on science and research, residence halls, and student health and recreation. On-going work at the Tech Park on North Campus will continue as well. In addition to new construction, major renovations to aging buildings like Gant will occur and some buildings deemed past useful life will be removed.

#### Projected Near-Term Demand:

Main Campus Near-Term Increase = 0.12 MGD <sup>1</sup>

Mansfield Near-Term Increase = 0.35 MGD <sup>2</sup>

Storrs Center = 0.2 MGD <sup>2</sup>

North Campus + Tech Park = 0.3 MGD <sup>3</sup>

Projected Demand Increase = 0.97 MGD <sup>4</sup>

Existing Demand = 1.21 MGD <sup>5</sup>

Total Projected Demand = 2.18 MGD

- With 10% Conservation = 2.02 MGD

- With 20% Conservation = 1.86 MGD

- With 30% Conservation = 1.69 MGD

Currently there is enough projected safe yield supply from the existing wellfields to meet this increase in demand; however, there is limited excess capacity and upgrades to the distribution system are critical to this near-term plan. In order to adequately provide potable water, including both supply and pressure, based on the planned campus development, the following goals and proposed improvements should be considered:

#### Goals:

- Provide additional water supply to campus for near-term and additional growth within UConn's Depot Campus and Tech Park, Storrs Center, and the Town of Mansfield.
- Provide increased flow and pressure distribution to

the near-term development areas, particularly the South Campus.

- Evaluate existing water system and wellfield infrastructure for critical repair and replacement needs.
- Continue to implement water reduction strategies across campus.

#### Improvements:

- Continue on-going replacement of the main water supply line from the Willimantic wellfield to a point on Hunting Lodge Road, the first phase in the replacement of the entire Willimantic wellfield transmission line.
- Supplement the water supply from the two existing wellfields. To complete this, UConn and the Connecticut Water Company (CWC) have reached an agreement that the CWC will provide 1.85 MGD from its reservoir to UConn for water supply to the campus and town users. Work is anticipated to begin on the CWC water main extension in the spring of 2015 (pending approval of the project and associated permitting) and should be completed within two years. With the connection of the CWC water main to the UConn system, the projected supply to UConn will increase from 3.1 MGD permitted (including Willimantic and Fenton River Wellfields) to 4.95 MGD. Having this infrastructure in place in the next five years will insure mid- and long-term proposed development will not be impacted by a lack of water supply.
- Install a new looped water service system, or replace existing mains, where required for near-term development within the main campus core and in conjunction with utility tunnel, roadway, and landscape construction. It is presumed that new water mains will be installed within new utility tunnels.

- Evaluate existing infrastructure. A detailed system-wide conditions assessment and flow/pressure distribution modeling study should be performed during this phase to determine specific main replacement, storage, and pumping needs throughout the campus and an approximate schedule for these upgrades based on existing pipe conditions and areas of proposed development.
- Assess the impacts of potential improvements at the existing wellfields.
  - It may be possible for additional supply to be made available through the relocation of Well #2 at the Willimantic River wellfield to increase the volume of withdrawal. Additional study is required to confirm.
  - Expand emergency power to all wells and treatment facilities.
  - It may be possible that the replacement of the pump station and 50,000 gallon clear well basin at the Fenton River wellfield with a 250,000 gallon basin could provide a more energy efficient system. Additional study is required to confirm.
  - Implement improvements to system inventory/data management systems, metering, storage facilities, valving, and security.

### Mid-Term Campus Plan (6-10 Years)

From years 2020-2025, the expansion of the campus is expected to include new research and classroom buildings, residence halls, student activity spaces, and parking garage upgrades. In addition to new construction, major renovations to aging buildings will continue to take place and more buildings deemed past useful life will be removed.

# Potable Water Service

## Projected Mid-Term Demand:

Main Campus Mid-Term Increase = 0.05 MGD <sup>6</sup>  
Depot Campus = 0.3 MGD <sup>7</sup>  
North Campus + Tech Park = 0.3 MGD <sup>8</sup>  
Projected Demand Increase = 0.65 MGD <sup>9</sup>  
+ Near-Term Demand = 2.18 MGD  
Total Projected Demand = 2.83 MGD  
- With 10% Conservation = 2.61 MGD  
- With 20% Conservation = 2.38 MGD  
- With 30% Conservation = 2.15 MGD

If not installed in the near-term phase, upgrades to the distribution system will be required in this phase. Should the CWC connection not occur, UConn will need to evaluate other options to provide adequate supply or further conservation measures, including expanded reclaimed water supply. In order to adequately provide potable water, including both supply and pressure, based on the planned campus development, the following goals and proposed improvements should be considered:

### Goals:

- Continue implementation of near-term campus plan goals.
- Provide increased flow and pressure distribution based on mid-term development plans.
- Continue to implement water reduction strategies across campus.

### Improvements:

- Install a new looped water service system, or replace existing mains, where required for mid-term development within the main campus core and in conjunction with utility tunnel, roadway, and landscape construction. It is presumed that new water mains will be installed within new utility tunnels.

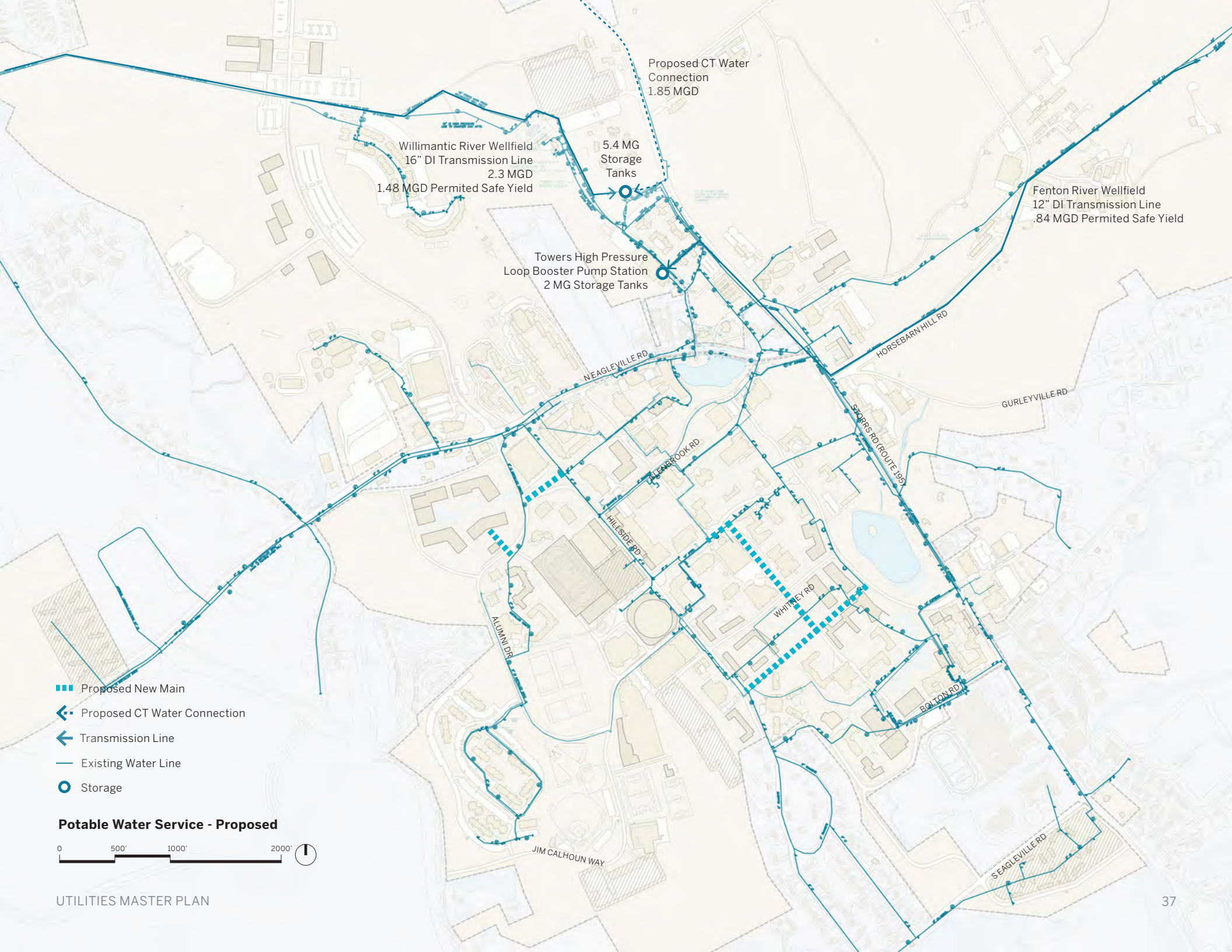
## Long-Term Campus Plan (11-20 Years)

