University of Houston
Energy Master Plan

Jacobs

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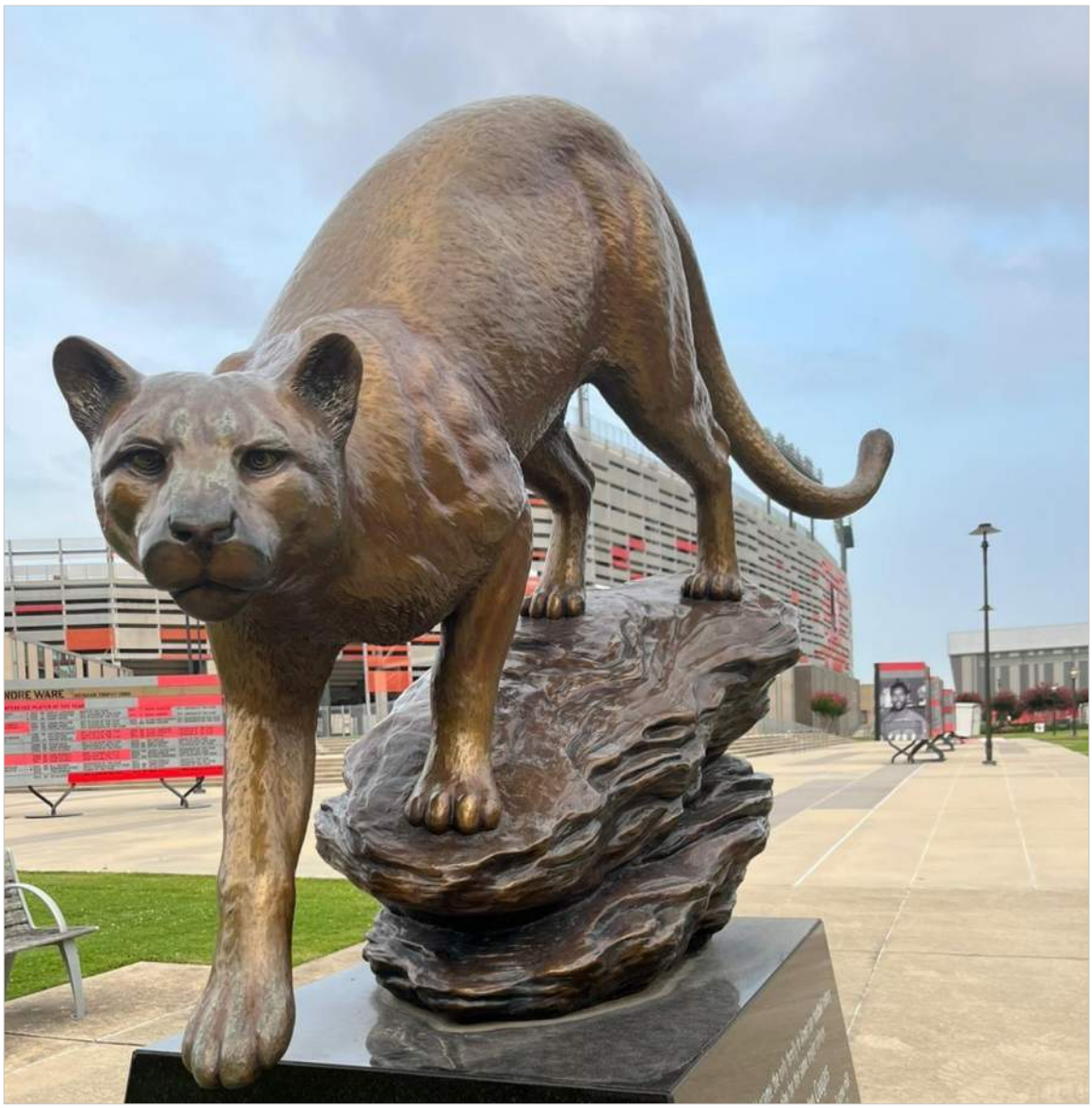
Revision 5



University of Houston Energy Master Plan

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Appendix A Existing Building Chilled Water Loads

Appendix B Existing Building Steam Loads

Appendix C Pumping Systems

Appendix D Proposed Meter List

Appendix E Chilled Water Piping Data

Appendix F Piping Model Outputs

Appendix G Equipment Selection Considerations

Appendix H Conceptual Drawings

Appendix I Cost Estimates

Appendix J Proposed Funding Schedule

^{o}C	degree(s) Celsius
^{o}F	degree(s) Fahrenheit
A	ampere(s)
AASHE	Advancement of Sustainability in Higher Education
AFT	Applied Flow Technologies
ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
ATMOS	ATMOS Research & Consulting
$Btuh/ft^2$	British thermal unit(s) per hour per square foot
Bus 1	busbars connected to Transformer 1
Bus 2	busbars connected to Transformer 2
CHP	combined heat and power
CO_2	carbon dioxide
COM	College of Medicine
COVID-19	coronavirus disease 2019
CPE	CenterPoint Energy
CUI	corrosion under insulation
CUP	Central Utility Plant
EMP	Energy Master Plan
EPA	U.S. Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ERP	Energy Research Park
FGI	Facility Guidelines Institute
gpm	gallon(s) per minute
GWP	global warming potential
HDPE	high-density polyethylene
HVAC	heating, ventilation, and air-conditioning
IAPMO	International Association for Plumbing and Mechanical Officials
IEEE	Institute of Electrical and Electronic Engineers
IT	information technology
kA	kiloampere(s)
kpph	kilopound(s) per hour
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)

LCCA	life cycle cost analysis
MMBtu	million British thermal units
MVA	megavolt-ampere(s)
MW	megawatt(s)
NBBI	National Board of Boiler and Pressure Vessel Inspectors
O&M	operations and maintenance
PRV	pressure-reducing valve
psi	pound(s) per square inch
psig	pound(s) per square inch, gauge
SCADA	supervisory control and data acquisition
Shah Smith	Shah Smith & Associates, Inc.
STARS	Sustainability Tracking Assessment and Rating System
UH	University of Houston
UMC	Uniform Mechanical Code
UP	Union Pacific Railroad
USGBC	U.S. Green Building Council

1. Executive Summary

1.1 Introduction

Since its founding in 1927, the University of Houston (UH) has become an integral part of the Houston community and is a Carnegie Tier One research university. It is driven by a mission of providing educational opportunities for students and a vision of building a top 50 public university as measured by graduation rate, affordability, social mobility and student-related institutional investment, among other measures.

The *University of Houston Campus Master Plan—Centennial Plan 2027* (UH 2019) sets forth plans to make UH a destination university where people study, work, live, and play. By 2040, UH anticipates campus building space to grow by approximately 3 million square feet. UH realizes campus utility systems will be an important part of campus expansion and commissioned Jacobs to create this Energy Master Plan (EMP). Its purpose is not only to support campus growth, but to also to increase the reliability, resiliency, efficiency and sustainability of the campus' electric power and thermal energy systems.

1.2 Objectives

This EMP's objective is to create a road map for enhancing UH's campus thermal and electrical infrastructure to meet the demands of the future campus growth. To accomplish these objectives, Jacobs has done the following:

- Identified key benchmarks and drivers for energy usage
- Defined current and future energy needs and requirements
- Provided recommendations to address existing deficiencies
- Identified feasible projects that increase capacity while promoting reliability, resiliency, energy conservation and sustainability

1.3 Campus Growth

UH is projected to grow at an annual rate of 2–3% for the foreseeable future. To accommodate this growth, the campus must add facilities for more students, which will increase the campus electric and thermal demands as described in Section 1.5 below.

1.4 Utility Reliability, Resiliency, and Redundancy

A continuous and reliable supply of electric and thermal energy to campus facilities is critical to carrying out UH's mission. Any prolonged loss of electric power or thermal utilities is not only an inconvenience to the students and faculty; such an event could also jeopardize critical research activities, place millions of square feet of facilities at risk of damage or create unsafe living conditions for campus residents.

UH's EMP must address resilience against hazards, including the impacts of climate change such as the increased duration, frequency and intensity of precipitation, extreme heat, and extreme cold. In February 2021, winter storm Uri highlighted the need for resilience against disruptions to public utilities that were once taken for granted. Winter storm Uri created demand conditions that Texas' power grid could not support, resulting in prolonged outages, extensive property damage and unsafe living conditions for residents across the state.

Section 1.9 of this EMP contains a list of the recommendations and costs.

1.5 Existing Utilities and Demand Growth

1.5.1 Chilled Water System

The chilled water used to cool facilities across the main UH campus is produced in the existing Central Utility Plant (CUP). The distribution piping is primarily located inside approximately 3 miles of underground tunnels. Based on this EMP's analysis, Jacobs estimates that the existing plant will not have sufficient firm chiller capacity to support campus growth past 2028. Figure 1-1 shows projected campus demand growth from 2022–2040. Section 3 of this EMP has information specific to the current and future chilled water demands, and about the current chilled water system's condition and reliability.

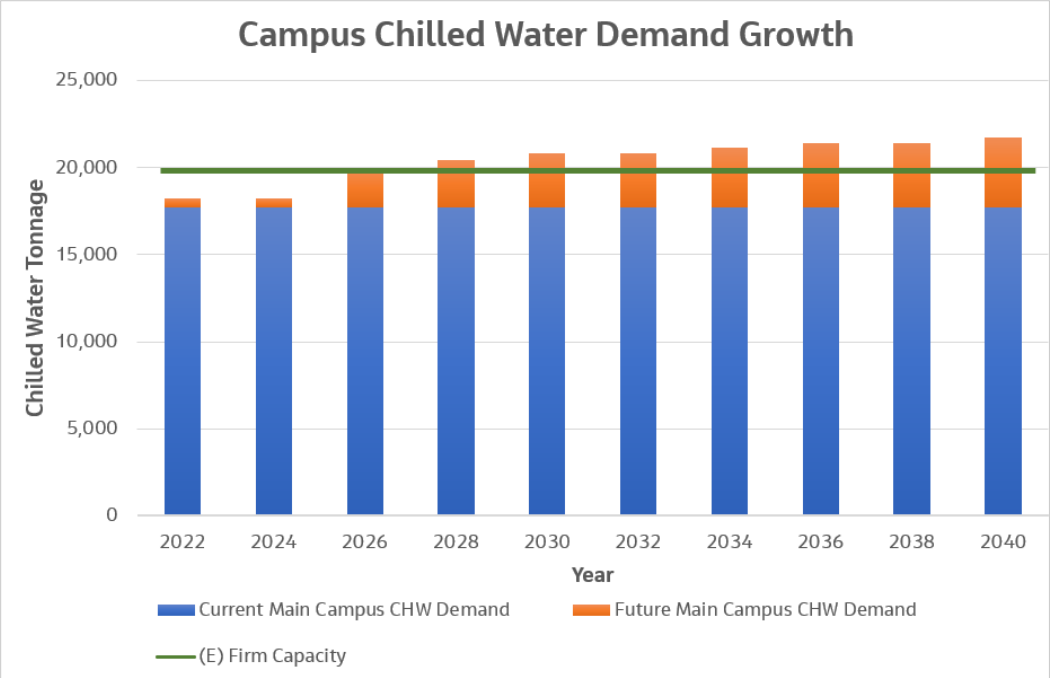

Figure 1-1. Projected Campus Chilled Water Demand Growth 2022–2040

1.5.2 Steam System

The steam used to heat facilities across the main UH campus is also produced in the existing CUP and distributed through the underground utility tunnels. The steam system has sufficient firm boiler capacity to support campus growth until 2040 as shown in Figure 1-2. No increase in steam capacity is required to satisfy projected campus growth. However, the reliability of steam supply to the campus could be enhanced by adding steam boilers at a second location on the distribution system and upgrading aging piping system infrastructure in the utility tunnels. Section 4 of this EMP has additional information specific to the condition and reliability of the existing steam system.

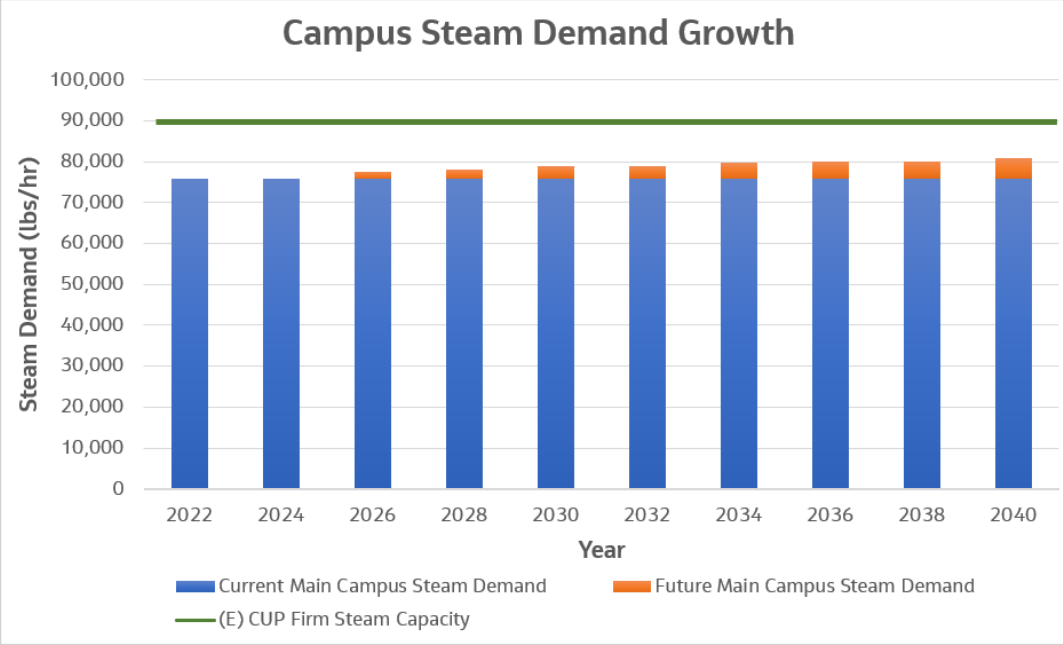

Figure 1-2. Projected Campus Steam Demand Growth 2022–2040

1.5.3 Electrical System

The primary source of electrical power for the campus is Cougar Substation, which is served by CenterPoint Energy (CPE) 138-kilovolt (kV) feeders. The 138-kV supply feeds are stepped down to 12.47 kV before being distributed to the campus. The existing Cougar Substation has sufficient firm transformer capacity to support projected campus growth until 2040, but deficiencies in the distribution system from the substation to the main campus exist. Figure 1-3 shows projected campus demand growth from 2022–2040. Section 5 of this EMP has information specific to the current and future electrical demands and conditions of the specific systems. Several electrical system components are reaching the end of their useful service life. Similarly, the existing electrical system has constraints that jeopardize reliability and may present challenges when connecting new loads.

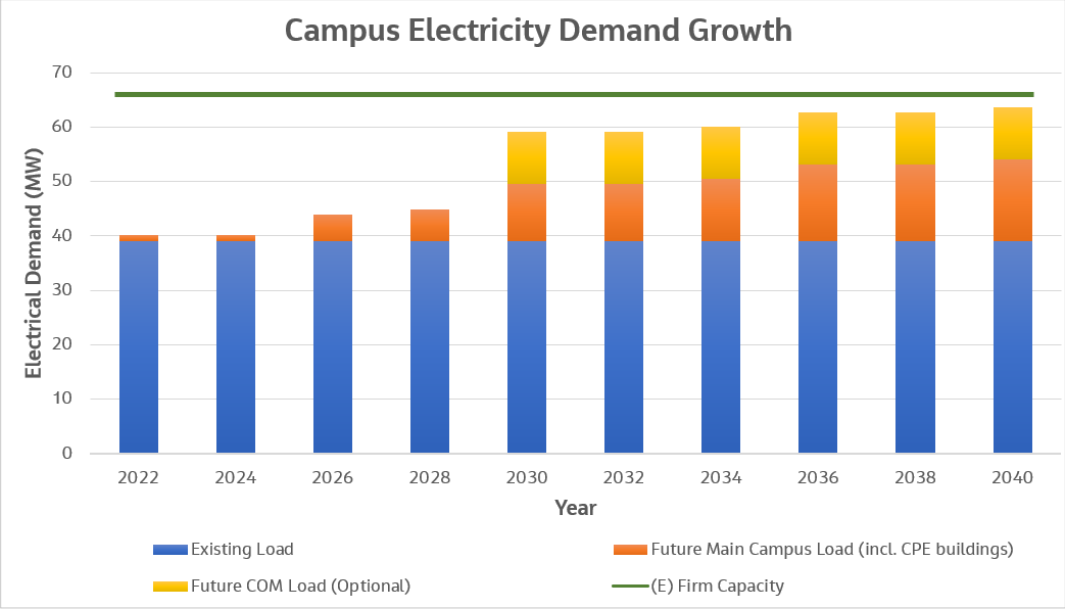

Figure 1-3. Projected Campus Electrical Demand Growth 2022–2040

1.6 Utility System Upgrade Project Alternatives

Jacobs evaluated 10 different improvement alternatives including combined heat and power (CHP). These alternatives vary from minimalist solutions that would accommodate the minimum amount of chilled water capacity required for short-term campus growth, to robust combined heat and power generation solutions capable of maintaining a continuous supply of electric and thermal energy to all facilities on the main campus—even during severe winter weather events or peak summer demand when electric power from the grid is not available. A summary of each alternative can be found in Section 8.7 of this EMP.

Section 8.8 of this EMP evaluated the life cycle costs of the different alternatives. The analysis determined that none of the CHP alternatives provided a positive life cycle cost. While CHP provided additional resiliency and redundancy when compared to other options without any electrical generating equipment, a satellite utility plant with backup generation was more economical. The cost of fuel and equipment maintenance for a continuously-operated power plant would exceed the relatively low cost paid by UH for electricity from CPE. Over the life of the facility, making power on site with a CHP would increase the total cost of electric energy.

Section 8.10 of this EMP evaluated alternatives in terms of life cycle cost and other factors such as resiliency and carbon footprint reduction. Alternatives that include new power generation and boiler equipment at a second location scored higher in resiliency than options which only increase chilled water capacity. In terms of carbon footprint, continuously-operated power generation options offer minimal opportunities for carbon footprint reduction. This is partially due to the growing percentage of carbon-neutral generation systems available on the Texas power grid and is discussed in Section 8.9 of this EMP.

The utility plant configurations of particular interest are:

- **Alternative 0A—CUP Expansion**. This alternative would expand the existing CUP to meet the chilled water loads. No additional steam boilers or generators would be installed. This alternative is not recommended as it is expensive, will be difficult implement due to space constraints, and does not meet all of UH's requirements.

- **Alternative 0C—Satellite Utility Plant with Backup Generators**. This utility plant alternative would expand the steam and chilled water infrastructure by constructing a new satellite utility plant with chillers, boiler and backup generators. The utility plant would not be a CHP as the generators would only be operated in an emergency condition.
- **Alternative 2—Reciprocating Engine Generator with Absorption Chillers**. This alternative is similar to Alternative 0C except the reciprocating engine generators would operate continuously and the waste heat from the generators would be used in absorption chillers. Although not recommended, this alternative provides several benefits compared to the other CHP alternatives.

Based on the scoring criteria as described in Section 8.10, construction of Alternative 0C – Satellite Utility Plant with backup generators is recommended.

1.7 Electrical Substation and Distribution System Upgrades

Given the age of several electrical system components, UH must make a capital investment to maintain reliable electric service. The following four improvement options are considered in this EMP:

- **Option 1—Business as Usual.** Option 1 replaces only system components that have exceeded their useful service life without investing in any other improvements to increase reliability or resiliency.
- **Option 2a—Upgrade Cougar Substation.** Option 2a would include the work of Option 1 and add additional measures to improve the reliability of Cougar Substation and power distribution. These upgrades would include reconfiguration of the 138-kV buses, installing a new duct bank parallel to the existing Cougar 1, 2 and 3 duct banks across the railroad and Spur 5 and installing an additional indoor 15-kV switchgear in the Cougar Substation to facilitate adding new feeders for future loads.
- **Option 2b—Upgrade Cougar Substation and Construct New Duct Banks.** Option 2b is a variation of Option 2a; overhead sections of the Cougar 1, 2 and 3 feeders would be eliminated. Option 2b would construct new duct banks and install new cables to route Cougar feeders 1,2 and 3 underground from the Cougar Substation to the CUP.
- **Option 3—New Substation.** Option 3 would replace Cougar Substation, and according to analysis, is the most reliable, resilient and expandable option, ensuring UH has the electrical capacity and flexibility needed for many years to come.

Based on the scoring criteria as described in Section 5.7.5, replacement of Cougar Substation (Option 3) may offer the highest overall value to the University.

1.8 Site Evaluations

Jacobs evaluated multiple sites for a new substation or a new utility plant. Section 9 contains additional information about each site, and an analysis of site locations. If UH proceeds with a new substation as recommended in this EMP, Jacobs recommends the parking lot 4A site on the southeast corner of campus as the ideal location as shown in Figure 1-4. With the construction of a new substation, the existing Cougar feeders 4 and 5 would be used to serve the Technology Bridge part of campus.

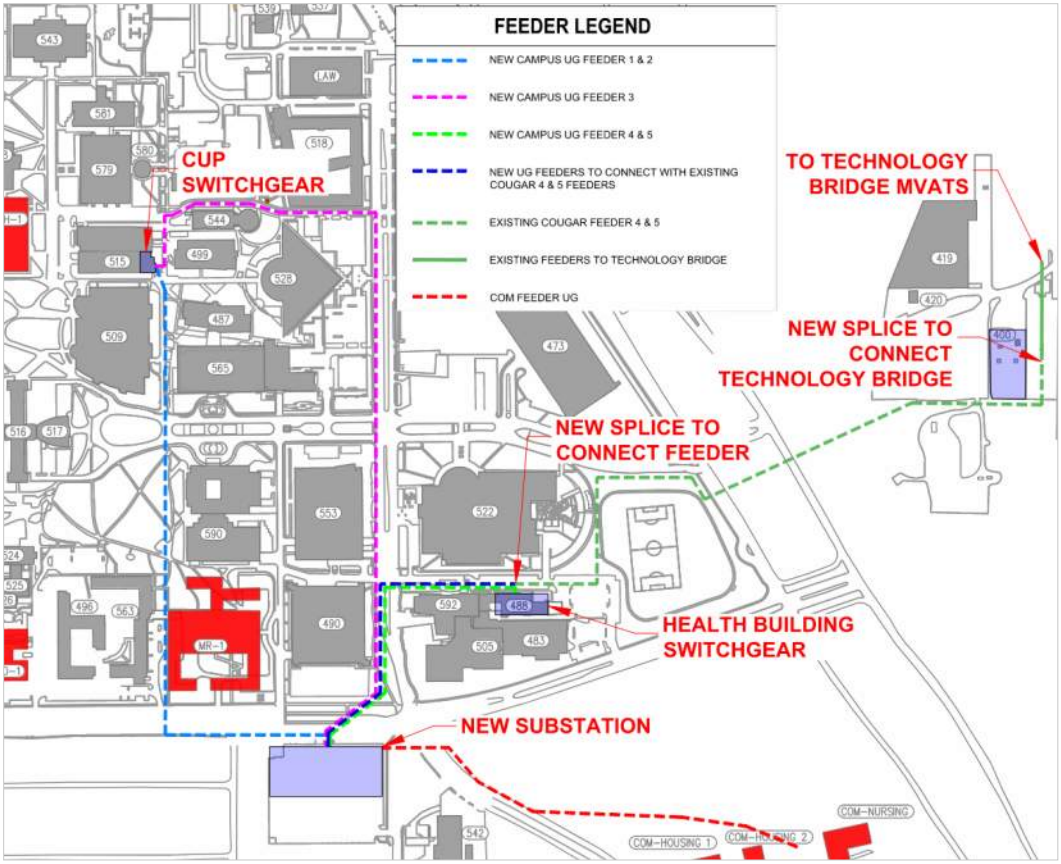

Figure 1-4. Proposed Site of New Electric Substation

If UH proceeds with a new utility plant as recommended in this EMP, the existing campus property on the north side of campus appears to be the most feasible location. It is identified as Utility Plant Location Option 2 as shown in Figure 1-5. However, UH should continue to monitor future needs and reconfirm site feasibility prior to initiating detailed design.

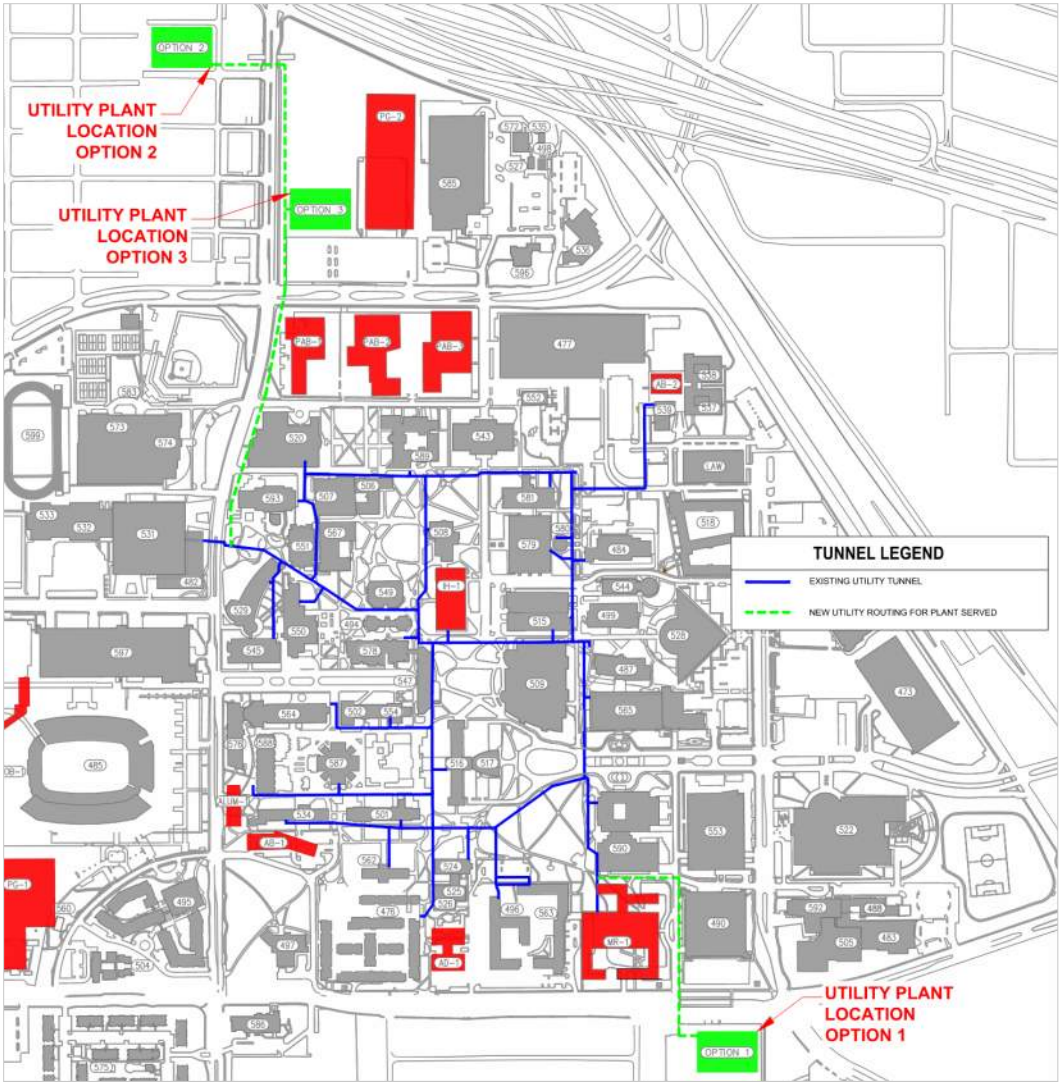

Figure 1-5. Proposed New Utility Plant Site Options

1.9 Recommendations and Estimated Costs

This EMP serves as a road map for UH to meet the future demands of campus growth while increasing reliability, resiliency, efficiency and sustainability. Recommendations for meeting future demands are throughout this EMP, and key recommendations are as follows:

- New satellite utility plant, Alternative 0C
  - At a minimum, this plant would add 1,000 tons of capacity to support projected chilled water load growth on the main campus through 2030 and would be expandable to 3,000 tons of capacity for additional load through 2040. This satellite plant will augment the existing CUP chiller capacity. This recommendation does not include integrating the College of Medicine onto the main campus chilled water system, which is not recommended.
  - Additional steam capacity is not required but would improve campus resiliency if added to the satellite utility plant. Recommended capacity of redundant steam boiler is 90,000 lbs/hr.
  - Backup generators would improve campus resiliency if added to the satellite utility plant. However, a microgrid study would be required to verify how power from the new plant would be deployed to facilities across campus. A total power output capacity of 24 megawatts (MW)

would be needed to protect all facilities from a winter storm outage similar to the one that occurred in February 2021. To allow the campus to operate without interruption during a summer power outage a total output capacity of 44MW would be needed. A 44MW utility plant would cost approximately $135M.

- A new electric substation to replace Cougar Substation.
  - The new substation would be configured with three transformers connected in a ring with a provision to add one more in the future to support additional campus growth including the College of Medicine. The project would also include three new feeders to Campus Switchgear A, two new feeders to Campus Switchgear B and feeders to serve College of Medicine. The existing Cougar 4 and 5 circuits would be reused as Technology Bridge feeders. Section 5.5.1 contains additional information.
  - If not replaced, multiple deficiencies at Cougar Substation need to be addressed, including replacement of electrical feeders from Cougar Substation to the CUP and replacing transformers that may be reaching the end of their useful service life.
- Installing electric, chilled water, steam and condensate metering across campus to measure building level energy use. This should include a supervisory control and data acquisition (SCADA) system to collect, monitor and record meter data.
- Upgrading building heating, ventilation and air-conditioning (HVAC) controls, upgrading lighting, and building recommissioning/retro-commissioning to optimize energy efficiency.
- Installing photovoltaic (PV, or solar) panels on building roofs where possible.
- Replacing infrastructure that has reached end of life.
- Upgrading existing utility systems to enhance performance.

Table 1-1 shows the recommended projects and associated costs for the recommended projects.

Table 1-1. EMP Cost Estimate Summary

Item	Description	EMP Report Section(s)	Approximate Cost ($)	Remarks
1	New satellite utility plant with 24MW of backup power, Alternative 0C located at site Option 2	8.7, 8.8, 9.2	112.3M	Cost will depend on utility plant alternative and site location selected. The cost for utility plant integration of $30.7M included.
2	New electrical substation	5.5, 5.7	40.7M	Option 3 in Section 5.7
3	SCADA system with new electric, chilled water, steam, and condensate meters	3.5, 4.5, 5.5, 7.5	2.9M	--
4	HVAC Control Upgrades	7.2	51.7M	--
5	Lighting Upgrades	5.5	7.6M	--
6	Retro-Commissioning buildings	7.3	21.5M	--
7	Photovoltaic panels on building roofs	5.5	85.4M	--
8	Replacement of infrastructure and equipment at end of life	3.3, 3.4, 4.3, 5.3, 5.4,6.2, 6.3	27.0M	Electrical alternates listed in Section 5.8 not included. Refer to Appendix I for breakdown.
9	Upgrading existing utility systems to enhance performance	3.5, 5.5, 7.6, 7.7	5.8M	Refer to Appendix I for breakdown.

1.10 Carbon Footprint

UH is committed to sustainability and the reduction of its carbon footprint. As of 2018, energy consumption on the UH campus generated approximately 226,208 tons of carbon per year. However, there are multiple opportunities for UH to make improvements in this sustainability metric. The projects most likely to have the biggest impact would include installing solar panels on campus buildings, and implementing energy efficiency measures at the building level. Figure 1-6 illustrates the overall carbon footprint reduction that could be achieved by 2040 assuming items 4, 5, and 7 from Table 1-1 are completed.

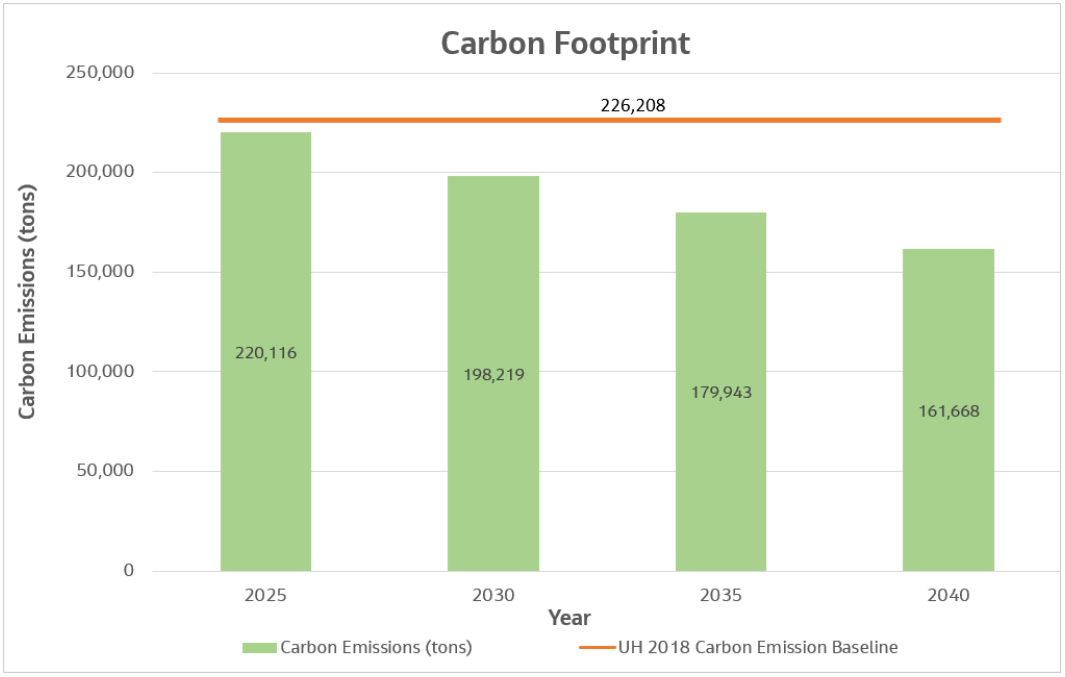

Figure 1-6. Projected Carbon Footprint Reduction 2022–2040

Figure 1-7 illustrates the approximate carbon footprint reduction by system that could be achieved by 2040 assuming all recommended system upgrades are completed.

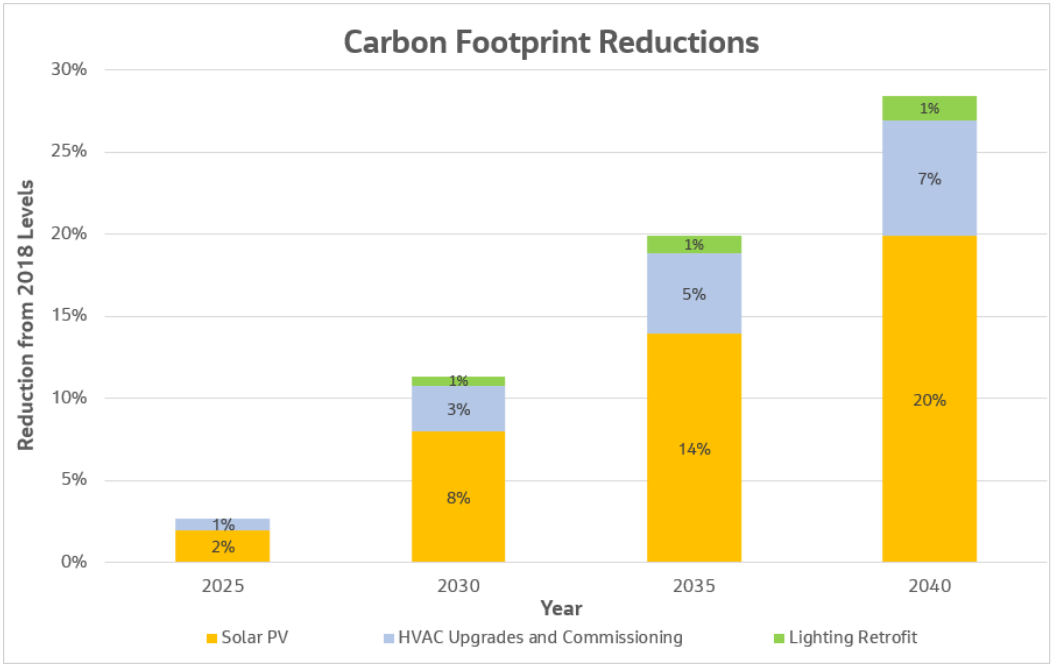

Figure 1-7. Projected Carbon Footprint Reduction 2022–2040

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2. Introduction

2.1 Background

The University of Houston (UH), located in Houston, Texas, was founded in 1927 as the Houston Junior College, becoming a university in 1934. UH's main campus has grown since moving to its current location in 1936, and consists of 667 acres with an additional 74 acres comprising the Technology Bridge a short distance away. Today, UH is a Carnegie Tier One research university with a mission of providing educational opportunities for students and a vision of building a top 50 public university as measured by graduation rate, affordability, social mobility and student-related institutional investment, among other measures.

Since UH's founding, the campus has expanded considerably, and continues to do so. The *University of Houston Campus Master Plan—Centennial Plan 2027* (UH 2019) (2027 Centennial Plan) anticipates campus enrollment will continue to grow 2–3% annually for the foreseeable future. To accommodate this growth, the campus needs to grow as well. Planning for expansion of campus facilities necessitates a clear understanding of the campus utility systems that will serve them and a plan for similar utility system improvements.

In 2021, UH commissioned Jacobs to develop this Energy Master Plan (EMP) to address both immediate and long-term electrical and thermal utility needs based on the 2027 Centennial Plan, while also reviewing methods to increase reliability, promote sustainability, and decrease energy use. This EMP documents Jacobs' findings and recommendations for UH to realize 2027 Centennial Plan objectives while also creating a more resilient and sustainable campus.

2.2 Project Objectives

This EMP's objective is to provide a road map for enhancing campus thermal and electrical infrastructure to meet growth demands projected in the 2027 Centennial Plan. Jacobs has done the following to develop this EMP:

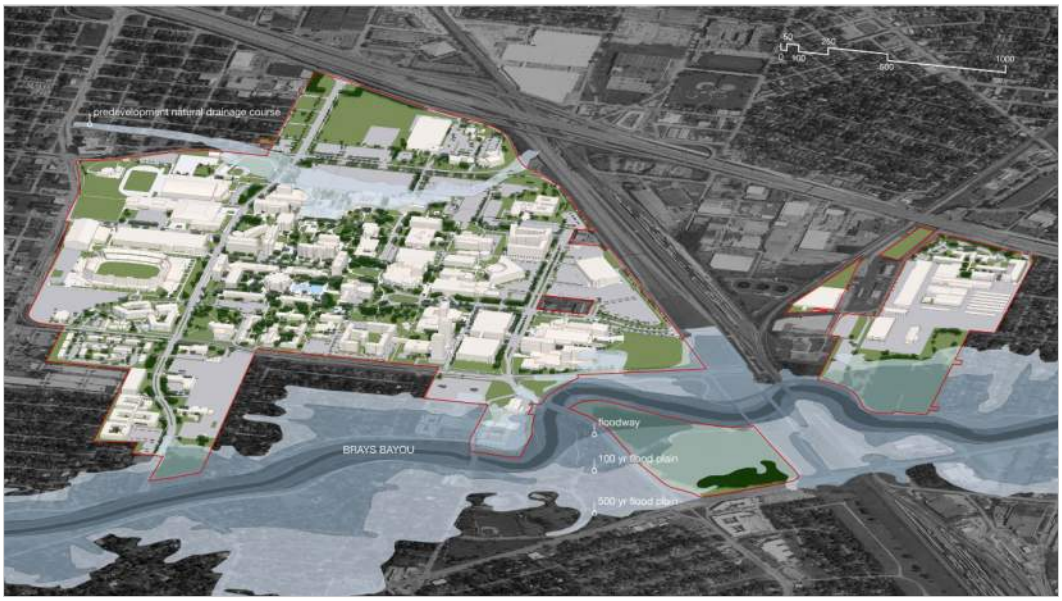
- Identified key benchmarks and drivers for energy usage
- Defined current and future energy needs and requirements
- Provided recommendations to address existing deficiencies
- Identified feasible projects that increase capacity while promoting reliability, resiliency, energy conservation and sustainability

2.3 Site Characteristics

2.3.1 Location

UH's campus is southeast of downtown Houston and is surrounded by low-rise residential and commercial properties in an urban environment. Most of the surrounding land has been developed, presenting challenges to further campus expansion. As such, the campus plan as outlined by the 2027 Centennial Plan includes the replacement of older buildings with new, higher density facilities to make better use of the land available. The campus has also recently begun developing a parcel of land on its south side for the College of Medicine (COM). The COM is separated from the main campus by the existing Brays Bayou. The Technology Bridge on the east side of campus is similarly separated from the main campus by a highway and railroads.