The long-term, 11-20 year plan could include the construction of additional academic, residential, fine arts, and other facilities. It is anticipated that during this phase the Tech Park at North Campus will be complete as well. Major renovations to aging buildings will focus on modernization and increases in efficiency.

## Projected Long-Term Demand:

Main Campus Long-Term Increase = 0.13 MGD <sup>10</sup>  
Mansfield's Long-Term (2040) = 0.16 MGD <sup>11</sup>  
Projected Demand Increase = 0.29 MGD <sup>12</sup>  
+ Mid-Term Demand = 2.83 MGD  
Total Projected Demand = 3.12 MGD  
- With 10% Conservation = 2.89 MGD  
- With 20% Conservation = 2.64 MGD  
- With 30% Conservation = 2.34 MGD

The existing wellfields would no longer meet the increased demand from on-campus as well as off-campus uses in the long term, and an additional water supply source would be required. The CWC connection is anticipated to be installed in the near term to eliminate this concern, but should the connection not occur, UConn will need to evaluate other options to provide adequate supply or further conservation measures including expanded reclaimed water supply.



- Proposed New Main
- Proposed CT Water Connection
- Transmission Line
- Existing Water Line
- Storage

### Potable Water Service - Proposed





# Wastewater / Sanitary Service

## Existing Conditions

The University owns and operates a collection and treatment system for wastewater that is generated both on and off campus. Due to the transient nature of the student population, flows are reduced dramatically during the summer months. The following flow and treatment plant data was provided in the Water and Wastewater Master Plan, dated June 2007:

### Average Daily Flow

Design – 3.0 MGD (following upgrades in 1995)  
Current – 1.21 MGD (41% of capacity)

### Peak Flow

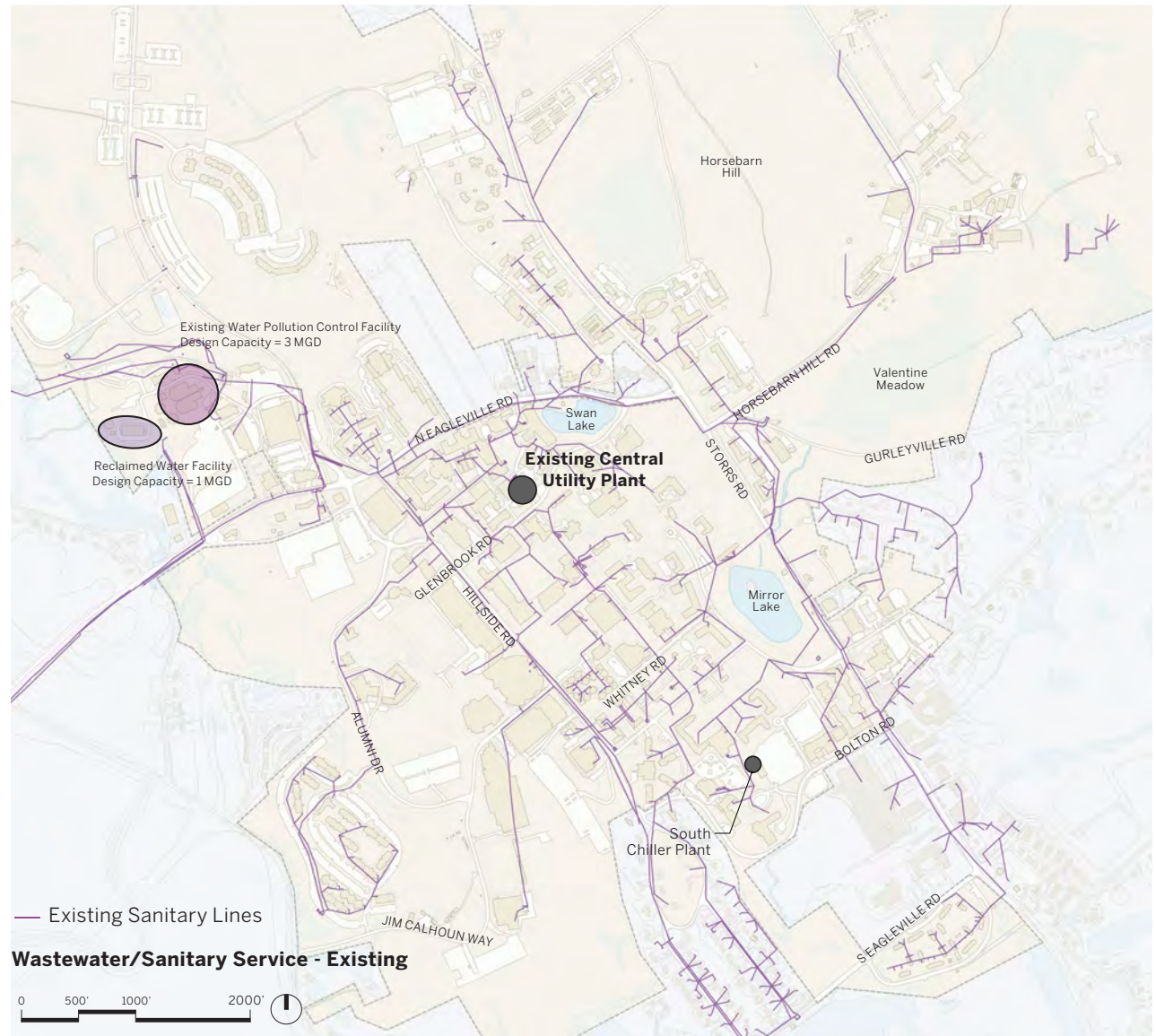
Design – 7.2 MGD  
Current – 6.5 MGD (90% of capacity)