Due to proximity to Brays Bayou to the south, and a predevelopment natural drainage course to the north, some sections of campus are prone to flooding during extreme weather events. Weather events such as hurricanes are not unusual due to the proximity of Houston to the Gulf Coast. Therefore, campus facilities must be built to withstand extreme weather events without significant damage. Currently, projects are in design to expand the existing stormwater system to reduce flooding. However, flooding is a design parameter that must be addressed during the design of any new facility. Figure 2-1 shows a floodplain map from the 2027 Centennial Plan.



Source: UH 2019

Figure 2-1. Campus Floodplains

2.3.2 Energy Usage

Energy use is an important metric for higher education campuses. Figure 2-2 estimates the relative energy usage intensity of UH as compared to other peer institutions in Texas and the national average based on publicly available information. Data about energy usage at UH and other peer institutions was obtained from multiple sources including the State Energy Conservation Office's (SECO's) *SECO Utility Management Report* (2020), the Association for the Advancement of Sustainability in Higher Education's Sustainability Tracking Assessment and Rating System (STARS), and the U.S. Environmental Protection Agency's (EPA's) Energy Star Portfolio Manager. Since information was prepared by and drawn from multiple sources, it may not represent a perfectly accurate comparison.

While higher than the national average, UH has a similar energy usage intensity to other universities in Texas.

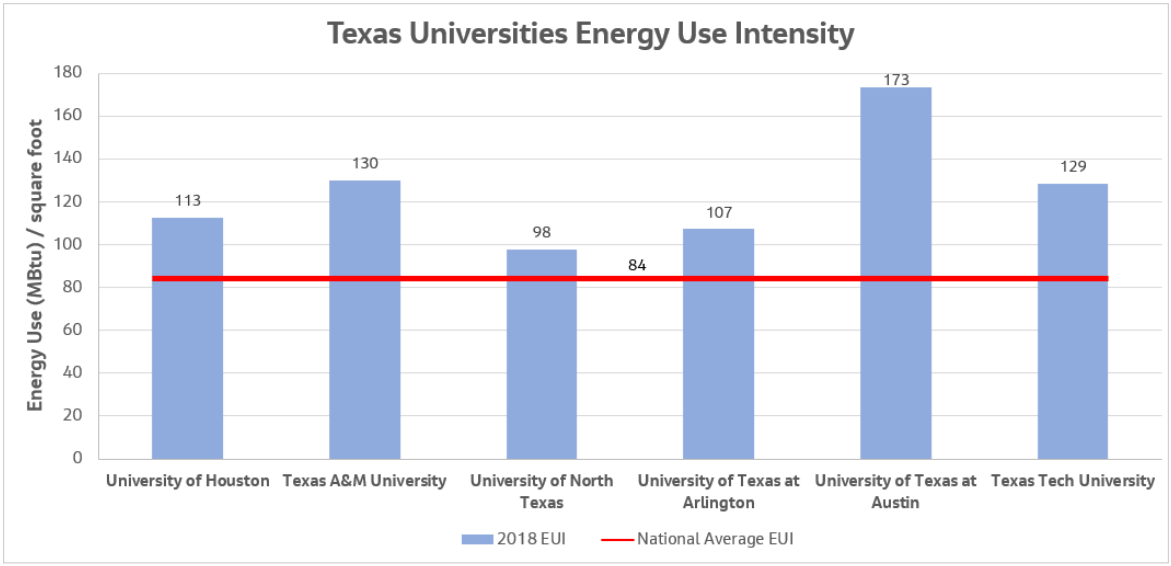


Figure 2-2. Energy Use Intensity

2.4 Existing Utility Infrastructure

The existing utility infrastructure reviewed by Jacobs as part of this EMP included the steam, chilled water, electrical, and utility tunnel systems. A significant portion of the steam and chilled water infrastructure was constructed prior to 1965 when the campus underwent an expansion, and the current Central Utility Plant (CUP) was constructed and brought online. The steam and chilled water system capacities were increased in 2012 during a CUP renovation project. The firm capacity of the steam boilers is 90,000 pounds per hour (lbs/hr) of steam. The firm capacity of the chilled water system is 19,800 tons.

In addition to the main CUP, UH has utility plants that serve the Health District and the Recreation and Wellness areas of campus. These utility plants serve the local buildings and are sized for the buildings served. The Health District utility plant has steam boilers with a firm capacity of 3,500 lbs/hr and a chilled water firm capacity of 3,300 tons. The Wellness and Recreation utility plant has hot water boilers and a chilled water firm capacity of 485 tons.

Cougar Substation, located east of the main campus, serves the majority campus buildings and is the primary electrical service for the campus. Cougar Substation is owned and operated by UH. The firm capacity of the electrical substation is 66 megawatts (MW) and is distributed from Cougar Substation to campus using 12.47-kilovolt (kV) feeders. The feeders terminate in switchgears located in the CUP and in the Health Building, where electric power from the utility is then distributed throughout campus.

2.5 Current and Future Campus Building Projects

2.5.1 Current Projects

There are currently several buildings under construction on campus. Jacobs has accounted for the thermal and electric demand of these buildings in this evaluation using both design information provided by UH and by using historical data for similar buildings. Renovations to existing facilities are also ongoing but are not anticipated to add or remove significant load to any of the utility systems reviewed as part of this EMP.

2.5.2 Future Projects

According to the 2027 Centennial Plan, UH is projected to grow at an annual rate of 2–3% for the foreseeable future. To accommodate this growth, the campus must add facilities for more students, and adopt a multifaceted strategy to address campus expansion. Figure 2-3 shows proposed buildings in red overlaid with the existing campus. The proposed building locations are conceptual and subject to change. A larger image can be found in Appendix H.

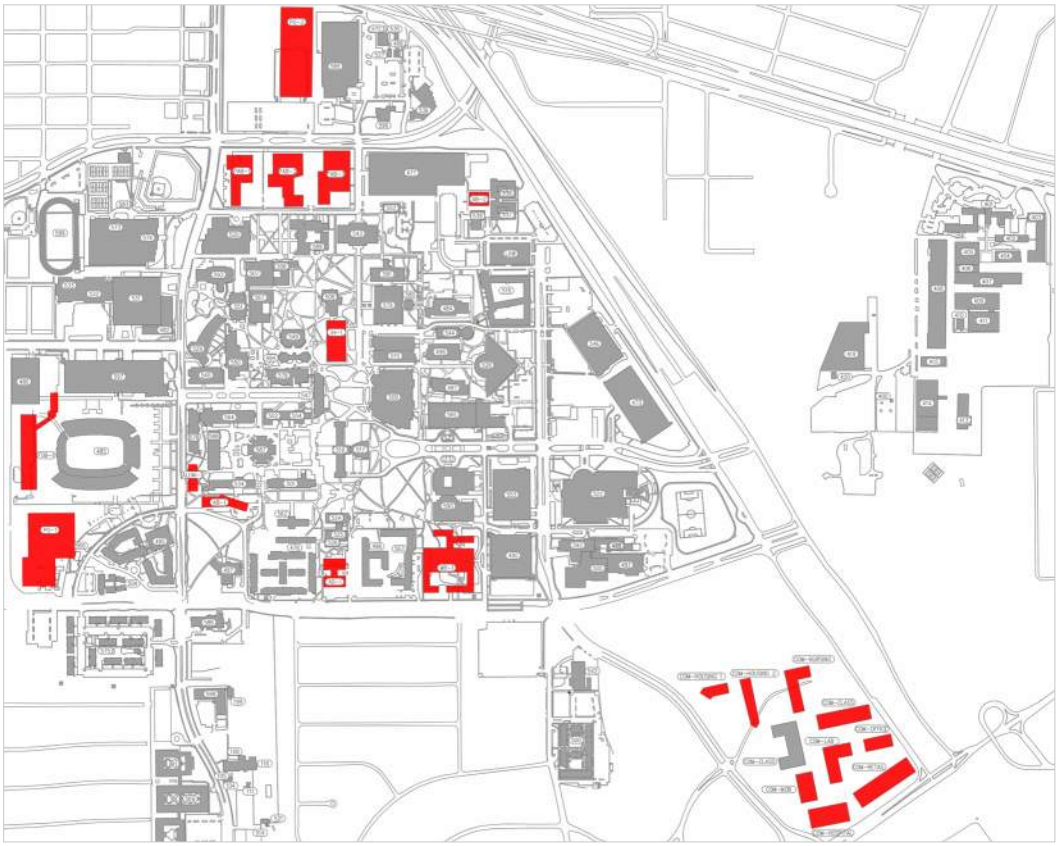


Figure 2-3. Projected New Buildings 2022–2040

Figure 2-4 shows anticipated campus building square footage growth from 2022–2040.

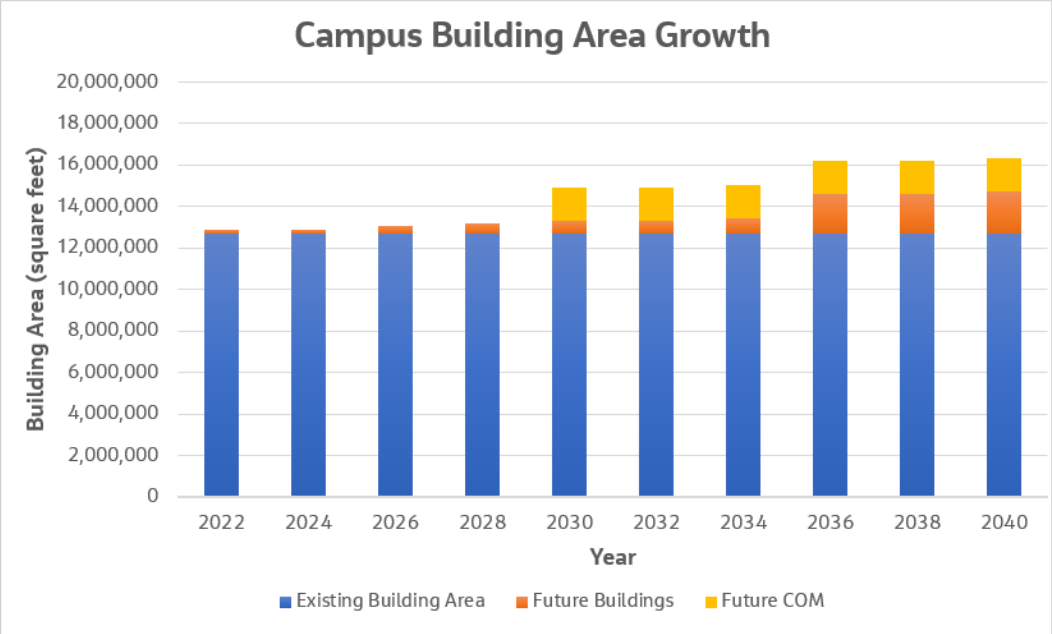


Figure 2-4. Projected Campus Building Growth 2022–2040

In addition to new buildings, renovations to existing buildings are being proposed that will change the occupancy type and usage of existing spaces inside buildings and cause them to have new energy requirements. The impacts of these upgrades are not known at this time. However, for this EMP, Jacobs has assumed that these renovation projects will have a minimal impact to the overall campus thermal and electrical energy demand.

2.6 Campus Utility Systems Resiliency

2.6.1 Resiliency Considerations and Examples of Failures

A continuous and reliable supply of electric and thermal energy to campus facilities is critical to carrying out the mission of the University. Any prolonged loss of electric power or thermal utilities is not only an inconvenience to the students and faculty. Such an event could also jeopardize critical research activities, place millions of square feet of facilities at risk of damage or create unsafe living conditions for campus residents.

For these reasons, resilience against both natural and human-created hazards is an important criterion to address in this EMP. In the context of climate change, resilience requires considering the impacts of climate change such as the increased duration, frequency and intensity of precipitation, extreme heat, and extreme cold. Houston's *Climate Impact Assessment for the City of Houston* (ATMOS Research & Consulting 2020) notes that it is likely Houston will experience greater temperature extremes, both hot and cold, and weather events could be more frequent or more intense. With respect to weather such as hurricanes, they are likely to be stronger and occur with more rainfall. In February 2021, winter storm Uri highlighted the need for resiliency against utility disruptions and equipment failure. The storm created demand conditions that the state's power grid could not support, and many portions of the state experienced prolonged outages. The Federal Energy Regulatory Commission's (FERC's) *The February 2021 Cold Weather Outages in Texas and the South Central United States* (FERC 2021) has additional information specific to utility disruptions.

Cyberattack is a human-made resiliency concern. With an accelerated rate of change in the social and technological landscape (for example, the ability of unauthorized users to cause disruption on a computer network or similar web-based system), resiliency should also be technological, with UH systems secured via both physical and software barriers. The severity of disruption from unauthorized user intrusion can range from a minor inconvenience to a complete lockout of authorized users, and even the destruction of a digital system. An example of this is the September 2021 ransomware attack against Howard University in Washington D.C., when the university's information technology systems were taken down entirely. The campus was forced to close for four days while it addressed the outage. Table 2-1 lists some hazards that warrant focus during the detailed design of any new campus project.

Table 2-1. Hazard Identification

Resiliency Category	Example
Natural	Tornado, flood, winter storm, extreme heat
Human-Created	Cyberattack, criminal
Technological	Utility disruption, equipment failure

UH's goal is to implement a resiliency strategy that seeks to improve performance prior to an event and to reduce the time to recover function. The strategy has two main components: 1) implementing focused improvements to address aging systems and increase preparedness, and 2) implementing resiliency strategies so new facilities can minimize system disruptions. Jacobs' suggested approach for addressing these potential hazards is discussed in the following subsections.

2.6.2 Improvements to Address Aging Infrastructure

As directed by UH, Jacobs reviewed condition assessment information that was either created by other consultants or provided by Engineering Services personnel and consolidated pertinent information into this EMP document. This information was utilized to identify deficiencies in the existing infrastructure that could limit resiliency or impede future campus growth.

The improvements identified throughout this report are necessary to extend the useful service life of the thermal and electric systems and to improve reliability and resiliency. Some of these improvements would also reduce energy use. Other improvements will allow the operations staff to respond more effectively to abnormal operating conditions such as loss of power from ERCOT during extreme weather events. Sections 3 through 7 of this EMP contain information specific to each of the utility systems reviewed.

2.6.3 Integration of Resiliency into New Facilities and Infrastructure

The resiliency of new facilities and infrastructure should be integrated into a project's early design to determine the extent of resiliency required. During Jacobs' review of new buildings and infrastructure for this EMP, a preliminary review of necessary resiliency was performed; a more thorough and detailed risk analysis should be undertaken during a project's detailed design. While risk analysis will be specific to each project, some items of particular interest for each risk analysis are as follows:

- Proximity of any facility or system to historical floodplains: If a building is in proximity to a floodplain, then a risk assessment should be performed, and the building should either be relocated or raised above the 500-year floodplain.
- Mitigating risk of failure: Possible examples for additional resiliency could include local backup generation for buildings with a critical need for reliable power, new substations, spare feeders or onsite power generation for campus distribution as discussed in this EMP.

- Configuration of the campus thermal distribution system: Risk could be minimized by maintaining "looped" systems capable of isolating branch lines without interrupting building services or by generating thermal utilities at multiple locations on a single connected distribution system.
- Integration of controls into the campus building management system: Risk could be minimized by developing a robust control architecture with defense-in-depth cybersecurity protection to prevent access by unauthorized personnel. This would require sensitive systems to have multiple layers of security or be air-gapped from the local network.

2.7 Campus Sustainability

UH is committed to sustainability through its on-campus initiatives. Through the Office of Sustainability, the university seeks to educate both campus and community members about the importance of thinking and acting sustainably to use resources responsibly while improving the livelihood of present and future generations. As this EMP will have a long-term impact on the campus as a whole, sustainability is an important aspect.

To evaluate campus sustainability, UH has begun rating certain characteristics of the campus based on the Association for the Advancement of Sustainability in Higher Education's (AASHE's) Sustainability Tracking Assessment & Rating System (STARS) (AASHE 2022). Jacobs reviewed the main STARS credit categories for this EMP as follows:

- Institutional characteristics
- Operations
- Planning and administration

Jacobs evaluated the existing sustainable design tools used by UH when reviewing sustainability strategies during projects. As projects are still in the conceptual design phase, additional coordination will be required when infrastructure upgrades and modifications proceed into detailed design. Existing sustainability guidelines and tools include the following:

- UH Section 12.0: Construction Systems and Assemblies Standards and Guidelines (UH 2018)
- U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) rating system (USGBC 2022)
- AASHE's STARS (AASHE 2022)

While sustainability is taken into consideration, life cycle costs, reliability, and operational impacts must also be factored into the design decisions. This is further detailed throughout this EMP.

2.8 Scope and Limitations of Energy Master Plan

The contents of this EMP are offered as guidance for evaluating the overall condition of campus utilities and infrastructure systems and for understanding the relative benefit and challenges of future projects to increase the capacity, efficiency, reliability and sustainability of the energy systems to support the 2027 Centennial Plan. The projects discussed in this EMP have been evaluated at a conceptual level. Opinions of construction or operational costs or operating conditions are based on screening level evaluations and are not the result of detailed estimates. Further refinement of each discreet project is recommended to confirm project scope, regulatory requirements, capitol costs and projections of operational costs.

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3. Chilled Water Systems

3.1 Overview

The UH campus has three utility plants that produce chilled water. The largest is the central utility plant (CUP), which serves most of the main campus. Two satellite utility plants are located outside of the CUP. The first is the Recreation and Wellness Plant and the second is in the Health District Plant. These plants do not connect into the existing chilled water distribution system that connects most of the buildings on campus to the CUP. The Recreation and Wellness Plant and Health District Plant are sized and designed to serve only the local buildings. Integration of these two remote chilled water plants into the main campus system would not be economical and is not considered in this EMP. Similarly, buildings located in the Technology Bridge area of campus are mainly cooled by air-cooled chillers. Based on the distance from the main campus and the difficulty of installing chilled water lines under the highway spur and railroad, connection of these buildings and their cooling systems to the main campus is not evaluated or discussed in this EMP.

The main campus chilled water system is primarily confined within the approximately 3-mile tunnel distribution system on campus. The age of each section varies depending on its location. The original chilled water system was constructed in 1962 and expanded in 1987. According to the *Chilled Water, Steam, and Condensate Distribution Study* (2013 Shah Smith report) (Shah Smith 2013), most of the construction is carbon steel piping. The 2013 Shah Smith report also reviewed the condition of the piping, and those recommendations are noted in Section 3.4.

3.2 Chilled Water Flow Modeling

To determine chilled water system capacity (that is, both how it exists currently and how future modifications would affect it) Jacobs developed a hydraulic flow model of the system.

3.2.1 Approach

Jacobs developed flow models for the existing and proposed system configurations using Applied Flow Technologies (AFT) Fathom, a hydraulic modeling software package for incompressible fluids. AFT Fathom uses inputs such as flow rates, routing distance, valves, fittings, and equipment pressure drops to calculate velocities and pressure losses throughout an entire system. By using AFT Fathom models, areas with insufficient flow or pressure drops (i.e., "bottlenecks") can be identified. Once completed, the model can be modified to predict the impact of future load growth or proposed system enhancements.

To help validate the baseline model and associated data against previous studies and data, Jacobs first created a baseline model to reproduce existing conditions. The existing conditions, including flow rates, were taken from the 2013 Shah Smith report, as a comprehensive analysis had previously been completed. Drawings from the *Thermal Utility Master Plan* (Lockwood, Andrews & Newnam, Inc. 1984), data from the Shah Smith 2013 report, and information collected during interviews with UH staff were used to create the piping system in the area around the CUP. This information was used in the Fathom flow model.

Once the baseline model was able to replicate the Shah Smith data, then additional AFT Fathom models representing different system configurations with possible future system loads were created. These variant models considered the impact of different pipe sizes, pipe routing configurations, flows, and multiple chilled water plant locations. Refer to Appendix F for the models.

3.2.2 Existing Chilled Water Loads

Figure 3-1 shows the chilled water load profile from 2018. The maximum campus load for this year occurred in August, with a peak demand of approximately 17,400 tons. Additional data from UH indicates that the historic peak campus load has actually reached as high as 17,600 tons. This information was used to estimate UH chilled water system diversity, or the historical ratio of actual building energy consumption measured at the plant versus the theoretical maximum demand of every building on campus.

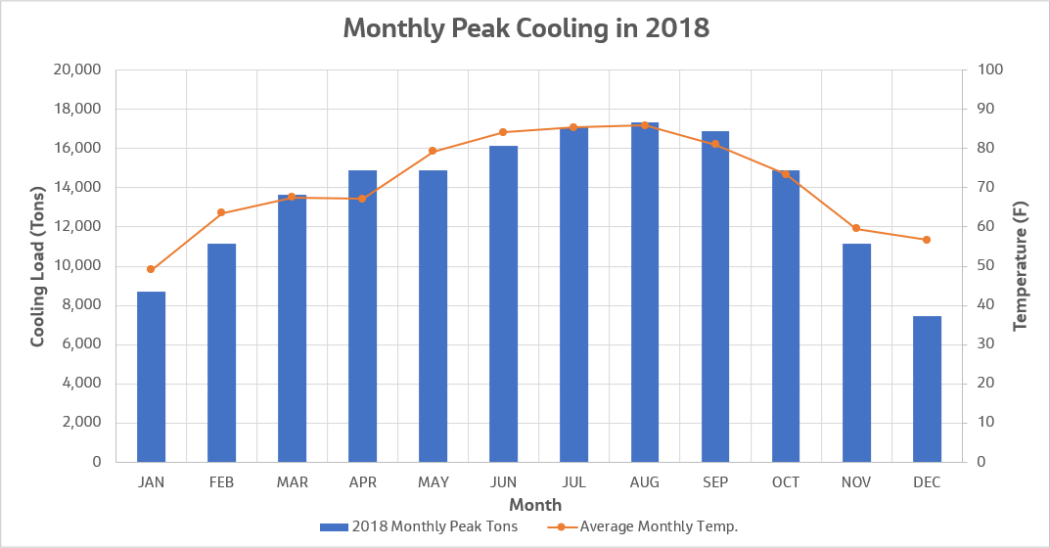

Figure 3-1. 2018 Peak Monthly Chilled Water Load vs Average Monthly Temperature

Appendix A contains a summary of the loads used to model existing buildings. The flow rates were based on information in the 2013 Shah Smith report and on information collected during interviews with UH staff.

Several buildings were added to the campus after the completion of the 2013 Shah Smith report. As there is limited documentation available for these buildings, Table 3-1 presents the approximate peak thermal loads based on similar buildings on campus. These data differ slightly from the future chilled water loads, as the diversity has been adjusted to make the existing chilled water loads more closely match peak CUP chilled water loads.

Table 3-1. Existing Buildings Load Development

Building Type	Base Load (Btuh/ft^2) [a, b]	Diversified Load (Btuh/ft^2) [c]
Dormitory or Residential Housing	34.0	20.4
Athletics	38.0	22.8
Classroom	50.9	30.6
Office	55.5	33.3
Laboratory	88.2	52.9
Library	36.8	22.1
Food Services	74.3	44.6

Note:

[a] Building cooling load is approximate based on similar buildings on campus.

[b] Assumes a 10-degree Fahrenheit (°F) temperature difference on a chilled water system.

[c] Most building loads used load data from the 2013 Shah Smith report. Diversity factor of 85% was used to adjust loads for buildings constructed after 2012 to match peak cooling load data provided by UH.

3.2.3 College of Medicine Hospital Chilled Water Connection

The UH *College of Medicine Master Plan* (UH 2019) shows a proposed 150,000-square foot hospital being constructed on the south side of campus. The hospital has been excluded from this EMP.

3.2.4 Future Chilled Water Loads 2022–2040

As many future campus buildings are still in the conceptual phase, Jacobs made assumptions about their respective chilled water demand. To account for future chilled water load, an averaged load per square foot was used. Table 3-2 lists the assumed values used to develop future chilled water loads.

Table 3-2. Future Buildings Load Development

Building Type	Base Load (Btuh/ft^2) [a, b]	Diversified Load (Btuh/ft^2) [c]
Dormitory or Residential Housing	21.5	21.5
Athletics	47.0	47.0
Classroom	32.2	32.2
Office	35.1	35.1
Laboratory	104.5	104.5
Library	23.2	23.2
Food Services	47.0	47.0
Medical Office Building	42.9	42.9
Retail	28.6	28.6

Note:

[a] Building cooling load is approximate based on similar buildings on campus and engineering judgment.

[b] Assumes a 10 °F dT on chilled water system.

[c] Diversity factor of 100% used to allow for a factor of safety. This factor will likely be similar to the existing diversity factor.

Table 3-3 lists new buildings identified by UH that are scheduled for construction between 2022 and 2040.

Table 3-3. Flow Modeling Analysis Building Loads

Building	Building Name	Building Type	Diversified Building Load (tons) [a]	AFT Model Flow (gpm) [a]
487-EXP	Student Center North Expansion	Food Services	235	564
AB-1	Academic Building 1	Classroom	215	515
AB-2	Academic Building 2	Classroom	322	773
AD-1	Administration Building	Office	234	561
ALUM-1	Alumni Building	Office	175	421
IH-1	Innovation Hub	Lab	1,045	2,508
LAW	Law Building	Office	555	1,332
MR-1	Moody Tower Replacement	Housing	536	1,288
PAB-1	Performing Arts Building 1	Classroom	322	773
PAB-2	Performing Arts Building 2	Classroom	322	773
PAB-3	Performing Arts Building 3	Classroom	322	773
537	Bates Law [c]	Office	244	585
503	Technology Annex [b]	Lab	(117)	(280)
584	Moody Towers [b]	Housing	(375)	(901)
590C	Hilton Hotel Section C	Housing	63	150
COM-Class	College of Medicine Building 1	Classroom	342	821
COM-Nursing	Nursing	Classroom	255	612
COM-Office	Office	Office	438	1,052
COM-Retail	Retail	Retail	238	572
COM-Lab	Lab, Research, Vivarium	Lab	1,741	4,180
COM-MOB	Clinic	Medical Office Building	358	858
COM-Housing 1	Housing	Housing	193	464
COM-Housing 2	Housing	Housing	193	464
		Total	7,793	18,703

Note:

[a] Uses diversified load.

[b] Building assumed to be demolished; thus, removal of the load.

[c] Existing building connection serves three other buildings. Load revised to show new Academic Building and removal of Building 540.

Table 3-4 compares chilled water plant available capacity to required demand. The difference between plant capacity and combined existing and new building loads represents the amount of cooling that will needed as the campus expands. Recommendations for implementation of additional cooling are described throughout this EMP. In Table 3-4, positive values denote production and negative values denote consumption. In the "Capacity vs Load Difference" row below, the negative values shown in Table 3-4 indicate the existing CUP cannot support campus expansion without creating additional capacity.

Table 3-4. Available Capacity vs Building Demand

Item	Load (tons)	System Flow (gpm)	Data Source	Remarks
Plant Capacity [a]	19,800	47,520	Table 3-5	
Existing Building Loads	(17,696)	(42,477)	Appendix A	
Future Building Loads	(4,034)	(9,682)	Table 3-3	For main campus only
COM	(3,759)	(9,021)	Table 3-3	All buildings shown on the COM master plan except the hospital.
Extra Capacity for Growth and Factor of Safety	(1,000)	(2,400)		
Capacity vs Load Difference	**(6,689)**	**(16,060)**		

Note:

[a] Refer to Section 3.3 for existing chiller information. Load shown is firm capacity for the existing CUP.

Figure 3-2 shows the projected chilled water consumption growth and existing chiller firm capacity from 2022–2040. The COM is not included in the figure as integration of the COM into the existing chilled water infrastructure is not recommended. Section 3.6 has additional information.

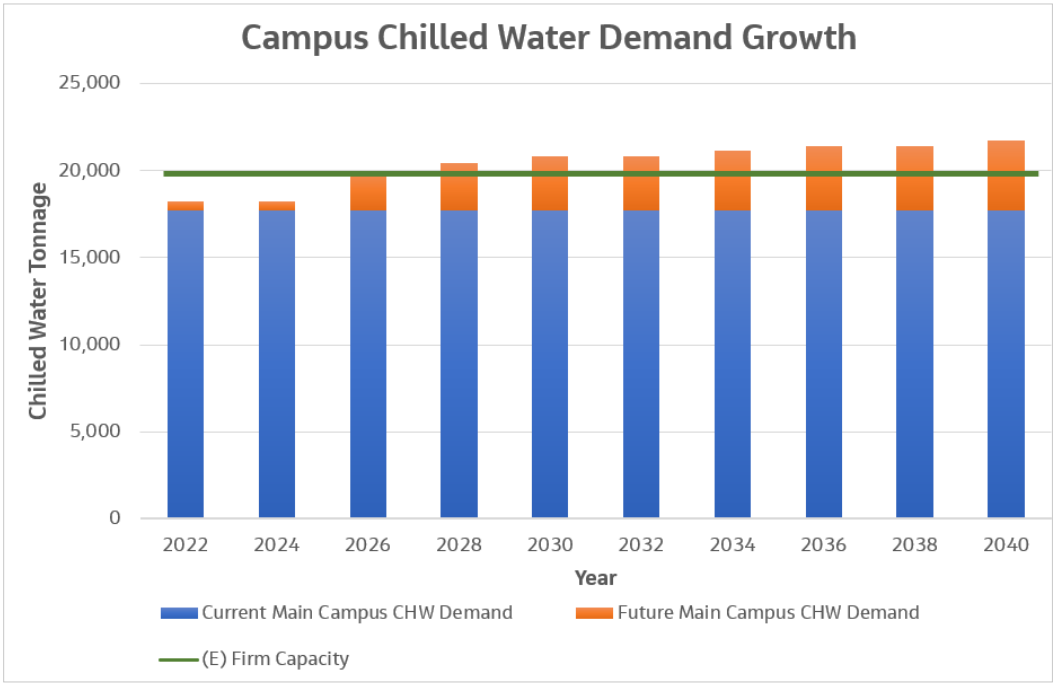

Figure 3-2. Projected Campus Chilled Water Growth 2022–2040

3.2.5 Chilled Water Modeling Assumptions

To model the chilled water system, Jacobs made the following assumptions about the system and general controls operation.

- Buildings are assumed to have building pumps inside of the building and were treated as if they were decoupled from the distribution loop.
- A pressure differential of 10 feet was maintained across every building connection.

- Piping infrastructure was assumed to be carbon steel with minimal deformation or scaling that could impact pressure losses.
- A maximum temperature differential of 10°F was assumed on the supply and return loops of the chilled water system during peak cooling conditions. This temperature differential is higher than the normal 7–8°F differential UH staff informed Jacobs of. The lower temperature differential was implemented in 2018 as part of an energy savings strategy.
- System diversity was assumed to occur simultaneously for all buildings. This assumption was needed because individual campus buildings are not metered. As a result, chilled water requirements per building on an hourly basis are not known. It is likely that building peak loads vary and do not occur simultaneously, but without metering data, quantifying this assumption was not possible.

3.3 Equipment and Infrastructure

3.3.1 Existing Chillers

The chillers in the CUP vary in both age and characteristics. The CUP chiller plant was expanded in 2011 to include three new chillers. Table 3-5 documents the chillers and their associated characteristics. Equipment life span has been based on ASHRAE equipment data for centrifugal chillers across the United States, with a median age of replacement for all centrifugal chillers of approximately 25 years.

Table 3-5. Existing CUP Chillers

Chiller	Manufacturer	Capacity (tons)	Design Chilled Water Flow (gpm)	Type	Compressor Drive	Refrigerant	Installation Year	Estimated Remaining Life (years)	Comments
1	York	2,700	6,471	Centrifugal	Variable Speed	134A	2019	22	--
2A	York	2,250	5,400	Centrifugal	Constant Speed	134A	2005	8	--
2B	York	2,250	5,400	Centrifugal	Constant Speed	134A	2005	8	--
3	York	4,500	10,800	Centrifugal	Constant Speed	R22	1986	(11)	Replacement of this chiller is in progress.
4	York	5,000	24,000	Centrifugal	Constant Speed	134A	2005	8	--
5	York	2,700	6,471	Centrifugal	Variable Speed	134A	2011	14	--
6	York	2,700	6,471	Centrifugal	Variable Speed	134A	2011	14	--
7	York	2,700	6,471	Centrifugal	Variable Speed	134A	2011	14	--

3.3.2 Existing Cooling Towers

The existing cooling towers at the CUP are site-built concrete towers with concrete basin. The towers are arranged to allow any tower to operate with any chiller to give maximum flexibility and redundancy. The towers are relatively new and no structural or mechanical deficiencies were observed. Table 3-6 lists the design characteristics of the towers. The ASHRAE equipment database has limited data available for site-built cooling towers. However, based on Jacobs' experiences with similar towers, it is estimated the lifespan should be approximately 30 years.

Table 3-6. Existing CUP Cooling Towers

Tower	Manufacturer	Type	Fan (hp)	Fan Drive	Flow (gpm)	Installation Date	Estimated Remaining Life (years)
1	Tower Engineering	Counter Flow	300	Variable Speed	15,000	2013	21
2	Tower Engineering	Counter Flow	300	Variable Speed	15,000	2013	21
3	Tower Engineering	Counter Flow	300	Variable Speed	15,000	2012	20
4	Tower Engineering	Counter Flow	300	Variable Speed	15,000	2011	19
5	Tower Engineering	Counter Flow	300	Variable Speed	15,000	2011	19

3.3.3 Existing Condenser Water Pumps

The condenser water pumps were installed with the first set of cooling towers. The pumps appear to be in good working order and interviews with UH staff did not reveal any existing deficiencies. The life of a condenser water pump will vary depending on constituents in the water pumped. Oxygen and dirt or other solids in water will have an abrasive and corrosive effect on the pump. The operating life of a condenser water pump is approximately 15 years before a rebuild is required and 30 years before a full replacement is typically needed. Table 3-7 lists system condenser pumps and characteristics as well as estimated remaining service life.

The control sequence for the condenser water pumps states that the variable speed drives are to be run at full speed. Refer to the control sequence in Appendix E, specifically drawing A01-04 line 13.1.1. Jacobs recommends revising the control sequence to take advantage of the efficiency which can be gained from variable speed drives, such as optimized condenser water flow. The addition of variable speed drives to constant speed pumps might be possible. However, the electrical motors should be inspected to verify that motor is compatible with variable speed drives. Additionally, upgrading drives may not be economically feasible. Based on the electric utility rate in Section 8.4, a new variable speed drive may cost more than recovered costs over the life of the motor.

Table 3-7. Existing CUP Condenser Water Pumps

Pump	Manufacturer	Type	Motor Size (hp)	Head (feet)	Flow (gpm)	Installation Year	Estimated Remaining Life (years)	Pump Speed
1A	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Variable
1B	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Constant
2A	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Variable
2B	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Constant
3A	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Variable
3B	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Constant
4A	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Variable
4B	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Constant
5A	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Variable
5B	Sulzer	Vertical Turbine	300	105	7,500	2011	19	Constant

3.3.4 Existing Chilled Water Pumps

The useful life of a chilled water pump will vary based on the amount of time the pump is operated and the service conditions, such as water quality and number of motor starts. A well-maintained chilled water pump that undergoes relatively few start-stops has a typical operating life of approximately 30 years. Pumps exceeding the typical operating life could still be usable, but Jacobs recommends rebuilding pumps and motors with verification of pump condition by a factory service technician. Table 3-8 lists existing pumps, their characteristics and their estimated remaining life. As shown in Table 3-8, Pumps 1 through 4 are older, constant speed pumps. When these pumps are replaced, they will need to be upgraded with variable speed drives to comply with motor requirements specified in the International Energy Conservation Code. The control sequence for the plant will also need to be revised to accommodate the variable speed drives. For costing, Jacobs has assumed these pumps and motors will be replaced with variable speed drives.

Table 3-8. Existing CUP Chilled Water Pumps

Pump	Manufacturer	Type	Motor Size (hp)	Head (feet)	Flow (gpm)	Installation Year	Estimated Remaining Life (years)	Speed
1	Johnston	Vertical Turbine	200	150	4,500	1967	(25)	Constant
2	Johnston	Vertical Turbine	200	150	4,500	1967	(25)	Constant
3	Floway	Vertical Turbine	300	160	6,000	1972	(20)	Constant
4	Floway	Vertical Turbine	450	160	9,000	1972	(20)	Constant
5	Armstrong	Vertical Turbine	350	165	6,240	2019	27	Variable
6	Armstrong	Vertical Turbine	350	165	6,240	2019	27	Variable
7	Removed from service							
8	Aurora	Horizontal Split Case	350	165	6,240	2011	19	Variable
9	Aurora	Horizontal Split Case	350	165	6,240	2011	19	Variable
10	Aurora	Horizontal Split Case	350	165	6,240	2011	19	Variable

3.3.5 Existing Condenser Water Piping and Valves

The condenser water piping and equipment is located at the CUP. The condenser water piping was modified when the cooling towers were replaced in 2011. Condenser water piping can have a relatively short lifespan due to oxygen that is inherently dissolved in water that passes through a cooling tower. Oxygen reacts with steel piping and causes corrosion. While additives are available to reduce corrosion, steel pipe in contact with oxygen will corrode over time. The typical lifespan of steel condenser water piping is 15–20 years; Jacobs recommends annual pipe inspections determine pipe wall thickness and progression of any corrosion.

Control valves are an important part of the piping system. The valves direct the water to the equipment and help to maintain control setpoints such as pressure and temperature. Jacobs recommends operating and inspecting automatic control valves annually. Pneumatic actuators can have a long lifespan, sometimes exceeding 30 years, if they are properly maintained.

3.3.6 Existing Chilled Water Distribution Infrastructure

On campus, chilled water is distributed from the existing CUP to individual buildings through piping located in the tunnel system. This tunnel system was constructed in several phases beginning in the early 1960s and late 1980s. A significant portion of the chilled water infrastructure is original carbon steel piping with glass fiber insulation and has some deficiencies. The deficiencies are discussed in depth in Section 3.4.

The chilled water system is a looped system. Several of the loops were added to the system as the campus expanded to serve new buildings. This has created a networked piping system where water can flow in different directions depending on which part of campus has the greatest demand for chilled water.

A recent expansion of the CUP in 2012 added chilled water capacity and installed a new set of 30-inch pipes that supply chilled water to two of the critical system loops on campus. This piping interconnects with chilled water loops in the tunnel system to the west of the CUP.

3.3.7 Campus Chilled Water Controls

Chilled water pump operation is currently controlled using input from a single differential pressure sensor located in the south tunnel. The control system stages the number of pumps to maintain an approximate 5-pound per square inch gauge (psig) pressure differential during peak cooling conditions. Appendix E contains a map of the existing differential pressure sensors in the campus system and notes the location of the sensor in the south tunnel.

As some of the pumps in the system are constant speed, the system preferentially runs the variable speed pumps before running the constant speed pumps to better optimize energy use. Appendix E contains the current control sequence for reference. There is an existing energy optimization control system that is designed to help optimize pump and chiller staging. However, per interviews with UH staff, there are times when CUP operators override this system to maintain cooling setpoints at problematic buildings.