### Collection

The campus wastewater collection system is a combination of gravity and pumped sewers that are collected and treated at UConn's Water Pollution Control Facility (WPCF). Sanitary sewer collection occurs through two separate systems, one at the Main Campus and one at the Depot Campus. Non-campus users such as local residences, businesses, schools, and other town property tie into the UConn system as well. In general, the collection system is quite dated, with pipes from the 1940s or earlier. The following provides a general overview of each system:

### Main Campus

- System age ranges from 1940 to present and is predominantly clay pipe and brick manholes
- The system includes areas of combined storm and sanitary sewers
- The WPCF was designed assuming a daily flow of 2.0 MGD from the Main Campus



### Depot Campus

- The majority of the system was installed from the 1900s to the 1920s
- The system includes areas of combined storm and sanitary sewers
- There are significant inflow and infiltration issues on this campus
- A forcemain was constructed in 2001 to pump the effluent to the Water Pollution Control Facility (WPCF) on the Main Campus
- The WPCF was designed assuming a daily flow of 0.3 MGD from the Depot Campus which is currently providing about 80% of that allotted flow

For a detailed assessment of the existing wastewater collection system, see the *Infiltration/Inflow Study – Sanitary FINAL Report*, prepared by URS in May 2011.

### Water Pollution Control Facility

The WPCF serves the Main Campus and the Depot Campus as well as non-university owned properties immediately surrounding the campus. Operation of the WPCF in compliance with the required permits has been reported to be difficult given the transient nature of the student population, which provides the majority of the sewer effluent. The useful life of the equipment utilized in the WPCF is expected to be about 20 years, which means that much of the plant will need to be renovated, replaced, or expanded within the next few years. In 2013, Woodard & Curran prepared a Vulnerability Assessment for the WPCF. The assessment identified a number of deficiencies which should be fixed immediately, including the headworks, carrousel basins, pump stations, emergency backup, and process equipment. UConn has begun to implement a number of these critical repairs.

<b>Assumptions: (GPD/SF)</b>	<b>New Buildings</b>	<b>Demolition</b>	<b>Renovation</b>
Academic / Teaching	0.075	0.098	-0.023
Administration	0.075	0.098	-0.023
Arts / Culture	0.049	0.064	-0.014
Athletics + Recreation	0.123	0.160	-0.037
Misc	0.002	0.003	-0.001
Parking	0.000	0.000	0.000
Residence / Dining	0.098	0.127	-0.029
Science	0.126	0.164	-0.038
Student Services	0.075	0.098	-0.023
Support / Utility	0.002	0.003	-0.001

### Load Projections + Assumptions

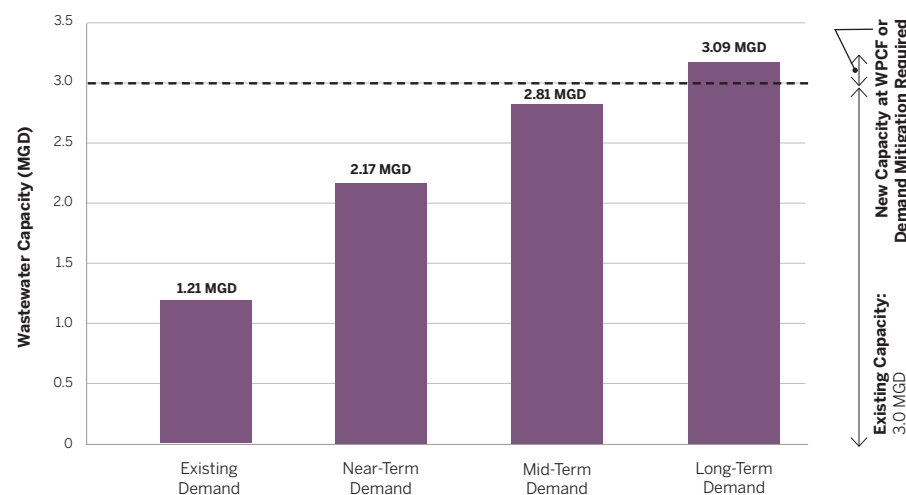
	Sanitary Water (Gallons-Per-Day)			
	<b>Present</b>	<b>Near Term</b>	<b>Mid Term</b>	<b>Long Term</b>
Average Flow	1,210,000	2,170,000	2,810,000	3,090,000
Required Capacity	(1,790,000)	(830,000)	(190,000)	90,000

\*Renovated buildings are assumed to be approximately 30% more efficient after renovation. Indicated value is relative energy savings.

\*\* Load projections based on new, removed, and renovated space by phase and use type, as outlined in the Campus Master Plan and the Load Calculations at the end of this report.

### Impact on Utility Systems

The ability of the WPCF to manage the increase in flow will be dependent on which repairs are completed in the near-term phase and whether improvements to other sanitary infrastructure add capacity. Barring this, however, the capacity of the WPCF will be exceeded in the long-term – assuming business as usual – which will require upgrades or replacement of the facility. However, demand mitigation and reduction in overall potable water usage should be encouraged to keep waste water below the 3.0 MGD capacity of the WPCF, if at all possible.





# Wastewater / Sanitary Service

## Near-Term Campus Plan (0-5 Years)

Projected Average Flow <sup>13</sup>:

Main Campus Near-Term Increase = 0.11 MGD <sup>14</sup>

Mansfield Near-Term Increase = 0.35 MGD <sup>15</sup>

Storrs Center = 0.2 MGD <sup>15</sup>

North Campus + Tech Park = 0.3 MGD <sup>16</sup>

Projected Average Flow Increase = 0.96 MGD <sup>17</sup>

Existing Average Flow = 1.21 MGD <sup>18</sup>

Total Projected Average Flow = 2.17 MGD

Based on current plans to repair various components of the WPCF, it is anticipated that within this timeframe the WPCF will be able to handle the increase in flow; however, upgrades to the collection system are recommended in the near-term plan based on planned campus development. The following goals and proposed improvements should be considered:

### Goals:

- Provide adequate sanitary sewer service campus-wide.
- Implement previously recommended repairs and improvements to reduce infiltration/inflows into the existing system.

### Improvements:

- Complete repairs to critical items identified in the previously discussed WPCF Vulnerability Assessment; this is an on-going construction project.
- Complete on-going sewer construction in Storrs Road including replacing the sewer line, repairing 16 manholes, rebuilding and upsizing the Gurleyville Sewage pump station, and replacing the Horsebarn Hill pump stations.
- Install new sanitary mains, or replace existing mains, where required for near-term development. Any new piping and pumps installed should be sized to accommodate the future development for each phase of the Master Plan throughout campus.
- Evaluate existing infrastructure. Existing infrastructure can be reused when it is sized appropriately and is not in conflict with proposed near- or long-term projects. Additional study should be performed to determine

specific main replacement and pumping needs throughout the campus and an approximate schedule for these upgrades based on condition of pipe and proposed development.