Additional differential pressure sensors and flow meters would allow for better chilled water system operation and control optimization as the chilled water pumps and chillers could be better controlled to meet the system demands. A complete optimization project would need to be undertaken once the additional differential pressure sensors and flow meters were installed to quantify energy savings and further optimize system performance.

3.4 Chilled Water System Deficiencies Identified for Remediation

3.4.1 Chilled Water Pipe Insulation

A prior condition assessment of the tunnel system by Shah Smith in 2013 reported that the existing chilled water pipe insulation is in poor condition. While not critical to system operation, energy efficiency could be improved by replacing pipe insulation. The 2013 Shah Smith report noted that existing piping insulation was retaining water. Figure 3-3 shows a photograph from the 2013 Shah Smith report where water was observed flowing out from insulation. Another critical factor is that wet insulation tends to cause corrosion under insulation (CUI). This happens when water is trapped and stays in continuous contact with metal pipe. This is not uncommon in chilled water piping systems as chilled water pipe temperatures are often below the dew point of air causing condensation on the pipe. As chilled water piping is replaced, Jacobs recommends specifying pipe with an external coating to prevent CUI, reducing the corrosion rate. Current UH design standards list either cellular glass or polyethylene as acceptable forms of pipe insulation, which will help to prevent water from accumulating next to piping. For the cost estimate in this EMP, Jacobs assumed that pipe insulation will be replaced when the chilled water piping is replaced.

Source: Shah Smith 2013

Figure 3-3. Saturated Chilled Water Piping Insulation Leaking Water

3.4.2 Chilled Water Piping Corrosion

The 2013 Shah Smith report noted several deficiencies mostly related to pipe supports and exterior corrosion. This is not uncommon for a tunnel system of this age; however, repairs will be required to maintain reliable operation into the future. Most of the chilled water piping is in acceptable condition, with some sections in need of replacement due to corrosion. Figure 3-4 is a photograph from the 2013 Shah Smith report (Shah Smith 2013) showing pipe with external corrosion. Refer to Section 3.5 EMP for addi

tional discussion about replacing chilled water piping. Refer to Section 6.3 for more information about replacing pipe supports.

Source: Shah Smith 2013

Figure 3-4. Corrosion at H36 on the Chilled Water System

3.4.3 Chilled Water System Leaks

The chilled water system only requires make-up water due to leaks as it was designed as a closed system. However, due to system leaks, the campus uses approximately 1,000 gallons of water per a day. Section 7 of this EMP provides additional information about the water leakage rates of the chilled water system. Some of this water being lost is due to labs using and dumping water directly to drain; this is currently being addressed by the university. The remainder of water loss is due to leaks, usually caused by loss of pipe integrity, which is not uncommon in a campus distribution system. Leaks in piping itself would be partially addressed as piping is replaced.

3.4.4 Chilled Water Valve Replacement in Tunnel System

Valves are a critical item in a chilled water piping system. Valves allow a portion of the system to be isolated for maintenance, repair, or modification. As noted in the 2013 Shah Smith report, most of the system's valves are original and have exceeded their design lifespan of 30 years. Appendix E contains a copy of Appendix 4 from the 2013 Shah Smith report, which discusses valves. Jacobs assumed a lump sum replacement value for the EMP cost estimate. However, it is likely that replacement work will need to be phased across several years. This would also be coordinated with any scheduled piping upgrades to minimize downtime at any individual building.

3.4.5 Chilled Water Velocities at CUP

As the campus has grown, so has the chilled water plant. The CUP expansion in 2012 added three new chillers to serve the campus. New piping from the new chilled water pumps created a parallel feed that connects into the chilled water system west of Building 503. However, even with this additional parallel feed, when the campus cooling load is at its peak, there are several sections on the south side of the CUP with pipe water velocities exceeding 10 feet/second. The typical recommended maximum velocity for chilled water piping to minimize erosion is 10 feet/second per the ASHRAE *2021 Handbook Fundamentals* (ASHRAE 2021). Figure 3-5 shows the high velocity areas based on the peak cooling loads of the current campus and the existing piping configuration. Piping shown in orange and red note the velocities have been exceeded, which means some of the piping is undersized at peak loads. A larger image of the base analysis piping system can be found in Appendix F.

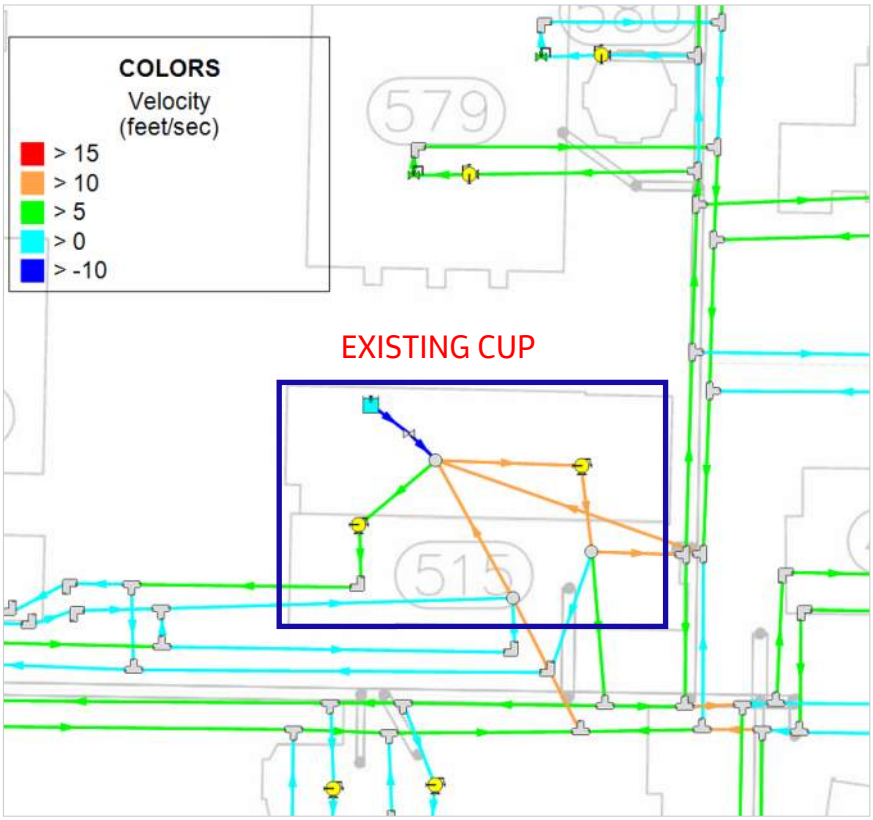

Figure 3-5. Piping South of Central Utility Plant with High Velocities

To address high velocities in system piping, Jacobs does not recommend any further installation of chillers at the CUP unless additional piping is also installed to reduce velocities exceeding 10 feet/second as shown in Figure 3-5. Additional information about expanding the existing CUP can be found in Section 8.7 of this EMP.

3.4.6 Chilled Water Pressure Differential at Athletics Area of Campus

The campus chilled water system serves Buildings 482, 531, and 574 in the Athletics Area of campus. This location also has the worst differential pressure between supply and chilled water piping systems at approximately -15 pounds per square inch (psi) during peak cooling. A negative value indicates the return pipe is at a higher pressure, which can indicate a building may not be receiving adequate chilled water as building pumps are typically not sized for this additional pressure rise. Ideally, differential pressure should

be positive. However, this is not always possible in a large campus system. The 2013 Shah Smith report contains additional information specific to the negative pressures in the piping in the Athletics area of campus.

There are options for resolving pressure issues depending on how the campus elects to proceed with chilled water system expansion. The first option would be to increase pipe size from the tunnel connection east of Building 549 to the tee east of Building 482. The second option would be placing a new satellite chilled water production facility at Site Option 3 (refer to Section 9). This would help to resolve pressure issues. For cost estimating purposes, Jacobs has assumed piping will be increased in size. Figure 3-6 shows the section of pipe used to estimate cost of replacement. A larger version of this image can be found in Appendix H.

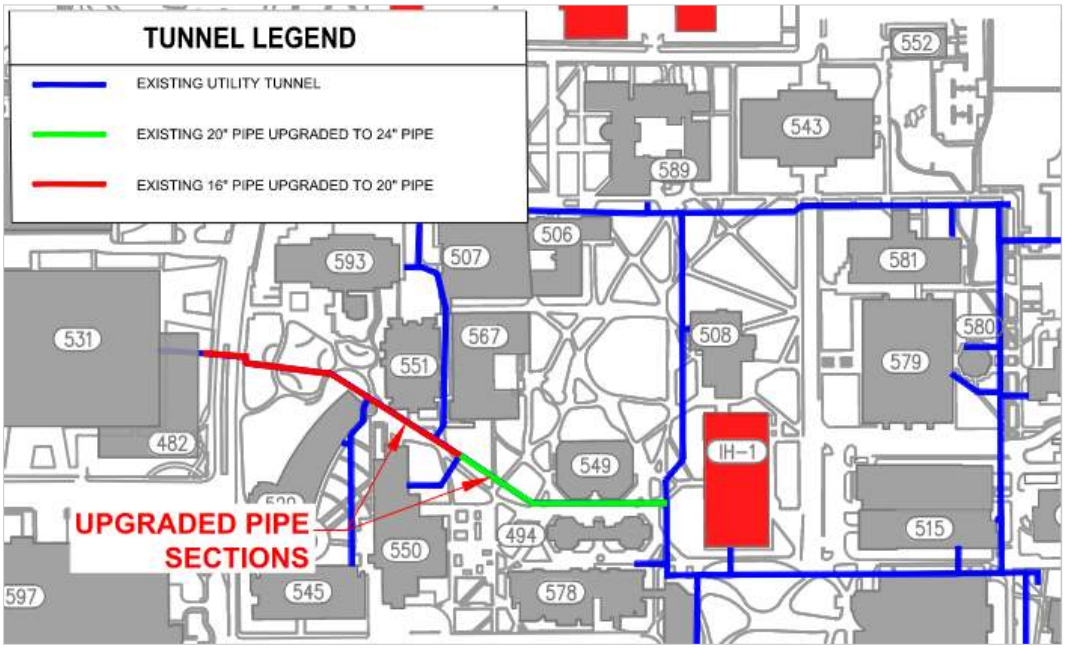

Figure 3-6. Piping Serving the Athletics Section of Campus

3.5 Chilled Water System Upgrades

The existing chilled water system is cooling the campus adequately without redundancy. However, there are some upgrades that could increase system reliability, decrease energy costs, and decrease operations and maintenance (O&M) costs.

3.5.1 Chilled Water Pumping Configuration

The existing chilled water pumping system is a variable volume primary system. There are two pump systems in the CUP with a cross connection between the systems for redundancy. The original system serves Chillers 1 through 4, and the second system serves Chillers 5 through 7. Chillers 1 through 4 are installed in the original section of the CUP. As such the piping and pumps are configured to only support those chillers, and additional capacity is not available. When the CUP was expanded in 2011, additional pumping was required, and new pumps were installed.

There are several pumping configurations available to distribute chilled water from the CUP to individual buildings connected to the campus loop. Appendix C describes the arrangement and operation of each pumping scheme.

If the existing CUP is expanded, Jacobs recommends leaving the current variable volume system in place. This would allow for better system integration and control among existing and new systems.

If UH determines that a new satellite plant or CHP is best solution, then Jacobs recommends a variable primary/variable secondary pumping scheme. This system would be able to isolate control of system production components (such as the chillers and plant) from the distribution system and the connected buildings. To provide increased operational flexibility, Jacobs recommends that the pumps are connected in a header configuration to allow any pump to operate with any chiller.

3.5.2 Chilled Water Pump Upgrades

The chilled water pumps are a mix of constant and variable speed pumps. Also, based on the age of the pumps, some are likely approaching their end of useful life. It is likely that, by replacing pumps, pumping efficiencies will increase, as the pumps will have variable speed drives, which will both reduce electricity costs, and help reduce the campus' carbon footprint. Variable speed drives will also help with better chilled water flow control, as any operating pumps would better match chilled water system pressure requirements. For the EMP cost estimate, Jacobs assumed the pumps will be replaced in their entirety and that they will be upgraded with variable speed drives.

3.5.3 Condenser Water Filtration

The use of filtration systems, beyond that of a standard wire mesh strainer, on the condenser water systems will help to improve heat transfer in the chillers by removing fine particulate matter that accumulates on chiller tubes. This is typically accomplished by using a side stream filtration system. For the cooling towers at UH, Jacobs recommends a high-efficiency sand filtration system similar to the Nalco UltraSand Plus HEF. The approximate system requirements are listed in Table 3-9.

Table 3-9. Filtration System Schedule

System	Type	Flow (gpm)	Filtration Level	Size (hp)	Electrical
Condenser Water	Sand	400	<1.0 micron	10	480-volt, three phase

While filtration will not eliminate the need for annual tube cleaning, it would likely reduce the amount of sediment on tubes during the year and increase chiller efficiency. A filtration system may also reduce the need for chemicals in condenser water by reducing biological growth/contaminants that algae and bacteria eat.

3.5.4 Tunnel System Chilled Water Piping Replacement

The chilled water distribution system is critical for the campus. A break in this system has the potential to take down the cooling systems across the entire campus. While a catastrophic rupture is unlikely, it is not out of the realm of possibility. Ruptures could be caused by localized corrosion or by excessive force on piping caused by pipe support failure. The 2013 Shah Smith report, specifically in Appendix 5, notes that there are some pipes that are well past their useful life. To resolve this deficiency, piping will need to be replaced. Piping could be replaced either like for like, which would then mean the campus would likely need to replace piping in the future, or UH could elect to replace steel pipes with high-density polyethylene (HDPE) pipes, which would not corrode. Replacing the piping will be a multi-year project that will have to be carefully phased. Prior to undertaking this project, Jacobs recommends a developing a phasing plan based on non-destructive testing to determine areas of pipe that are most degraded. For cost estimating, Jacobs assumed that a fixed amount of piping would be replaced each year to minimize disruptions to the campus distribution system, and to allow for more manageable costs.

3.5.5 Chilled Water Metering

Most of the buildings on campus do not have metering on the chilled water system. While metering is done at the CUP to determine campus chilled water demand, individual building demands are not known. To help better determine loads at individual buildings and to better monitor potential leaks, Jacobs recommends installing meters on every building served by the chilled water system. Measuring energy consumption at the building level is an important part of an energy management process and would be key to identifying buildings for upgrades as described in Section 7 of this EMP. The meters would be Onicon F-1200 dual turbine flow meters per campus design standards (UH 2018) and would be installed on both the supply and return sides of the chilled water piping serving each building. Appendix D contains a complete list of meters and associated buildings requiring meters.

3.6 College of Medicine Chilled Water Connection Challenges

Placing the COM onto the existing chilled water system presents some challenges, as described below.

First, the COM campus would add approximately 3,800 tons onto the existing chilled water system. To accommodate the additional load, sections of the existing chilled water piping infrastructure will need to be upgraded. Specifics of the upgrade will depend on where additional chillers are located on campus. Additionally, if the COM is connected via a single set of pipes to the chilled water system, any failure would cause all COM cooling to fail.

Additionally, chilled water piping would need to cross Brays Bayou. One possible solution would be to suspend the chilled water supply and return lines below the bridge structure crossing the bayou. However, the feasibility of this concept has not been verified with the Texas Department of Transportation or City of Houston. If piping cannot be attached to the existing bridge, then pipes will either need to be installed using directional drilling under Brays Bayou, or a new structure will need to be built to support the piping.

Finally, the current chilled water system operates using 5–10°F temperature differential between supply and return. If the COM was on a separate chilled water system, more efficient chillers, a higher temperature differential of 10–15°F, and more energy efficient control systems could be used. This would decrease electricity usage and decrease the campus' carbon footprint.

Based on the challenges described above, Jacobs does not recommend integrating the COM into the campus chilled water system.

3.7 Recommended Chilled Water Projects

As part of this EMP, Jacobs recommends the chilled water deferred maintenance and upgrade projects as described in Table 3-10 to increase system reliability and reduce energy use. Expansion of the chilled water system capacity is discussed separately in Section 8 of this EMP.

Table 3-10. Chilled Water System Cost Estimate Summary

Item	Identifier	Description	Cost ($)		Remarks
			Deficiency	Upgrade	
1	CHW-01	Survey of chilled water system with non-destructive testing	107,000	--	--
2	CHW-02	Replace Chilled Water Pump 1 with a new 4,500-gpm vertical turbine pump on variable speed drive	247,000	--	--
3	CHW-03	Replace Chilled Water Pump 2 with new 4,500-gpm vertical turbine pump on variable speed drive	247,000	--	--
4	CHW-04	Replace Chilled Water Pump 3 with new 6,000-gpm vertical turbine pump on variable speed drive	304,000	--	--
5	CHW-05	Replace Chilled Water Pump 4 with new 9,000-gpm vertical turbine pump on variable speed drive	428,000	--	--
6	CHW-06	Optimize chilled water control system after equipment in CUP has been upgraded	--	76,000	--
7	CHW-07	Replace 500 feet of 20-inch chilled water supply and return piping per year in the distribution system in the tunnels; does not include pipe supports	10,880,000	--	$680,000 per year for 16 years. Replaces approximately 50% of piping.
8	CHW-08	Replace chilled water piping serving Athletics Area of campus	3,225,000	--	--
9	CHW-09	Replace chilled water valves in distribution system	1,336,000	--	--
10	CHW-10	Install condenser water filtration system	--	138,000	--
11	CHW-11	Chilled water meters for all buildings on campus	--	679,000	--
		Total	16,774,000	893,000	--

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4. Steam and Condensate Systems

4.1 Overview

The UH campus has three utility plants that heat a majority of the campus. The steam equipment servicing the majority of the main campus is located in the CUP. Two satellite utility plants are located outside of the CUP. The first is the Recreation and Wellness Plant and the second is in the Health District Plant. These plants do not connect into the existing steam system that connects most of the buildings on campus to the boilers in the CUP. The Recreation and Wellness Plant and Health District Plant are sized and designed to serve the local buildings. Integration of these two plants onto the steam and condensate distribution system serving the rest of campus would not be economical and is not considered in this EMP.

Campus steam at the CUP is generated using three boilers that create saturated steam at 80 pounds per square inch gauge (psig). This steam is then sent out to the campus for year-round use, including comfort heating, domestic water heating, and some process applications such as sterilizing laboratory equipment.

Steam is reduced from the received pressure to 15 psig at the building for use in heat exchangers by using pressure-reducing valves (PRVs). These PRVs are typically sized for an entering steam pressure of 75 psig, Should the pressure in the distribution system fall below 75 psig at any building connection, then it is possible for a critical flow condition to exist in the PRV, which will limit mass flow through the PRV.

All of the steam distribution and condensate return piping is within the same tunnel system that also contains the chilled water piping. Most of the steam and condensate piping appears to have been installed when the tunnels were originally constructed. It is likely that some sections may have been replaced but accurate records are not available. For the purposes of this EMP, Jacobs assumed piping was installed at the same time as the chilled water piping in the early 1960s and late 1980s.

4.2 Steam System Modeling

Jacobs developed a model of the steam system to evaluate current system capacity and how future modifications might affect capacity. This section describes the methods used to develop steam loads, and the approach for developing the piping model.

4.2.1 Approach

Jacobs developed flow models for the existing and proposed system configurations using AFT Arrow, which is a compressible fluid modeling software package for compressible fluids such as steam. AFT Arrow uses inputs such as flow rates, routing distance, valves, fittings, and equipment pressure drops to calculate velocities and the pressure losses throughout the entire system. As a result, Jacobs can identify areas with insufficient flow or pressure drops and model different configurations to determine the most efficient method to serve the systems.

To help validate the baseline model and associated data against previous studies and data, Jacobs first created a baseline model to reproduce existing conditions. Existing conditions, including flow rates, were taken from the 2013 Shah Smith report. Once the baseline model was able to replicate the Shah Smith data, then additional AFT Arrow models representing different system configurations with possible future system loads were created. These variant models updated pipe sizes, pipe routing configurations, flows, and steam boiler plant locations. Refer to Appendix F for the models.

4.2.2 Existing Steam Loads

As hourly steam loads were not available, Jacobs used monthly gas consumption and typical equipment efficiencies to estimate daily average steam production. Figure 4-1 shows the average daily steam load profile for 2018. Jacobs used the 2018 data instead of the 2019 data because the average monthly temperatures more closely match the historical average. This also removed the abnormally low campus load data created by the impact of the COVID-19 pandemic from early 2020 until late 2021.