- Implement the repairs identified in the Infiltration/Inflow (I/I) Study completed by URS in 2011 to offset the increase in flows from the Master Plan development. The study included detailed inspections of the existing sanitary infrastructure on the Main Campus, identified significant deficiencies, and recommended repairs to the existing system including re-lining, manhole rim, and sewer main replacements. These repairs were anticipated to reduce the average daily flow by 0.94 MGD.
- Conduct a conditions assessment and infiltration/inflow study at the Depot Campus. Separate sanitary and stormwater flows and implement I/I and piping repairs. Although outside the limits of the URS 2011 study, Depot is reported to have had the majority of the system installed in the 1900s to 1920s with combined sanitary and stormwater systems and significant I/I issues.

## Mid-Term Campus Plan (6-10 years)

Projected Average Flow <sup>19</sup>:

Main Campus Mid-Term Increase = 0.04 MGD <sup>20</sup>

Depot Campus = 0.3 MGD <sup>21</sup>

North Campus + Tech Park = 0.3 MGD <sup>22</sup>

Projected Average Flow Increase = 0.64 MGD <sup>23</sup>

± Near-Term Average Flow = 2.17 MGD

Total Projected Average Flow = 2.81 MGD

At this phase of the Master Plan, UConn will need to assess the operation of the WPCF and determine the required improvements to accommodate the increase in flow. The ability of the WPCF to manage the increase in flow will be dependent on which repairs were completed in the near-term phase and whether improvements to other sanitary infrastructure, including addressing the combined sewers and infiltration/inflow issues at the Depot Campus, have occurred. Regardless, upgrades to the collection system will continue as part of the mid-term plan.

### Goals:

- Assess alternate wastewater treatment methods to decrease demand at WPCF.
- Evaluate condition and capability of existing WPCF.

### Improvements:

- Continue to install new sanitary mains, or replace existing mains, where required for mid-term development within the main campus.
- Replace existing infrastructure as required based on near-term evaluation and confirmed mid- and long-term needs.
- Evaluate results of near-term improvements to the WPCF to determine what will be required to accommodate the increase in flow in both the mid-term and long-term development plans.
- Implement required improvements at Depot Campus identified during the near-term phase.

## Long-Term Campus Plan (11-20 years)

Projected Average Flow <sup>24</sup>:

Main Campus Long-Term Increase = 0.12 MGD <sup>25</sup>

Mansfield Long-Term (2040) = 0.16 MGD <sup>26</sup>

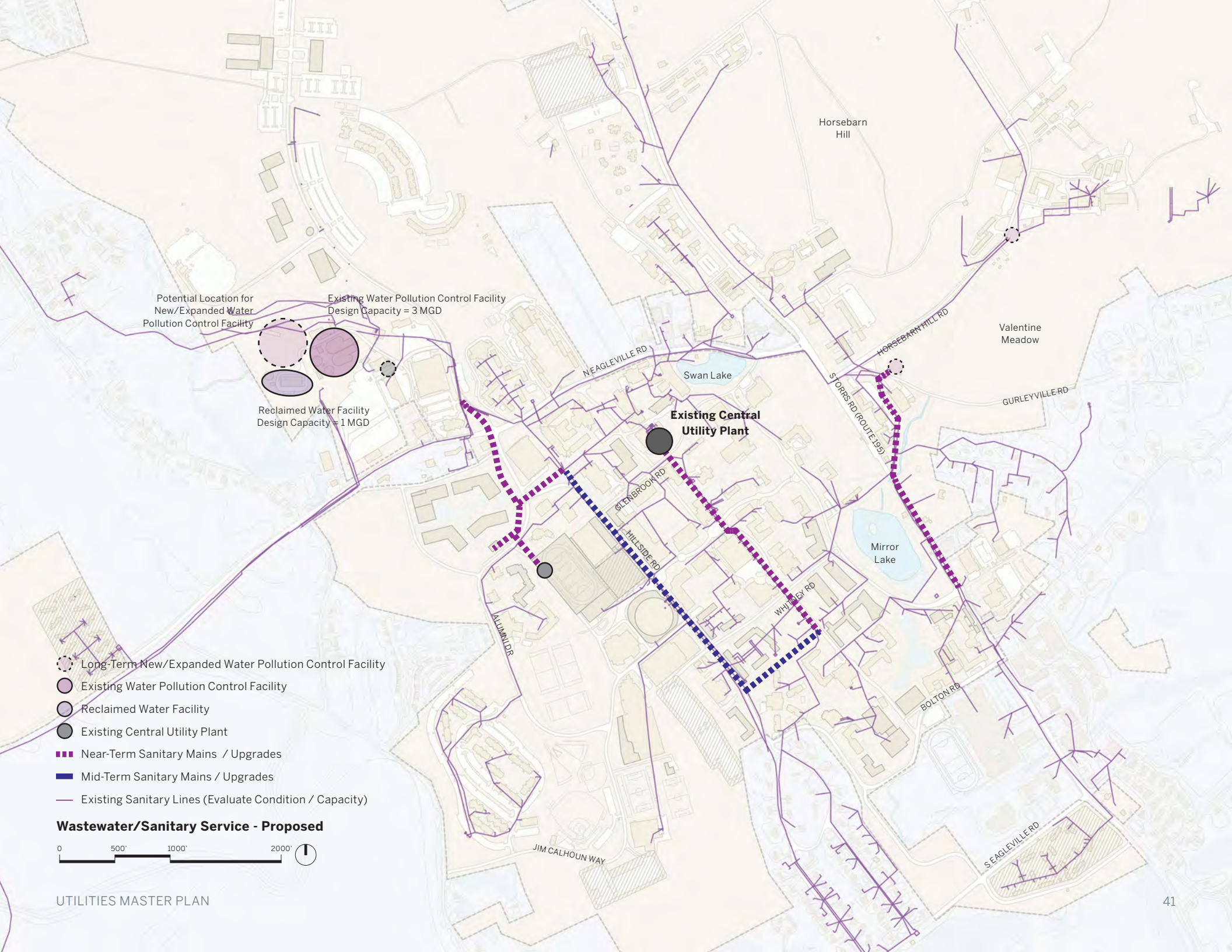
Projected Average Flow Increase = 0.28 MGD <sup>27</sup>

± Mid-Term Average Flow = 2.81 MGD

Total Projected Average Flow = 3.09 MGD

The treatment plant could be at capacity or exceeded during this term. If UConn does not implement further water conservation, sewer separation, or infiltration/inflow control measures, the existing plant will either need to be expanded or replaced to accommodate long-term build out of the campus and population both on and off-campus. Should the existing plant need to be replaced or expanded, the existing location offers the following advantages:

- Potential reuse of existing gravity piping and pump station infrastructure
- Adjacency to the newly constructed reclaimed water facility
- This location is not a high priority for future development due to the limitations of the adjacent capped landfills



Potential Location for  
New/Expanded Water  
Pollution Control Facility

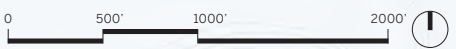
Existing Water Pollution Control Facility  
Design Capacity = 3 MGD