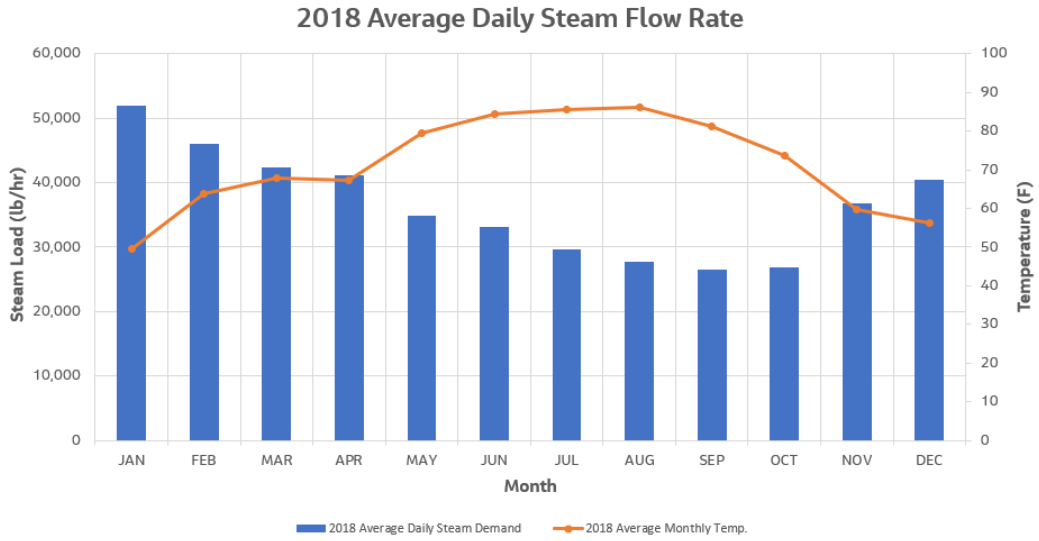

Figure 4-1. 2018 Steam Load

Appendix B contains a summary of loads that were used during analysis for the existing buildings. Flow rates were based on the 2013 Shah Smith report and on information collected during interviews with UH staff.

Several buildings were added to the campus after the completion of the 2013 Shah Smith report. As there is limited documentation regarding the actual diversified loads for the buildings, data regression of similar buildings on campus was performed to estimate the diversified load. Table 4-1 presents the approximate base and diversified loads for similar buildings on campus.

Table 4-1. Existing Building Load Development

Building Type	Base Load (Btuh/ft^2) [a, b]	Diversified Load (Btuh/ft^2) [c]
Dormitory or Residential Housing	17.3	7.8
Athletics	21.3	9.6
Classroom	12.2	5.5
Office	12.2	5.5
Laboratory	22.5	10.1
Library	13.1	5.9
Food Services	11.3	5.1

Note:

[a] Building heating load is approximate based on similar buildings on campus and engineering judgment.
[b] Assumes 5 psig steam used in the heat exchangers.
[c] Uses a diversity factor of 45% to adjust load to that more closely matched existing building loads.

4.2.3 College of Medicine Hospital Steam Connection

The UH *College of Medicine Master Plan* (UH 2018) shows a proposed 150,000-square foot hospital being constructed on the south side of campus. The hospital has been excluded from consideration in this EMP.

4.2.4 Future Steam Loads 2022–2040

As many future campus buildings are still in the conceptual phase, Jacobs made assumptions about their respective steam demand. To account for the future steam load, an averaged load per square foot was used. Table 4-2 lists the assumed values. Table 4-2 lists the assumed values used to develop future steam loads.

Table 4-2. Future Buildings Load Development

Building Type	Base Load (Btuh/ft^2) [a, b]	Diversified Load (Btuh/ft^2) [c]
Dormitory or Residential Housing	17.3	7.8
Athletics	21.3	9.6
Classroom	12.2	5.5
Office	12.2	5.5
Laboratory	22.5	10.1
Library	13.1	5.9
Food Services	11.3	5.1
Medical Office Building	17.4	7.8
Retail	8.7	3.9

Note:

[a] Building heating load is approximate based on similar buildings on campus and engineering judgment.

[b] Assumes 5 psig steam used in the heat exchangers. Actual pressure in heat exchanger will vary depending on building load.

[c] Diversity factor of 45% used to adjust loads to match similar existing buildings more closely.

Table 4-3 lists loads for new buildings identified by UH that are scheduled for construction between 2022 and 2040.

Table 4-3. Flow Modeling Analysis Building Loads

Building	Building Name	Building Type	Peak Building Load (pounds per hour) [c]	AFT Model Flow (pounds per hour) [a]
487-EXP	Student Center North Expansion	Food Services	708	319
AB-1	Academic Building 1	Classroom	1,016	457
AB-2	Academic Building 2	Classroom	1,524	686
AD-1	Administration Building	Office	1,016	457
ALUM-1	Alumni Building	Office	762	343
IH-1	Innovation Hub	Lab	2,814	1,266
LAW	Law Building [e]	Office	--	--
MR-1	Moody Tower Replacement	Housing	5,411	2,435
PAB-1	Performing Arts Building 1	Classroom	1,524	686
PAB-2	Performing Arts Building 2	Classroom	1,524	686

Table 4-3. Flow Modeling Analysis Building Loads

Building	Building Name	Building Type	Peak Building Load (pounds per hour) [c]	AFT Model Flow (pounds per hour) [a]
PAB-3	Performing Arts Building 3	Classroom	1,524	686
540	Law Library [d]	Library	(337)	(337)
503	Technology Annex [b]	Lab	(392)	(392)
584	Moody Towers [b, f]	Housing	(5,024)	(2,435)
590C	Hilton Hotel Section C [e]	Housing	--	--
COM-Class	College of Medicine Building 1	Classroom	1,620	729
COM-Nursing	Nursing	Classroom	1,207	543
COM-Office	Office	Office	1,905	857
COM-Retail	Retail	Retail	907	408
COM-Lab	Lab, Research, Vivarium	Lab	4,689	2,110
COM-MOB	Clinic	Medical Office	1,815	817
COM-Housing 1	Housing	Housing	1,948	877
COM-Housing 2	Housing	Housing	1,948	877
		Total	29,827	13,798

Note:

[a] Building will be demolished.

[b] Building assumed to be demolished; thus, removal of the load.

[c] Assumes 5 psig steam used in the heat exchangers.

[d] Building served from Building 537.

[e] Building does not have a steam connection and is shown for completeness only.

[f] Existing load assumed to be the same a Moody Tower Replacement.

Table 4-4 compares the available capacity of existing steam boilers to required demand. Based on the calculation, expansion of the existing steam system is not required at this time. In Table 4-4, positive values denote production, and negative values denote consumption. In the "Capacity vs Load Difference" row below, the positive value shows that the existing CUP can support campus expansion without additional capacity.

Table 4-4. University of Houston Steam Demand Summary

Item	Load (kpph)	Data Source	Remarks
Boiler Capacity [a]	90.0	Table 4-5	Assumes two of the three boilers online
Existing Building Loads	(60.6)	Appendix B	--
Steam Plant Auxiliaries	(3.0)	--	Assumed 5% of existing campus load
Distribution Losses	(4.4)		Calculated value based off existing pipe sizes [b]
Future Building Loads	(4.8)	Table 4-3	--
COM	(7.2)	Table 4-3	All buildings shown on the COM masterplan except the hospital
Extra Capacity for Growth and Factor of Safety	(8.0)	--	Approximately 10% spare capacity beyond current future growth
Capacity vs Load Difference	**2.0**	--	--

Note:

[a] Refer to Section 4.3 for existing boiler information. Load shown is firm capacity for the plant.

[b] Preliminary heat loss calculations were performed assuming 1-inch fiberglass insulation with an all-service jacket with an ambient temperature of 75°F in still air. Additional heat losses possible if insulation is either wet or significantly degraded.

Figure 4-3 shows the projected steam consumption growth and existing boiler firm capacity from 2022–2040. The COM is not included in the figure as integration of the COM into the existing steam and condensate infrastructure is not recommended. Refer to Section 4.6 for additional information.

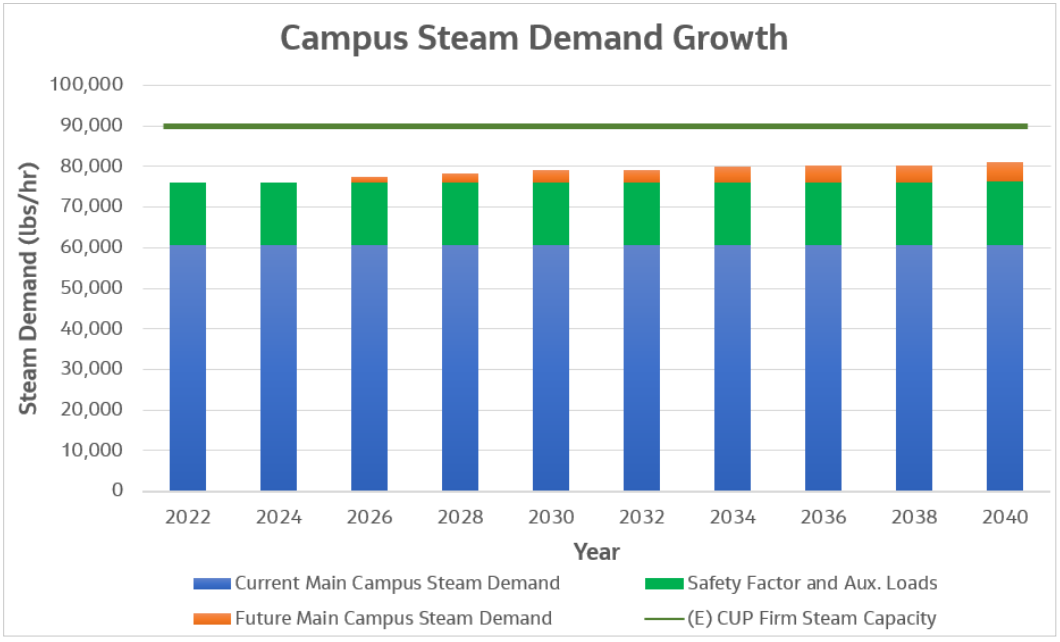

Figure 4-2. Projected Campus Steam Growth 2022–2040

4.2.5 Steam Modeling Assumptions

To model the steam system, Jacobs made the following assumptions about system capacities and general operation:

- Steam is generated by the boilers at 80 psig before being distributed from the CUP to the steam distribution systems serving the campus buildings.
- Piping infrastructure is carbon steel and has minimal deformation or scaling that might impact pressure losses.
- Steam for building heating and hot water production is reduced to 15 psig at each building.
- System diversity occurs simultaneously for all buildings at the same time. This assumption is needed because individual campus buildings are not metered and steam requirements per building by hour are not known. It is likely that building peak loads vary and are not concurrent, but without metering data to confirm, quantifying this assumption is not possible.

4.3 Equipment and Infrastructure

In 2012, the boilers and a significant portion of the existing steam equipment including the deaerator and feedwater pumps were replaced. As steam plant equipment is typically designed to have a service life of 30 years or more, and maintenance on existing equipment appears to be good based on visual inspections and information collected during interviews with UH staff, it is anticipated that most of equipment has a significant remaining service life. The sections below review equipment existing service life.

4.3.1 Existing Steam Boilers

In 2012, boilers were installed as part of a plant renovation project. The boilers are Victory water tube type with Power Flame burners. Combustion air is drawn from the mechanical room into the boilers. On the CUP roof, there is a feedwater economizer system above the boilers. The economizer appears to have a stainless steel casing around it to protect the piping and heat exchanging elements from the weather. Table 4-5 lists existing CUP boilers.

Table 4-5. Existing CUP Boilers

Boiler	Manufacturer	Capacity (lbs/hr)	Maximum Working Pressure (psig)	Type	Fuel	Installation Year	Estimated Remaining Life (years)
1	Victory Energy	45,000	200	Water tube	Natural gas	2012	20
2	Victory Energy	45,000	200	Water tube	Natural gas	2012	20
3	Victory Energy	45,000	200	Water tube	Natural gas	2012	20

4.3.2 Existing Deaerator Tank and Feedwater Pumps

There is a single deaerator (DA) tank in the CUP and serves the boiler feedwater pumps. A single DA tank is a single point of failure for the steam system; however, DA tanks are relatively robust as there are few moving parts. As a result, Jacobs does not recommend adding a second DA tank. Table 4-6 lists DA tank performance characteristics.

While DA tanks do operate at a lower pressure than a boiler, they are still pressure vessels, and require maintenance and inspection. Jacobs recommends developing a periodic maintenance program for the DA tank to verify all internal mechanisms have minimal wear and that no operational issues exist. This would require fully de-energizing the DA tank, which could require taking steam system offline. The recommended inspection interval is per the National Board of Boiler and Pressure Vessel Inspectors' (NBBI's) National Board Inspection Code (NBBI 2021) for a DA with no cracks and no required repairs.

Table 4-6. Existing Deaerator Tank

DA	Manufacturer	Capacity (lbs/hr)	Working Pressure (psig)	Type	Manufacture Year	Estimated Remaining Life (years) [a]	Comments
1	BFS Industries	90,000	5	Spray scrubber	2011	20	Recommended inspection interval: 3–5 years

Note:

[a] Assumed DA tank began operation in 2012 with the boilers. Life based on 2012 operation date.

4.3.3 Existing Steam and Condensate Piping Infrastructure

The existing steam and condensate distribution system is located in the utility tunnel system. Most of the steam and condensate pipes are believed to have been installed when the tunnels were originally constructed. This EMP did not evaluate the capacity of the condensate system but based on the analysis in the 2013 Shah Smith report, the condensate system likely has capacity for future growth.

Steam pipes typically will last 30+ years under normal operating conditions. Condensate piping has a reduced service life compared to steam piping, as internal corrosion reduces pipe wall thickness to the point of failure. A typical Schedule 80 condensate pipe will have a service life of 15 years. Based on the age of the campus' existing condensate piping, it is likely some replacement will be necessary to maintain the system in good working order. For cost estimating purposes, Jacobs assumed an annual pipe replacement program will need to be undertaken.

4.3.4 Steam Traps

Steam traps are required to remove water from steam piping and prevent damage to the steam system. Steam traps are located throughout the distribution system, inside buildings, and inside the CUP. While traps are necessary for operation, they have a limited service life and can fail in less than 10 years. As a safety feature, most steam traps fail open, which cause the traps to directly transfer steam to the condensate system, or blow out of the system completely, resulting in heat lost to the atmosphere, which decreases system efficiency. Jacobs recommends undertaking a continuous maintenance program to assess the condition steam traps. In the project list, the steam trap line item is an estimated cost for an inspect/replace program on campus.

4.3.5 Existing Water Treatment Equipment

The steam system requires make-up water for two reasons. First is the loss of water due to boiler blowdowns. This water is lost as it is used to remove precipitated hardness and maintain proper pH in the boiler. Second is condensate losses in the distribution system due to pipe leaks and equipment failures. Leaks and failures can prevent condensate from being pumped back to the condensate tank at the CUP. Currently the campus recovers approximately 80% of the condensate. Additional improvements would help to increase this recovery rate.

UH staff treat make-up water for use in the steam system using a zeolite softening system, which is in the CUP. This system is relatively new and appears to be in good working order. Zeolite systems use a resin to remove calcium and other minerals from water and replace it with sodium. This helps keep minerals from building up on boiler tubes, and can extend the boiler's useful life.

Treatment of condensate coming back from campus is done using a polishing softener system. This system helps remove any hardness that could enter condensate from items such as cracked heat exchangers. The polishing softener system is in the CUP, and according to information collected during interviews with UH staff, this system is in good working order.

4.4 Steam System Deficiencies Identified

4.4.1 Existing Central Utility Plant Configuration

The existing CUP was constructed prior to 1965 when the campus underwent an expansion. Much of the equipment configuration has remained similar since original installation. The main deficiency identified during the site walk was that the chillers and the boilers are contained within the same mechanical room. This is typically not allowed by International Association of Plumbing and Mechanic Officials (IAPMO) *2015 Uniform Mechanical Code* (UMC) (IAPMO 2015). However, there are some allowances in Chapter 11 of the UMC to allow for this type of configuration. This could become a more significant issue in the future when new low-GWP refrigerants classified as slightly flammable (A2L) are used new in chillers. Jacobs recommends further review in collaboration with the appropriate authority having jurisdiction when chillers are replaced.

4.5 Steam and Condensate Upgrades

4.5.1 Steam and Condensate Metering

Similar to the chilled water system, most of the campus buildings do not have steam or condensate meters. While metering is performed at the CUP to determine individual boiler flow rates, individual building demands are not known. To better determine individual building loads and identify potential leaks by identifying any unusual trends in the data, Jacobs recommends installing steam meters. The meters would be key to identifying buildings for upgrades as described in Section 7 of this EMP. The steam meters would be Onicon F-2500 type meters per the campus design standards (UH 2018). Alternatively condensate meters could be installed if installing steam meters cannot be done. Appendix D lists meters and associated buildings requiring meters.

4.6 College of Medicine Steam and Condensate Connection Challenges

Placing the COM onto the existing steam and condensate system presents a number of challenges, as described below.

First, while there is sufficient capacity to place the COM onto the steam system, the COM would be the furthest group of buildings from the CUP. To support the added steam load, steam and condensate piping would need to be upgraded in the utility tunnel system to limit pressure drop along the relatively large distance from the CUP to the COM. Additionally, a single steam pipe to the COM would constitute a single point of failure. Any failure or outage of that line could leave the entire COM campus without heat or domestic hot water.

Similarly, steam and condensate piping would need to cross Brays Bayou. One possible solution would be to suspend the steam and condensate lines below the bridge structure crossing the bayou. However, the

feasibility of this concept has not been verified with the Texas Department of Transportation or City of Houston. If piping cannot be attached to the existing bridge, then a new structure would need to be constructed for the piping. This would add cost to the project and would require regular maintenance.

Perhaps most importantly, hydronic (hot water) systems are superior to steam systems for modern thermal energy projects. A hydronic system can have boilers with efficiencies of over 90% and are more well suited to take advantage of lower temperature sources of waste heat, such as heat recovery chillers. A steam system, on the other hand, typically has an efficiency of approximately 76%. Hot water piping also has a longer service life and requires considerably less maintenance as compared to steam and condensate. For these reasons, Jacobs would recommend developing a hydronic system for heating needs at the COM.

Therefore, Jacobs does not recommend integrating the COM into the campus steam system.

4.7 Recommended Steam and Condensate Projects

As part of this EMP, Jacobs recommends the steam system deferred maintenance and upgrade projects as described in Table 4-7 to extend the life of the system, increase system reliability and reduce energy use.

Modifications to the steam production equipment are in Section 8 of this EMP.

Table 4-7. Steam System Cost Estimate Summary

Item	Identifier	Description	Cost ($)		Remarks
			Deficiency	Upgrade	
1	STM-01	DA tank inspections	27,000	--	--
2	STM-02	Replace of 500 feet of 6-inch condensate pipe per year; does not include pipe supports	3,904,000	--	$195,000 per year for 16 years. Replaces approximately 50% of piping.
3	STM-03	Steam trap maintenance program allowance	214,000	--	$86,000 every 10 years
4	STM-04	Steam meters for all buildings on campus	--	652,000	Meter only. For integration into SCADA system refer to Section 7
5	STM-05	Condensate meters for all buildings on campus	--	595,000	Meter only. For integration into SCADA system refer to Section 7
		Total	4,145,000	1,247,000	--

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5. Electrical Systems

5.1 Overview

Cougar Substation is the primary source of power for the main campus, providing power through five 12.47-kV feeders. The substation is east of State Highway 5 adjacent to Technology Bridge campus. This substation, originally built in 1998, is served by two 138-kV utility feeders, one from the University Substation and the other from PH Robinson Substation, which are both owned by CenterPoint Energy (CPE). The 138-kV supply feeds are stepped down to 12.47 kV through three transformers, and five outgoing 12.47-kV feeders from this substation serve the main campus.