Reclaimed Water Facility  
Design Capacity = 1 MGD

Existing Central  
Utility Plant

- Long-Term New/Expanded Water Pollution Control Facility
- Existing Water Pollution Control Facility
- Reclaimed Water Facility
- Existing Central Utility Plant
- Near-Term Sanitary Mains / Upgrades
- Mid-Term Sanitary Mains / Upgrades
- Existing Sanitary Lines (Evaluate Condition / Capacity)

**Wastewater/Sanitary Service - Proposed**





# Fire Protection Service

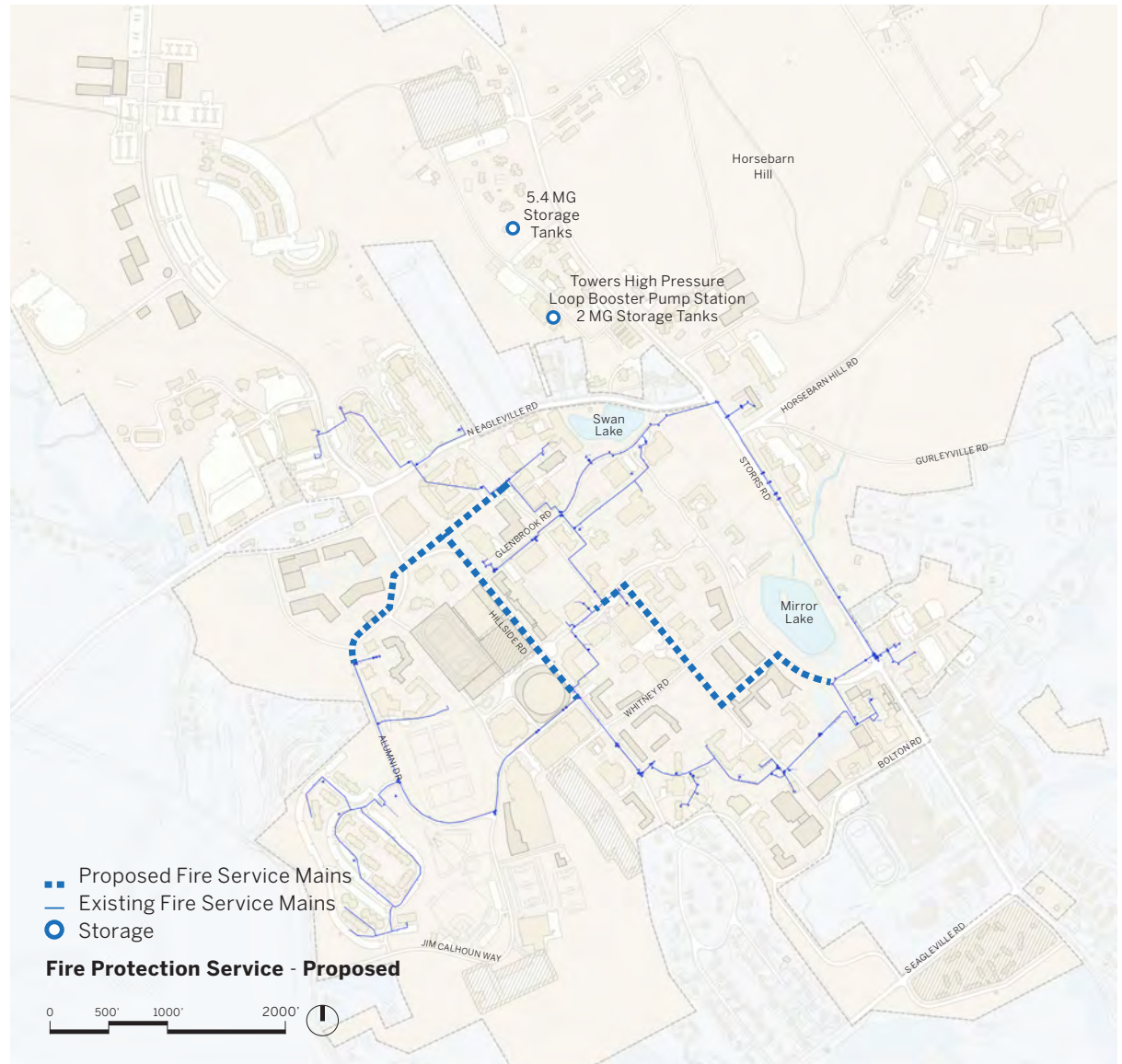
The two wellfields operated by UConn also supply the fire protection system at the Storrs Campus. While the central campus area has a dedicated fire protection loop, much of the fire protection system at the Main Campus is combined with the domestic water distribution system. Booster pumps are located around campus, including at the CUP and South Chiller Plant, and provide additional pressure to the fire protection system than what is provided from the 5.4 MG reservoir and the 1.0 MG storage standpipes located in the northeastern section of campus. The northern part of the Main Campus, including the Charter Oak apartments, is served by the Towers High Pressure Loop Pumping Station. The majority of the existing campus is supplied fire service from combined domestic and fire mains. Dedicated fire protection service is provided from a 1,250 gpm pump located at the Central Utility Plant (CUP). This provides fire protection service through a 12-inch pipe distribution main throughout limited portions of the campus along with associated pumps.

## Goals:

- Provide dedicated fire protection loops.
- Provide increased flow and pressure distribution to major development areas, particularly the South Campus.

## Improvements:

- Install a new looped water service system, or replace existing mains, where required for near-term development within the Main Campus and in conjunction with utility tunnel, roadway, and landscape construction. It is presumed that new water mains will be installed within new utility tunnels.
- Evaluate existing infrastructure. A detailed system-wide conditions assessment and flow/pressure distribution modeling study should be performed to determine specific main replacement, storage, and pumping needs throughout the campus and an approximate schedule for these upgrades based on existing pipe conditions and areas of proposed development.





## References

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- An Inventory of Existing, Scheduled, and/or Planned Implementation Actions in Support of the Eagleville Brook TMDL, October 22, 2009, Thames River Basin Partnership Coordinator
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- Responding to an Impervious Cover-Based TMDL, CLEAR/NEMO, 2011
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- 2004 Stormwater Quality Manual, The Connecticut Department of Environmental Protection
- The Runoff Reduction Method, Universities Council on Water Resources, Journal of Contemporary Water Research and Education, Issue 146, Pages 11-21, December 2010, Center for Watershed Protection, Joseph Battiatia, Kelly Collins, David Hirschman, Greg Hoffman
- UConn Infiltration/Inflow Study - Storm, Final Report, August 22, 2011, URS