Cougar 1, Cougar 2, and Cougar 3 are the three12.47-kV feeders serving the main campus and CUP loads through their respective campus and plant switchgear in the CUP. These feeder circuits were installed between 1970 and 1990 to support campus growth. Each feeder circuit is approximately 1 mile long, running between Cougar Substation and the CUP with about 0.4 mile of overhead conductors and 0.6 mile of underground cable sections.

Cougar Substation was equipped with two 141/12.47 kV transformers when it was built in 1998. In 2018, the substation was expanded to accommodate a third transformer and two more 12.47-kV circuits (Cougar 4 and Cougar 5) to support campus growth. Cougar 4 and Cougar 5 serve the campus through a campus switchgear in the Health Plant. Figure 5-1 shows the locations of Cougar Substation and the campus switchgear. A larger version of this image can be found in Appendix H.

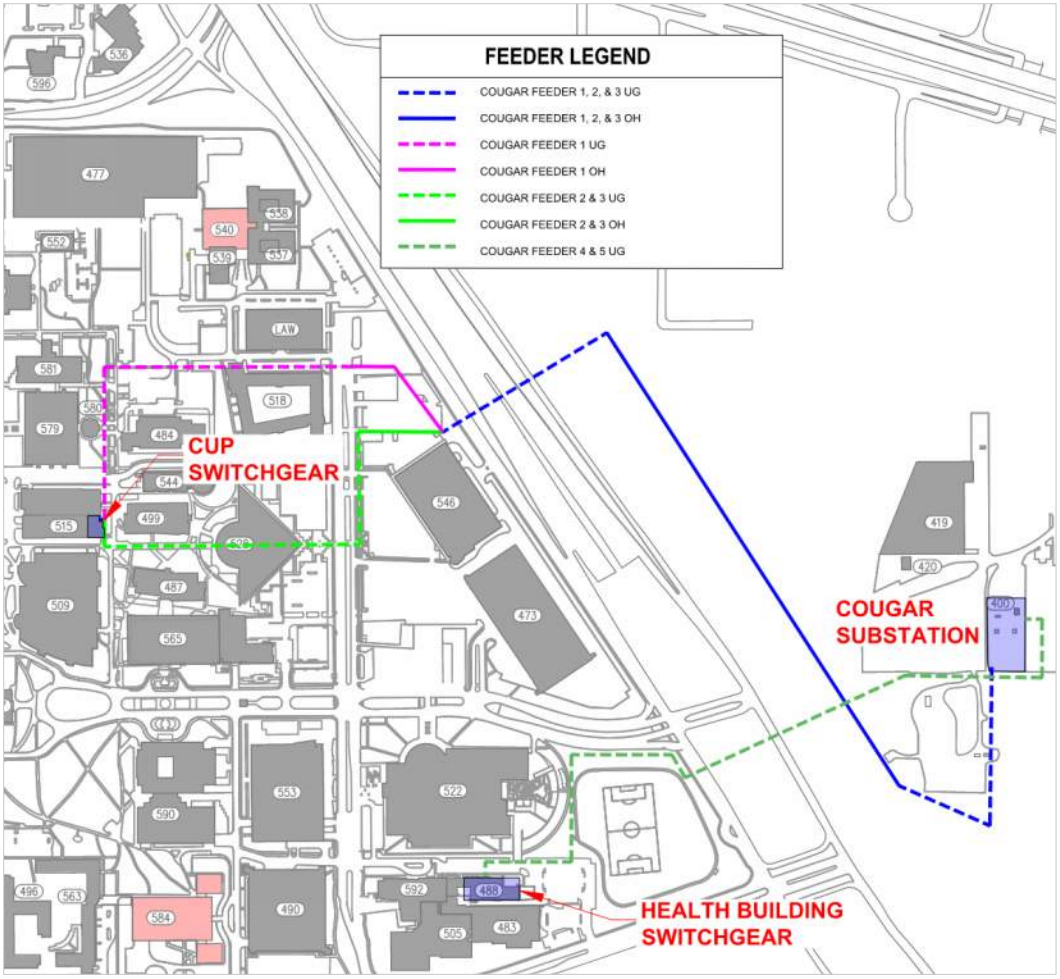


Figure 5-1. Cougar Substation and Campus Switchgear Locations

5.2 Electrical System Demand

5.2.1 Existing Campus Electrical Demand

Figure 5-2 shows campus electrical demand from January 2019 to January 2022. These data show combined electrical demand for all three transformers at Cougar Substation. Buildings not connected to the Cougar Substation distribution system are not included in electrical demand except the ones described below. For projecting electrical demand, Jacobs only used data from 2019, as 2020 and 2021 data are skewed due to reduced occupancy as a result of the COVID-19 pandemic. Typically, demand peaks during the summer, which is approximately correlated with peak cooling requirements. Peak electrical demand is approximately 39 MW. Minimum electrical demand occurs in the winter and is likely associated with the university's scheduled winter break. Minimum electrical demand is approximately 21 MW.

Power demand data for loads served directly by CPE is not available except for Cougar Place (495), Cougar Village 2 (496), Cougar Woods Dining Hall (497), Football Indoor Practice Facility (480), Guy V Lewis Development Facility (482) and TDECU Stadium (485). Demand readings from these loads were included in the load profile to analyze the capacity of Cougar Substation transformers should these loads be transferred to campus distributions system from CPE services in the future.

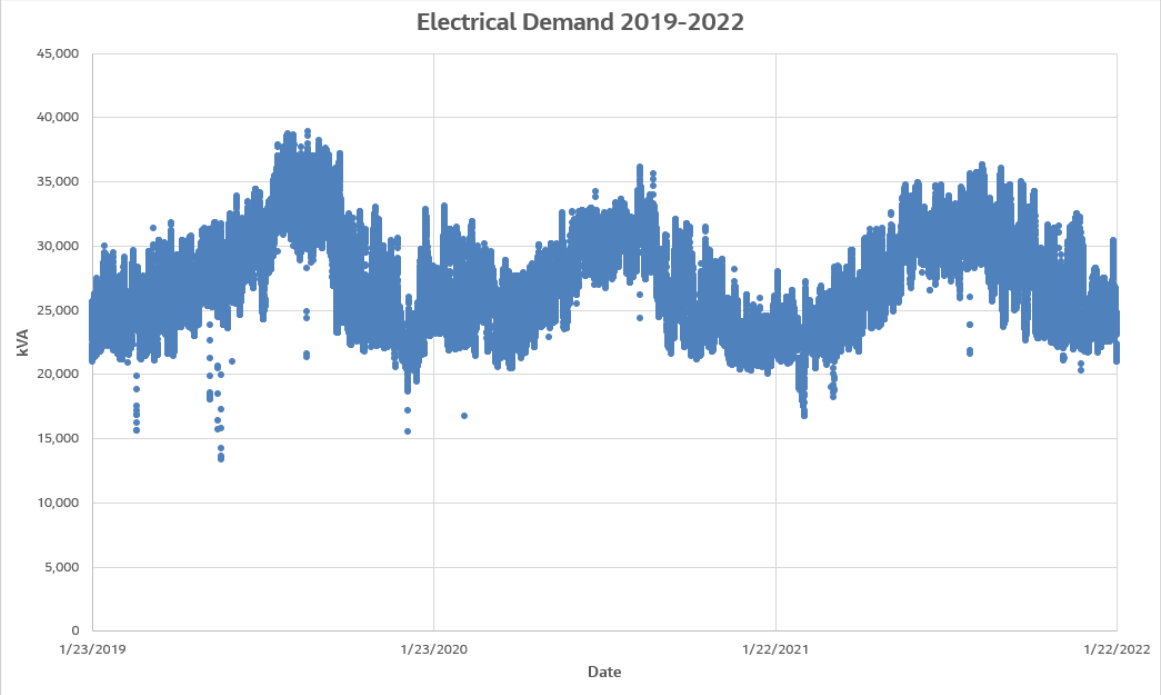


Figure 5-2. Existing Campus Electrical Load Profile

5.2.2 Campus Expansion 2022–2040

As the campus continues to expand, electrical demand will increase. As many campus buildings are still in the conceptual stage of development, Jacobs estimated future loads based on occupancy type of the planned additions. Table 5-1 shows the types of buildings that were used to develop projected loads and the assumed loads.

Table 5-1. Future Building Load Development

Building Type	Electrical Load (W/ft^2) [a, b]
Dormitory or Residential Housing	6.39
Athletics	NA [c]
Classroom	8.32
Office	6.39
Laboratory	11.91
Library	8.58
Food Services	6.95
Parking	0.18
Medical Office Building	6.39
Retail	6.74
Hospital	11.39

Note:

[a] Building load was approximated using similar buildings on campus, ASHARE 90.1 and engineering judgment.

[b] Assumes simultaneous peak use of all equipment.

[c] No future athletic buildings. For existing athletics building loads shown in Table 5-2, metering data from CPE used.

Table 5-2 lists new buildings identified by UH that are scheduled to be constructed between 2022 and 2040 that are also expected to connect to existing electrical infrastructure. The strategy to serve each building is discussed throughout this EMP.

Table 5-2. Future Building Loads

Building	Building Name	Building Type	Peak Electrical Load (kW)
487-EXP	Student Center North Expansion	Food Services	417
AB-1	Academic Building 1	Classroom	666
AB-2	Academic Building 2	Classroom	998
AD-1	Administration Building	Office	511
ALUM-1	Alumni Building	Office	383
IH-1	Innovation Hub	Lab	1,429
LAW	Law Building	Office	1,214
MR-1	Moody Tower Replacement	Housing	1,917
PAB-1	Performing Arts Building 1	Classroom	998
PAB-2	Performing Arts Building 2	Classroom	998
PAB-3	Performing Arts Building 3	Classroom	998
540	Law Library [a]	Library	(471)
503	Technology Annex [a]	Lab	(517)
584	Moody Towers [a]	Housing	(2013)
SH-1	Student Housing	Housing	1,456
		Subtotal, Future Building Loads	9,591
COM-Class	College of Medicine Building 1	Classroom	1,061
COM-Nursing	Nursing	Classroom	790
COM-Office	Office	Office	959
COM-Retail	Retail	Retail	674
COM-Lab	Lab, Research, Vivarium	Lab	2,382
COM-MOB	Clinic	Med. Office	639
COM-Housing 1	Housing	Housing	690
COM-Housing 2	Housing	Housing	690
COM-PG	Parking Garage	Parking Garage	87
		Subtotal, COM	7,972
495	Cougar Place	Housing	903 [b]
496	Cougar Village 2	Housing	586 [b]
497	Cougar Woods Dining Hall	Food Services	518 [b]
		Subtotal, CPE to Campus Load Transfer (Planned)	2,007
480	Football Indoor Practice Facility	Athletics	987 [b]
482	Guy V Lewis Development Facility	Athletics	516
485	TDECU Stadium	Athletics	2,013 [b]
		Subtotal, CPE to Campus Load Transfer (Future Consideration)	3,516
		Total	23,086

Note:

[a] Building to be either demolished or not in use. Corresponding loads from this building deducted from the future building loads.

[b] Peak demand for periods ranging from January 2019 to December 2019 and from July 2021 to June 2022.

Table 5-3 compares Cougar Substation available capacity against required demand. The difference between substation capacity and combined existing and new building demand represents the amount of capacity that must be added to support campus growth. In Table 5-3, substation reserve capacity is calculated by subtracting existing and planned future load estimates from the existing Cougar Substation capacity. A positive value denotes excess capacity is available.

Table 5-3. Available Cougar Substation Transformer Capacity Versus Demand

Item	Peak (MW)[a]	Data Source	Remarks
Cougar Substation capacity	108.3	Substation one-line diagram	Based on all three transformers operated at fan-cooled ratings.
Existing building loads	(39.0)	15-minute demand reading from UH	Peak occurs in 2019
Future building loads	(9.6)	Table 5-2	Rounded up from 9.591 MW
COM	(8.0)	Table 5-2	All buildings, excluding the hospital. Rounded up from 7.972 MW
CPE to campus load transfer (planned)	(2.0)	Table 5-2; demand reading from UH	--
CPE to campus load transfer (future consideration)	(3.5)	Table 5-2; demand reading from UH	--
Extra capacity for growth and factor of safety	(2.0)	--	Approximately 10% of future buildings load and COM load
Substation reserve capacity after planned growth	44.2	--	--
Substation reserve capacity with largest transformer out of service (i.e., firm capacity)	2.5	--	Only the two lower-rated transformers (T1 and T2) are in service. T1 and T2 are each rated 33.3 megavolt-ampere (MVA), totaling 66.6 MVA capacity

Note:

[a] Transformer rating in MVA and assumed that the loads will be maintained closer to unity power factors using capacitor banks.

As noted above, Cougar Substation has sufficient transformer capacity as designed to carry the peak electrical demand of all existing and planned future loads, even in an emergency scenario when one transformer is out of service. However, the age and condition of the Cougar feeders will be the constraint in the near future.

Figure 5-3 shows projected electrical system growth and existing firm capacity.

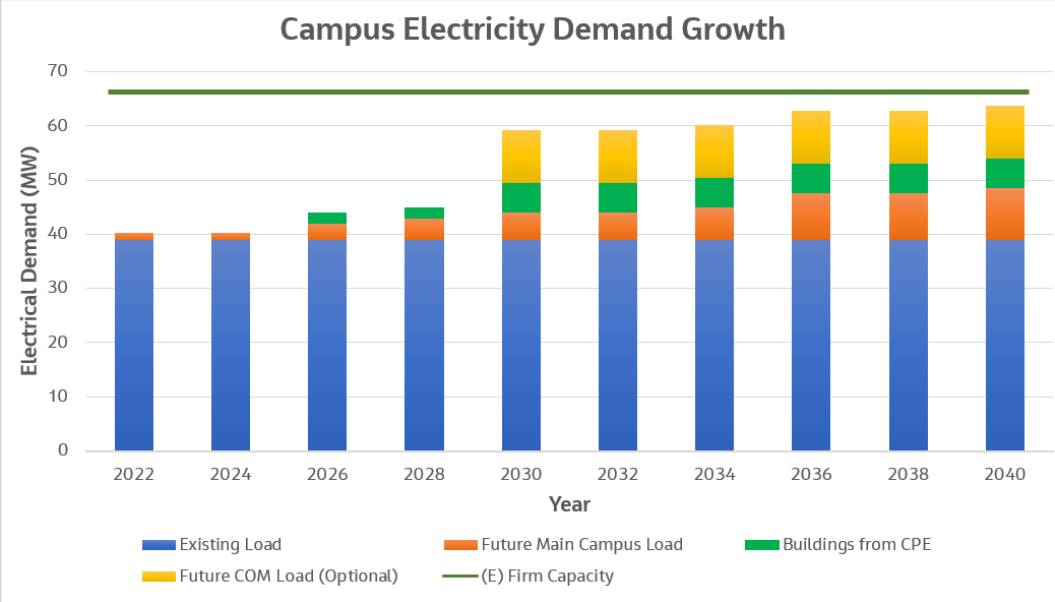


Figure 5-3. Projected Campus Electrical Demand Growth 2022–2040

5.2.3 College of Medicine Hospital Electrical Connection

The UH *College of Medicine Master Plan* (UH 2018) includes buildings listed in Table 5-2 and a proposed 150,000-square foot hospital to be constructed on the south side of campus. At present, COM loads are served directly from a 12.47-kV single 150 ampere (A) feeder from CPE. For the purposes of analysis, this EMP assumes that all COM buildings except for the proposed hospital may eventually be connected to the campus power distribution system. Refer to Table 5-2 for projected demand information. Section 5.6.1 discusses options for connecting COM loads to the campus electrical system and potential operation limitations. The hospital has been excluded from consideration in this EMP.

5.2.4 Electrical Demand Assumptions

To determine electrical demand, Jacobs made the following assumptions using data received from UH and from an understanding of general operation.

- Short-term data spikes that dropped below approximately 20 MW were not related to campus demand and were instead caused by external factors.
- 2019 demand data are representative of the how the existing campus facilities will operate after COVID-19 pandemic impacts are resolved.

5.3 Existing Equipment and Infrastructure

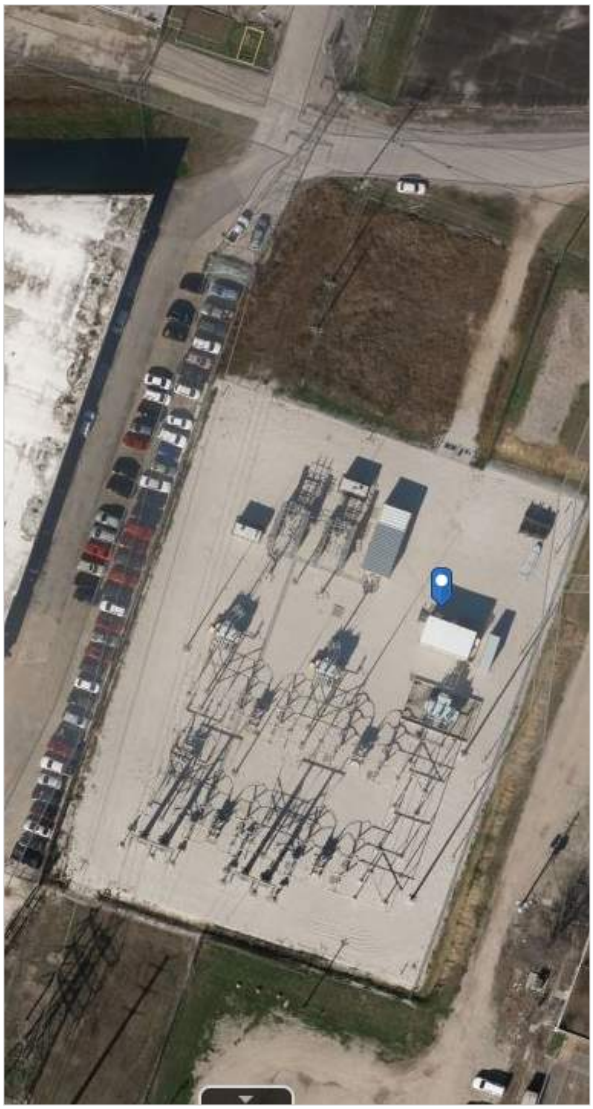
5.3.1 Campus Service

All campus electrical demand is served by two different types of supply sources. The first is via Cougar Substation, which is a university-owned and operated high-voltage substation located on the west side of Technology Bridge. The Cougar Substation is served by two 138-kV overhead transmission lines from CPE, which are connected to the CPE transmission system. The second source is CPE low- and medium-voltage supply, which serves some campus buildings. Most of the campus buildings and plant loads are powered from the Cougar Substation while relatively few buildings served directly by CPE distribution lines.

5.3.2 Cougar Substation

The Cougar Substation 138-kV busbars are arranged in a five-breaker ring configuration with five circuit positions, including two incoming utility circuits from CPE and three transformer circuits. Until 2018, the busbars were configured as a four-breaker ring, with two incoming and two transformer circuits. As part of utility expansion, a new transformer was added, modifying the four-breaker ring configuration to a five-breaker ring configuration. Figure 5-4 shows aerial views of the pre and post-expansion of the substation.

Cougar Substation in 2016



Cougar Substation in 2022 with Additional Circuit Position

Figure 5-4. Cougar Substation Layout, 2016 and 2022

Four of the 145-kV dead tank sulfur hexafluoride circuit breakers, which were installed as part of original construction, are rated for 2,000 A at 63 kilo amperes (kA). One new circuit breaker added in 2018 as part of a substation expansion project is rated for 4,000 A at 63 kA. Voltage is stepped down from 138 kV to 12.7 kV using Transformers 1 and 2, which are connected to separate outdoor aluminum buses through disconnect switches. There are two 3-phase bus sections directly fed from the transformers. The busbars

connected to Transformer 1 (or Bus 1) serve the Cougar 2 feeder through an outdoor 15.5-kV, 1200-A, 25-kA circuit breaker. The busbars connected to Transformer 2 (or Bus 2) serve the Cougar 3 feeders through a 15.5-kV, 1,200-A, 25-kA circuit breaker. These two buses serve the Cougar 1 feeder through two section breakers. Cougar 1 is normally connected to Bus 1. Buses 1 and 2 are connected to two 5.4-megavolt-ampere-reactive (MVAR) capacitor banks.