## Footnotes

1. See Load Calculations
2. Based upon Water and Wastewater Master Plan, dated June 2007. Projected flows include the Knollwood Apartments (already included in the sanitary sewer service area in 2006; however, not included in the provided flow data), the North Eagleville Road/King Hill Road intersection and areas identified in the Mansfield Water Supply Plan and the Mansfield Plan of Conservation and Development.
3. Based upon the 2012 North Campus Master Plan. Assume 50% completion.
4. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.
5. Based upon Water and Wastewater Master Plan, dated June 2007.
6. See Load Calculations
7. Based upon Water and Wastewater Master Plan, dated June 2007. Projected flows include the Knollwood Apartments (already included in the sanitary sewer service area in 2006; however, not included in the provided flow data), the North Eagleville Road/King Hill Road intersection and areas identified in the Mansfield Water Supply Plan and the Mansfield Plan of Conservation and Development.
8. Based upon the 2012 North Campus Master Plan. Assume 100% completion.
9. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.
10. See Load Calculations
11. Based upon "Infiltration/Inflow Study – Sanitary" prepared by URS, dated May 27, 2011
12. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.
13. There are a number of other unknown potential developments that would discharge to the WPCF including the Town of Mansfield, the Depot Campus, and advanced manufacturing within the Tech Park.
14. See Load Calculations
15. Based upon Water and Wastewater Master Plan, dated June 2007. Projected flows include the Knollwood Apartments (already included in the sanitary sewer service area in 2006; however, not included in the provided flow data), the North Eagleville Road/King Hill Road intersection and areas identified in the Mansfield Water Supply Plan and the Mansfield Plan of Conservation and Development.
16. Based upon the 2012 North Campus Master Plan. Assume 50% completion.
17. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.
18. Based upon Water and Wastewater Master Plan, dated June 2007.
19. There are a number of other unknown potential developments that would discharge to the WPCF including the Town of Mansfield, the Depot Campus, and advanced manufacturing within the Tech Park.
20. See Load Calculations
21. Based upon Water and Wastewater Master Plan, dated June 2007. Projected flows include the Knollwood Apartments (already included in the sanitary sewer service area in 2006; however, not included in the provided flow data), the North Eagleville Road/King Hill Road intersection and areas identified in the Mansfield Water Supply Plan and the Mansfield Plan of Conservation and Development.
22. Based upon the 2012 North Campus Master Plan. Assume 100% completion.
23. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.
24. There are a number of other unknown potential developments that would discharge to the WPCF including the Town of Mansfield, the Depot Campus, and advanced manufacturing within the Tech Park.
25. See Load Calculations
26. Based upon "Infiltration/Inflow Study – Sanitary" prepared by URS, dated May 27, 2011
27. Note that this flow does not include significant development within the Depot Campus or the Town of Mansfield.



# Waste

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## Organic Waste

UConn generates significant volumes of organic waste from food service, landscaping, and agricultural programs. It currently manages this waste through composting and some commercial sales. As UConn aspires to amplify its sustainable food and working landscape programs, this organic waste stream will serve as a valuable source of compost and fertilizer. Food services will need to keep exploring best methods for minimizing food waste and diverting it to appropriately scaled composting facilities. Landscaping and agricultural waste is a potential source of biomass for alternative energy plants. Organic waste management strategies will need to be evaluated for their carbon impacts as part of the overall ambition to achieve carbon neutrality by 2050.



UConn Compost Facility



Dining Services Produces Significant Organic Waste at Eight Separate Dining Halls

# Recycling

UConn is one of the largest material consumers in the region and has one of the best developed recycling programs. It can leverage this position and utilize lifecycle assessments to drive its purchasing policies, vendor relations, and recycling programs toward net zero waste. By consolidating its myriad recycling programs and examining the total throughput of material acquisition, usage, and disposition, UConn would discover opportunities to save measurable tonnage and associated carbon. The campus infrastructure exists for single stream recycling, but coordinated interdepartmental efforts could further shrink the waste volume through strategies such as bottled water elimination or equipment salvage programs. This

dedication can be extended to vendor requirements to reduce packaging, reclaim packing materials, and recommend environmentally-preferable alternatives.

As the campus grows, the demolition of decommissioned buildings as well as the construction of new buildings will create further opportunities for material reduction, salvaging, reuse, and recycling. At a regional scale, UConn can seek business partnerships to ensure responsible reclamation and disposition of construction materials. In support of its carbon neutral goals, UConn can also consider methodologies to account for embodied carbon savings related to its progressive material conservation and recycling programs.



Recycling Collected at “Green Game Day” at Gampel



New E-Waste Recycling Bins



Student Employees preparing a copier for recycling





# Load Calculations

## Development Summary

The future loads for electricity, high-pressure steam, chilled water, potable water, and waste water/sanitary represented in this report were projected using the following development totals, which correspond to the overall Campus Master Plan. The plan outlines growth in three primary phases – 5 years (near term), 10 years (mid term), and 20 years (long term) – in order to understand the impact that growth will have on utility systems.

These order-of-magnitude numbers should be understood as representing the capacity for growth at the Storrs Campus; only a portion of this growth – associated with *Next Generation Connecticut* or other University programs – is currently funded at this time. The numbers should ultimately be revisited as each new project is developed to understand the true impact on utility systems.

	Use Type	Near Term GSF	Mid Term GSF	Long Term GSF	Total GSF
NEW CONSTRUCTION BY USE	Academic / Teaching	0	0	510,000	510,000
	Administration	0	0	0	0
	Arts / Culture	34,000	0	122,000	156,000
	Athletics + Recreation	230,000	185,000	151,000	566,000
	Misc	0	0	120,000	120,000
	Parking	140,000	710,000	0	850,000
	Residence / Dining	420,000	583,000	645,000	1,648,000
	Science	427,000	160,000	824,000	1,411,000
	Student Services	60,000	115,000	0	175,000
	Support / Utility	15,000	90,000	0	105,000
		<b>1,326,000</b>	<b>1,843,000</b>	<b>2,372,000</b>	<b>5,541,000</b>
DEMOLITION BY USE	Academic	0	0	(201,000)	(201,000)
	Administration	0	0	0	0
	Arts / Culture	0	0	0	0
	Athletics + Rec	(72,000)	0	(45,000)	(117,000)
	Misc	(22,000)	0	(20,000)	(42,000)
	Parking	0	0	0	0
	Residence	0	(227,000)	(113,000)	(340,000)
	Science	0	(163,000)	(141,000)	(304,000)
	Student Services	0	(28,000)	0	(28,000)
	Support	0	0	0	0
		<b>(94,000)</b>	<b>(418,000)</b>	<b>(520,000)</b>	<b>(1,032,000)</b>
RENOVATION BY USE	Academic	68,000	388,000	374,000	830,000
	Administration	0	27,000	119,000	146,000
	Arts / Culture	0	0	141,000	141,000
	Athletics + Rec	0	0	0	0
	Misc	0	9,000	0	9,000
	Parking	0	0	0	0
	Residence	41,000	0	1,081,000	1,122,000
	Science	270,000	0	0	270,000
	Student Services	0	10,000	0	10,000
	Support	5,000	0	0	5,000
		<b>384,000</b>	<b>645,400</b>	<b>1,715,000</b>	<b>2,533,000</b>
	<b>Net New Space (GSF)</b>	<b>1,232,000</b>	<b>1,425,000</b>	<b>1,852,000</b>	<b>4,509,000</b>

## Load Calculations



Chilled Water (tons)

	Use Type	SF/TON	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	200	0	0	2,550	2,550
	Administration	200	0	0	0	0
	Arts / Culture	225	151	0	542	693
	Athletics + Rec	375	613	493	403	1,509
	Misc	400	0	0	300	300
	Parking	0	0	0	0	0
	Residence	200	2,100	2,915	3,225	8,240
	Science	175	2,440	914	4,709	8,063
	Student Services	200	300	575	0	875
	Support	400	38	225	0	263
			<b>5,642</b>	<b>5,123</b>	<b>11,728</b>	<b>22,493</b>
DEMOLITION	Academic	154	0	0	(1,307)	(1,307)
	Administration	154	0	0	0	0
	Arts / Culture	173	0	0	0	0
	Athletics + Rec	288	(250)	0	(156)	(406)
	Misc	308	(72)	0	(65)	(137)
	Parking	0	0	0	0	0
	Residence	154	0	(1,476)	(735)	(2,210)
	Science	135	0	(1,211)	(1,047)	(2,258)
	Student Services	154	0	(182)	0	(182)
	Support	308	0	0	0	0
			<b>(321)</b>	<b>(2,868)</b>	<b>(3,309)</b>	<b>(6,499)</b>
RENOVATION	Academic	-667	(102)	(582)	(561)	(1,245)
	Administration	-667	0	(41)	(179)	(219)
	Arts / Culture	-750	0	0	(188)	(188)
	Athletics + Rec	-1,250	0	0	0	0
	Misc	-1,333	0	(7)	0	(7)
	Parking	0	0	0	0	0
	Residence	-667	(62)	0	(1,622)	(1,683)
	Science	-583	(463)	0	0	(463)
	Student Services	-667	0	(15)	0	(15)
	Support	-1,333	(4)	0	0	(4)
			<b>(630)</b>	<b>(644)</b>	<b>(2,549)</b>	<b>(3,823)</b>
<b>Net Added Load (Tons)</b>			<b>4,691</b>	<b>1,610</b>	<b>5,870</b>	<b>12,171</b>



Steam (lbs/hr)

	Use Type	BTU/SF	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	40	0	0	21,250	21,250
	Administration	40	0	0	0	0
	Arts / Culture	40	1,417	0	5,083	6,500
	Athletics + Rec	50	11,979	9,635	7,865	29,479
	Misc	37	0	0	4,625	4,625
	Parking	0	0	0	0	0
	Residence	60	26,250	36,438	40,313	103,000
	Science	42	18,681	7,000	36,050	61,731
	Student Services	45	2,813	5,391	0	8,203
	Support	37	578	3,469	0	4,047
			<b>61,718</b>	<b>61,932</b>	<b>115,185</b>	<b>238,835</b>
DEMOLITION	Academic	52	0	0	(10,888)	(10,888)
	Administration	52	0	0	0	0
	Arts / Culture	52	0	0	0	0
	Athletics + Rec	65	(4,875)	0	(3,047)	(7,922)
	Misc	48	(1,102)	0	(1,002)	(2,104)
	Parking	0	0	0	0	0
	Residence	78	0	(18,444)	(9,181)	(27,625)
	Science	55	0	(9,271)	(8,019)	(17,290)
	Student Services	59	0	(1,706)	0	(1,706)
	Support	48	0	0	0	0
			<b>(5,977)</b>	<b>(29,421)</b>	<b>(32,137)</b>	<b>(67,535)</b>
RENOVATION	Academic	-12	(850)	(4,850)	(4,675)	(10,375)
	Administration	-12	0	(338)	(1,488)	(1,825)
	Arts / Culture	-12	0	0	(1,763)	(1,763)
	Athletics + Rec	-15	0	0	0	0
	Misc	-11	0	(104)	0	(104)
	Parking	0	0	0	0	0
	Residence	-18	(769)	0	(20,269)	(21,038)
	Science	-13	(3,544)	0	0	(3,544)
	Student Services	-14	0	(141)	0	(141)
	Support	-11	(58)	0	0	(58)
			<b>(5,220)</b>	<b>(5,432)</b>	<b>(28,194)</b>	<b>(38,846)</b>
<b>Net Added Load (lbs/hr)</b>			<b>50,520</b>	<b>27,079</b>	<b>54,855</b>	<b>132,454</b>



## Load Calculations



### Potable Water (GPD)

	Use Type	GPD/SF	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	0.083	0	0	42,330	42,330
	Administration	0.083	0	0	0	0
	Arts / Culture	0.054	1,836	0	6,588	8,424
	Athletics + Rec	0.136	31,280	25,160	20,536	76,976
	Misc	0.000	0	0	0	0
	Parking	0.000	0	0	0	0
	Residence	0.110	46,200	64,130	70,950	181,280
	Science	0.137	58,499	21,920	112,888	193,307
	Student Services	0.083	4,980	9,545	0	14,525
	Support	0.000	0	0	0	0
			<b>142,795</b>	<b>120,755</b>	<b>253,292</b>	<b>516,842</b>
DEMOLITION	Academic	0.108	0	0	(21,688)	(21,688)
	Administration	0.108	0	0	0	0
	Arts / Culture	0.070	0	0	0	0
	Athletics + Rec	0.177	(12,730)	0	(7,956)	(20,686)
	Misc	0.000	0	0	0	0
	Parking	0.000	0	0	0	0
	Residence	0.143	0	(32,461)	(16,159)	(48,620)
	Science	0.178	0	(29,030)	(25,112)	(54,142)
	Student Services	0.108	0	(3,021)	0	(3,021)
	Support	0.000	0	0	0	0
			<b>(12,730)</b>	<b>(64,513)</b>	<b>(70,915)</b>	<b>(148,157)</b>
RENOVATION	Academic	-0.025	(1,693)	(9,661)	(9,313)	(20,667)
	Administration	-0.025	0	(672)	(2,963)	(3,635)
	Arts / Culture	-0.016	0	0	(2,284)	(2,284)
	Athletics + Rec	-0.041	0	0	0	0
	Misc	0.000	0	0	0	0
	Parking	0.000	0	0	0	0
	Residence	-0.033	(1,353)	0	(35,673)	(37,026)
	Science	-0.041	(11,097)	0	0	(11,097)
	Student Services	-0.025	0	(249)	0	(249)
	Support	0.000	0	0	0	0
			<b>(14,143)</b>	<b>(10,583)</b>	<b>(50,233)</b>	<b>(74,959)</b>
Net Added Load (GPD)			<b>115,922</b>	<b>45,660</b>	<b>132,144</b>	<b>293,726</b>



### Wastewater (GPD)

	Use Type	GPD/SF	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	0.075	0	0	38,250	38,250
	Administration	0.075	0	0	0	0
	Arts / Culture	0.049	1,666	0	5,978	7,644
	Athletics + Rec	0.123	28,290	22,755	18,573	69,618
	Misc	0.002	0	0	240	240
	Parking	0.000	0	0	0	0
	Residence	0.098	41,160	57,134	63,210	161,504
	Science	0.126	53,802	20,160	103,824	177,786
	Student Services	0.075	4,500	8,625	0	13,125
	Support	0.002	30	180	0	210
			<b>129,448</b>	<b>108,854</b>	<b>230,075</b>	<b>468,377</b>
DEMOLITION	Academic	0.098	0	0	(19,598)	(19,598)
	Administration	0.098	0	0	0	0
	Arts / Culture	0.064	0	0	0	0
	Athletics + Rec	0.160	(11,513)	0	(7,196)	(18,708)
	Misc	0.003	(57)	0	(52)	(109)
	Parking	0.000	0	0	0	0
	Residence	0.127	0	(28,920)	(14,396)	(43,316)
	Science	0.164	0	(26,699)	(23,096)	(49,795)
	Student Services	0.098	0	(2,730)	0	(2,730)
	Support	0.003	0	0	0	0
			<b>(11,570)</b>	<b>(58,349)</b>	<b>(64,337)</b>	<b>(134,256)</b>
RENOVATION	Academic	-0.023	(1,530)	(8,730)	(8,415)	(18,675)
	Administration	-0.023	0	(608)	(2,678)	(3,285)
	Arts / Culture	-0.015	0	0	(2,073)	(2,073)
	Athletics + Rec	-0.037	0	0	0	0
	Misc	-0.001	0	(5)	0	(5)
	Parking	0.000	0	0	0	0
	Residence	-0.029	(1,205)	0	(31,781)	(32,987)
	Science	-0.038	(10,206)	0	0	(10,206)
	Student Services	-0.023	0	(225)	0	(225)
	Support	-0.001	(3)	0	0	(3)
			<b>(12,944)</b>	<b>(9,568)</b>	<b>(44,947)</b>	<b>(67,459)</b>
Net Added Load (GPD)			<b>104,934</b>	<b>40,937</b>	<b>120,791</b>	<b>266,662</b>

## Load Calculations



### Electricity (MW)

	Use Type	W/SF	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	6.5	0.00	0.00	3.32	3.32
	Administration	6.5	0.00	0.00	0.00	0.00
	Arts / Culture	6.5	0.22	0.00	0.79	1.01
	Athletics + Rec	6.5	1.50	1.20	0.98	3.68
	Misc	6.5	0.00	0.00	0.78	0.78
	Parking	1	0.14	0.71	0.00	0.85
	Residence	3.5	1.47	2.04	2.26	5.77
	Science	9	3.84	1.44	7.42	12.70
	Student Services	6.5	0.39	0.75	0.00	1.14
	Support	6.5	0.10	0.59	0.00	0.68
			<b>7.66</b>	<b>6.73</b>	<b>15.54</b>	<b>29.93</b>
DEMOLITION	Academic	8.45	0.00	0.00	(0.91)	(0.91)
	Administration	8.45	0.00	0.00	0.00	0.00
	Arts / Culture	8.45	0.00	0.00	0.00	0.00
	Athletics + Rec	8.45	(0.33)	0.00	(0.20)	(0.53)
	Misc	8.45	(0.10)	0.00	(0.09)	(0.19)
	Parking	1.3	0.00	0.00	0.00	0.00
	Residence	4.55	0.00	(0.30)	(0.15)	(0.44)
	Science	11.7	0.00	(1.38)	(1.19)	(2.57)
	Student Services	8.45	0.00	(0.13)	0.00	(0.13)
	Support	8.45	0.00	0.00	0.00	0.00
			<b>(0.43)</b>	<b>(1.80)</b>	<b>(2.55)</b>	<b>(4.78)</b>
RENOVATION	Academic	-1.95	(0.07)	(0.41)	(0.39)	(0.87)
	Administration	-1.95	0.00	(0.03)	(0.12)	(0.15)
	Arts / Culture	-1.95	0.00	0.00	(0.15)	(0.15)
	Athletics + Rec	-1.95	0.00	0.00	0.00	0.00
	Misc	-1.95	0.00	(0.01)	0.00	(0.01)
	Parking	-0.3	0.00	0.00	0.00	0.00
	Residence	-1.05	(0.01)	0.00	(0.32)	(0.34)
	Science	-2.7	(0.53)	0.00	0.00	(0.53)
	Student Services	-1.95	0.00	(0.01)	0.00	(0.01)
	Support	-1.95	(0.01)	0.00	0.00	(0.01)
			<b>(0.62)</b>	<b>(0.46)</b>	<b>(0.99)</b>	<b>(2.06)</b>
Net Added Load (MW)			<b>6.61</b>	<b>4.47</b>	<b>12.00</b>	<b>23.09</b>



### Emergency Power (MW)

	Use Type	W/SF	Near Term	Mid Term	Long Term	Total
NEW CONSTRUCTION	Academic	0.5	0.00	0.00	0.26	0.26
	Administration	0.5	0.00	0.00	0.00	0.00
	Arts / Culture	0.5	0.02	0.00	0.06	0.08
	Athletics + Rec	0.5	0.12	0.09	0.08	0.28
	Misc	0.5	0.00	0.00	0.06	0.06
	Parking	0.2	0.03	0.14	0.00	0.17
	Residence	0.5	0.21	0.29	0.32	0.82
	Science	4.5	1.92	0.72	3.71	6.35
	Student Services	0.5	0.03	0.06	0.00	0.09
	Support	0.5	0.01	0.05	0.00	0.05
			<b>2.33</b>	<b>1.35</b>	<b>4.48</b>	<b>8.16</b>
DEMOLITION	Academic	1.0	0.00	0.00	(0.20)	(0.20)
	Administration	1.0	0.00	0.00	0.00	0.00
	Arts / Culture	1.0	0.00	0.00	0.00	0.00
	Athletics + Rec	1.0	(0.07)	0.00	(0.05)	(0.12)
	Misc	1.0	(0.02)	0.00	(0.02)	(0.04)
	Parking	0.3	0.00	0.00	0.00	0.00
	Residence	1.0	0.00	(0.07)	(0.03)	(0.10)
	Science	6.0	0.00	(0.16)	(0.14)	(0.30)
	Student Services	1.0	0.00	(0.03)	0.00	(0.03)
	Support	1.0	0.00	0.00	0.00	0.00
			<b>(0.09)</b>	<b>(0.26)</b>	<b>(0.44)</b>	<b>(0.79)</b>
RENOVATION	Academic	-0.5	(0.03)	(0.19)	(0.19)	(0.42)
	Administration	-0.5	0.00	(0.01)	(0.06)	(0.07)
	Arts / Culture	-0.5	0.00	0.00	(0.07)	(0.07)
	Athletics + Rec	-0.5	0.00	0.00	0.00	0.00
	Misc	-0.5	0.00	0.00	0.00	0.00
	Parking	-0.1	0.00	0.00	0.00	0.00
	Residence	-0.5	0.00	0.00	(0.11)	(0.11)
	Science	-1.5	(0.14)	0.00	0.00	(0.14)
	Student Services	-0.5	0.00	(0.01)	0.00	(0.01)
	Support	-0.5	0.00	0.00	0.00	0.00
			<b>(0.18)</b>	<b>(0.22)</b>	<b>(0.43)</b>	<b>(0.82)</b>
Net Added Load (MW)			<b>2.06</b>	<b>0.87</b>	<b>3.62</b>	<b>6.55</b>





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