A substation expansion project in 2017 added a new transformer bay by reconfiguring the four-switch ring to a five-switch ring, and added the following components:

- 145-kV, 4,000-A, 63-kA circuit breaker
- 25/33/41.7-MVA transformer
- 15-kV, 2,000-A, 40-kA indoor metal-clad switchgear

The new transformer feeds the indoor switchgear in the new control building, and has the following compartments:

- Main breaker connected to Transformer T3
- Four outgoing feeders to serve campus load
- Two breakers to connect with the Transformers 1 and 2 secondary terminals
- One feeder to connect with new capacitor bank
- Bus potential transformer
- Control power transformer
- Provision for future feeder

There are two feeders leading from this switchgear to serve Technology Bridge through three medium-voltage automatic transfer switches (MVATS).

Information about the existing equipment at Cougar Substation is summarized in Tables 5-4 and 5-5.

Table 5-4. Cougar Substation Transformers

Transformer	Voltages (kV) [a]	Maximum Capacity (MVA) [a]	Installed Year	Current Age (Years) [a]	Remarks [a]
Transformer 1	141/12.47	33.3	1999	23	Manufactured in 1998
Transformer 2	141/12.47	33.3	1999	23	Manufactured in 1998
Transformer 3	141/12.47	41.7	2018	4	Manufactured in 2017

Note:

[a] Rating and year of manufacture from the equipment name plate

Table 5-5 summarizes information about the Cougar Substation switching equipment.

Table 5-5. Cougar Substation Switching Equipment

Equipment	Reference	Maximum Voltage (kV) [a]	Rated Current (A) [a]	Rated Short Circuit Current (kA) [a]	Installed Year	Current Age (years)	Remarks [a]
High-Voltage Circuit Breaker	J660	145	2,000	63	1999	23	Manufactured in 1998
High-Voltage Circuit Breaker	J710	145	2,000	63	1999	23	Manufactured in 1998; previous ID J670
High-Voltage Circuit Breaker	J680	145	2,000	63	1999	23	Manufactured in 1998
High-Voltage Circuit Breaker	J690	145	2,000	63	1999	23	Manufactured in 1998
High-Voltage Circuit Breaker	J700	145	4,000	63	2018	4	Manufactured in 2017
Medium-Voltage Circuit Breaker	CB10	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Circuit Breaker	CB20	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Circuit Breaker	1A0	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Circuit Breaker	02A0	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Circuit Breaker	03A0	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Circuit Breaker	04A0	15.5	1,200	25	1999	23	Manufactured in 1998
Medium-Voltage Indoor Switchgear	--	15	2,000/1,200	40	2018	4	Manufactured in 2017
Medium-Voltage Capacitor Bank 1	--	12.47	--	--	1999	23	5.4-MVAR capacitor bank.
Medium-Voltage Capacitor Bank 2	--	12.47	--	--	1999	23	5.4-MVAR capacitor bank.
Medium-Voltage Capacitor Bank 3	--	12.47	341	40	2018	4	Manufactured in 2017; system voltage is 12.47 kV, and the capacitor bank is rated to deliver 7363 KVAR at this voltage.

Note:

[a] Rating and year of manufacture from the equipment name plate

Apart from the equipment listed in Tables 5-5 and 5-6, the system includes 145-kV outdoor disconnect switches, medium-voltage outdoor disconnect switches, high- and medium-voltage surge arresters, and a control house at the substation.

5.3.3 Distribution from Cougar Substation to Campus

There are seven 12.47-kV feeders from Cougar Substation that serve the main campus and Technology Bridge electrical loads. Cougar Feeders 1, 2, and 3 serve campus loads (except for loads served by CPE) and CUP auxiliary loads. These feeders connect to an incoming switchgear at the CUP that in turn feeds the campus distribution switchgear and CUP switchgear.

The Cougar 1, 2 and 3 feeder circuits run partly overhead and partly underground. They originate from the Cougar Substation as underground insulated cable circuits and transition to overhead bare conductors through three separate riser poles inside the CPE substation. The Cougar 1 feeder overhead section is routed on a separate set of poles as a single circuit line whereas the Cougar 2 and 3 feeders share a common set of poles as double circuit lines. These overhead lines are routed along the east side of the railroad tracks running along Spur 5 and transition back to underground cables through riser poles located near the wastewater facility. Per Houston Lighting and Power record drawings, the section of feeders crossing the railroad tracks is comprised of polyvinyl chloride (PVC) conduits concrete-encased in a 42-inch steel casing. The circuits transition back to overhead poles on the West Side of Spur 5 and run across the parking lot next to the east parking garage. At Martin Luther King Boulevard near the campus parking lot, these circuits transition to underground and are routed to the CUP in concrete-encased duct bank. From Martin Luther King Boulevard, Cougar feeders 2 and 3 are routed together to the CUP. Cougar Feeder 1 is routed via an alternate path to the CUP.

The 2018 Cougar Substation expansion project created two additional feeders (Cougar 4 and Cougar 5) to serve the main campus and created two feeders (Energy Research Park 1 and Energy Research Park 2) to serve Technology Bridge loads. From the Cougar Substation, feeders 4 and 5 are routed underground in concrete-encased duct banks under the railroad and Spur 5 then run along University Drive before connecting to Campus Switchgear B located in the Health District Plant. Switchgear B powers a section of main campus.

The Energy Research Park 1 and 2 underground cable feeders from Cougar Substation that serve the Technology Bridge campus are routed in concrete-encased duct bank, replacing overhead residential services from CPE to improve reliability. Table 5-6 lists information about the Cougar Substation feeders.

Table 5-6. Cougar Substation Feeders

Feeder	Circuit Breaker	Outgoing Feeder Rating (A) [a]	Cable/Conductor Installed	Approximate Age (years)	Remarks
Cougar 1	01A0/04A0	1,200	1970s [b]	50	Overhead conductor and insulated underground cables
Cougar 2	02A0	1,200	1980s [b]	40	Overhead conductor and insulated underground cables
Cougar 3	03A0	1,200	1980s [b]	40	Overhead conductor and insulated underground cables
Cougar 4	52-F4	1,200	2018	4	Underground cables
Cougar 5	52-F5	1,200	2018	4	Underground cables
Energy Research Park 1	52-F1	1,200	2018	4	Underground cables
Energy Research Park 2	52-F2	1,200	2018	4	Underground cables
Spare	52-F6	-	-	-	No breaker; Spare cubicle space only

Note:

[a] Shah Smith 2015a
[b] Shah Smith 2012b

5.3.4 Campus Medium-Voltage Distribution

5.3.4.1 Campus Incoming Switchgear

The Cougar 1, 2 and 3 feeders are connected to an incoming 15-kV switchgear in the CUP building. The switchgear bus is configured as a ring with three bus sections (Sections 1, 2 and 3) connected through three tie breakers. Each bus section is connected to a main feeder from Cougar Substation and to one or two outgoing feeders. Bus Section 1 is connected to Cougar 1 and Campus Switchgear CA1; Bus Section 2 is connected to Cougar 2, Campus Switchgear CA2, and CUP Switchgear CP1; and Bus Section 3 is connected to Cougar 3 and CUP Switchgear CP2. Figure 5-5 shows an electrical diagram of switchgear in the CUP. This ring bus configuration offers reliability and operational flexibility to serve campus and utility plant loads using any of the three Cougar feeders. Table 5-7 lists information about the incoming switchgear.

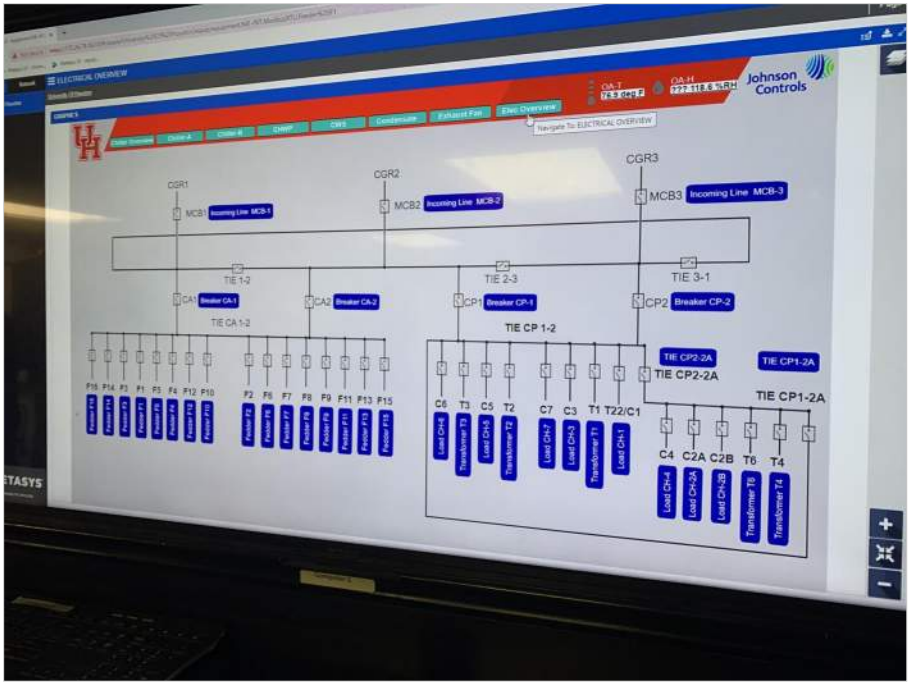


Figure 5-5. Campus Electrical Overview Schematic

Table 5-7. Campus Incoming Switchgear

Feeder	Circuit Breaker	Feeder Rating (A)[a]	Conductor/Switchgear Year Installed	Approximate Age (years)	Remarks
Cougar 1	MCB-1	1,200	1970s [b]/1990 [c]	50/32	Overhead conductor and insulated underground cables
Cougar 2	MCB-2	1,200	1980s [b]/1990 [c]	40/32	Overhead conductor and insulated underground cables
Cougar 3	MCB -3	1,200	1980s [b]/1990 [c]	40/32	Overhead conductor and insulated underground cables
Campus Switchgear A1	CA-1	1,200	-/1990 [c]	32	Busway
Campus Switchgear A2	CA-2	1,200	-/1990 [c]	32	Busway
CUP Switchgear 1	CP-1	1,200	-/1990 [c]	32	Busway
CUP Switchgear 2	CP-2	1,200	-/1990 [c]	32	Busway

Note:

[a] Shah Smith 2014

[b] Shah Smith July 2012b

[c] Switchgear year of manufacture from the equipment name plate

5.3.4.2 Central Utility Plant Medium-Voltage Equipment

The two 15-kV CUP switchgear (CP1 and CP2) are fed from the main incoming switchgear through two 1,200-A busways. The CUP switchgear are also arranged in a ring configuration, with three bus sections connected through three tie breakers. There are 13 outgoing feeders from these switchgears that feed various plant loads such as chiller pumps, motors, and other auxiliaries. Initially, the CUP had one switchgear with two sections before a third switchgear was added circa 2011–12, and was connected with the existing switchgear in a ring through tie breakers.

The campus switchgear (CA1 and CA2) are in the CUP, and are connected to the main incoming switchgear through busways. The campus switchgear is configured as a single bus with bus sections connected through a tie breaker. Each section is fed from one feeder from the main incoming switchgear. There are eight feeders in each section, 16 in total. One feeder from each section is paired with a feeder from the other section to serve the connected load as feeder pairs. As a result, there are eight sub-distribution networks served by these feeder pairs.

In 2018, Campus Switchgear B was added to the satellite plant in the Health District, and loads from feeder pairs 1-2, 5-7, and 11-12 were transferred from the campus switchgear in the CUP to Campus Switchgear B. After this transition, feeders F1, F2, F5, F7, F11 and F12 have become spares. According to existing records and the data collected through a site visit, Jacobs determined that the CUP switchgear neither have any spare feeders nor have provision or space to extend the switchgear. Tables 5-8 and 5-9 list more information about medium-voltage switchgear in the CUP.

Table 5-8. Central Utility Plant Medium-Voltage Switchgear CP1/CP2

Feeder	Circuit Breaker	Feeder Rating (A) [a]	Switchgear Installed [c]	Approximate Age (years)	Remarks
Chiller 6	CH-6	1,200	1990	32	Cable ampacity 150[b]
Transformer 3	T3	1,200	1990	32	Cable ampacity 295[b]
Chiller 5	CH-5	1,200	1990	32	Cable ampacity 150[b]
Transformer 3	T2	1,200	1990	32	Cable ampacity 295[b]
Chiller 7	CH-7	1,200	1990	32	Cable ampacity 150[b]
Chiller 3	CH-3	1,200	1986	36	Cable ampacity 295[b]
Chiller1/ Transformer 22	CH1/T22	1,200	1986	36	Cable ampacity 295[b]
Transformer 1	T1	1,200	1986	36	Cable ampacity 295[b]
Transformer 4	T4	1,200	2011	11	--
Transformer 6	T6	1,200	2011	11	--
Chiller 2B	CH-2B	1,200	2005	17	Cable ampacity 225[b]
Chiller 2A	CH-2A	1,200	2005	17	Cable ampacity 225[b]
Chiller 4	CH-4	1,200	2005	17	Cable ampacity 295[b]

Note:

[a] Feeder circuit breaker ratings as per label inscription on the switchgear

[b] Jonmar Electric Inc. 2011

[c] Switchgear year of manufacture was obtained from the equipment name plate in one of the associated sections

Table 5-9. Campus Medium-Voltage Switchgear CA1/CA2

Feeder	Circuit Breaker	Feeder Rating (A)[a]	Switchgear Installed [c]	Approximate Age (years)	Remarks
Feeder 1	F1	1,200	1990	32	Spare
Feeder 2	F2	1,200	1990	32	Spare
Feeder 3	F3	1,200	1990	32	Bus 2 associated feeder pair F8. Cable ampacity 225A[b].
Feeder 4	F4	1,200	1990	32	Bus 2 associated feeder pair F6. Cable ampacity 225A[b].
Feeder 5	F5	1,200	1990	32	Spare
Feeder 6	F6	1,200	1990	32	Bus 1 associated feeder pair F4 Cable ampacity 225A[b].
Feeder 7	F7	1,200	1990	32	Spare
Feeder 8	F8	1,200	1990	32	Bus 1 associated feeder pair F3. Cable ampacity 225A[b].
Feeder 9	F9	1,200	1990	32	Bus 1 associated feeder pair F10 Cable ampacity 225A[b].
Feeder 10	F10	1,200	1990	32	Bus 2 associated feeder pair F9 Cable ampacity 225A[b].
Feeder 11	F11	1,200	1990	32	Spare
Feeder 12	F12	1,200	1990	32	Spare
Feeder 13	F13	1,200	1990	32	Bus 1 associated feeder pair F14 Cable ampacity 295A[b].
Feeder 14	F14	1,200	1990	32	Bus 2 associated feeder pair F13 Cable ampacity 295A[b].
Feeder 15	F15	1,200	1990	32	Bus 1 associated feeder pair F16 Cable ampacity 260A[b].
Feeder 16	F16	1,200	1990	32	Bus 2 associated feeder pair F15 Cable ampacity 260A[b].

Note:

[a] Feeder circuit breaker ratings as per label inscription on the switchgear.

[b] Jonmar Electric Inc. 2011.

[c] Switchgear year of manufacture obtained from the equipment name plate.

5.3.4.3 Health District Plant—Campus Switchgear B

The Health District Plant houses the Campus Switchgear B, which was added as part of the substation expansion project. Campus Switchgear B has two bus sections connected through a tie breaker. Section 1 is fed from Cougar Feeder 4 and Section 2 is fed from Cougar Feeder 5 through underground cables. There are four outgoing feeders in each section, with three from each section connected to the existing distribution network as feeder pairs.

This switchgear has one equipped space and one full spare (with circuit breaker) on Section 2. Additionally, Section 1 has free floor space to add two cubicles in the future which could accommodate four feeders and Section 2 has floor space for one cubicle with two feeders. These will facilitate the expansion of switchgear and connect any future load to the campus switchgear. Table 5-10 lists information about Switchgear B.

Table 5-10. Health District Plant—Campus Medium-Voltage Switchgear B

Feeder	Circuit Breaker	Feeder Rating (A) [a]	Switchgear Installed [b]	Approximate Age (years)	Remarks
Feeder17	F17	1,200	2017	5	To existing Campus Feeder 11 at Recreation/Wellness Center; Bus 2 associated feeder pair F18.
Feeder 18	F18	1,200	2017	5	To existing Campus Feeder 12 at Recreation/Wellness Center; Bus 1 associated feeder pair F17.
Feeder 19	F19	1,200	2017	5	To existing Campus Feeder 5 at Moody Towers; Bus 2 associated feeder pair F20.
Feeder 20	F20	1,200	2017	5	To existing Campus Feeder 7 at Moody Towers; Bus 1 associated feeder pair F19.
Feeder 21	F21	1,200	2017	5	To new Health and Biomedical Building 1 and2 through MVATS-4; Bus 2 associated feeder pair F22.
Feeder 22	F22	1,200	2017	5	To new Health and Biomedical Building 1 and2 through MVATS-4; Bus 1 associated feeder pair F21.
Feeder 23	F23	1,200	2017	5	To existing Campus Feeder 1 at Entrance 1; Bus 2 associated feeder pair F24.
Feeder 24	F24	1,200	2017	5	To existing Campus Feeder 2 at Entrance 1; Bus 1 associated feeder pair F23.
Feeder 25	F25	--	--	--	Equipped space
Feeder 26	F26	1,200	2017	5	Spare
Feeder 27	F27	--	--	--	Free floor space
Feeder 28	F28	--	--	--	Free floor space
Feeder 29	F29	--	--	--	Free floor space
Feeder 30	F30	--	--	--	Free floor space
Feeder 31	F31	--	--	--	Free floor space
Feeder 32	F32	--	--	--	Free floor space

Note:

[a] Based on Electrical One-Line Diagram E0.20 dated May 2014

[b] Switchgear year of manufacture obtained from the equipment name plate

5.4 Electrical System Deficiencies Identified for Remediation

5.4.1 Cougar Substation Bus Configuration and Feeder Positions

The existing 138-kV buses are configured as a five-breaker ring with two feeder and three transformer positions, as shown in Figure 5-6. A ring bus is one of the most common busbar configurations, providing optimal operational flexibility and high reliability. However, to achieve high reliability, the main supply feeders and loads must be connected in such a way that the station does not lose power, and that continuity of supply to the loads is maintained during normal operating conditions and fault scenarios. For this reason, main supplies and loads are not usually connected to adjacent feeder positions. In Cougar Substation, the 138-kV supply feeders from CPE are connected to adjacent feeder positions in the ring. For example, during a breaker J660 failure event, the fault would have to be cleared by tripping breakers J710 and J690. This would result in total loss of power to all campus load served from Cougar Substation. Likewise, failure of either breaker J680 or J700 will result in losing two of the three existing transformers and all connected loads.

Cougar Substation reliability could be improved by swapping feeder positions between the 138-kV PH Robinson Feeder and Transformer 3, as shown in Figure 5-7. With this rearrangement, for any 145-kV circuit breaker failure condition, at least one 138-kV line and one transformer would remain in service. This may require relocating the existing line dead-end structures, transformer and substation equipment to facilitate busbar extension and reconfiguration. As noted in Figure 5-4, Cougar Substation has limited space, but with the development of efficient layout and outage/construction sequencing, this reconfiguration can be achieved.

University personnel have observed that the manual disconnect switches T1ALS and T2ALS which are provided on the secondary side of transformer T1 and T2 generate excessive arc across the contacts during the switching operations. This issue was witnessed by UH personnel while closing T2ALS to reenergize transformer T2. It is common to see arc between the contacts when interrupting transformer magnetizing current or line charging currents. To mitigate this issue, arcing horns are provided in the switches to increase the interrupting capability. However, if the switch or the arcing horn are not adequately rated, excessive arcing could occur. This could potentially damage the switch contacts and would also affect the safety of the operator who would be operating the switch through the mechanism provided directly below the switch. The university has identified this as a major safety concern. The university should verify the adequacy of these switches and pursue remediation of the deficiency at the earliest.

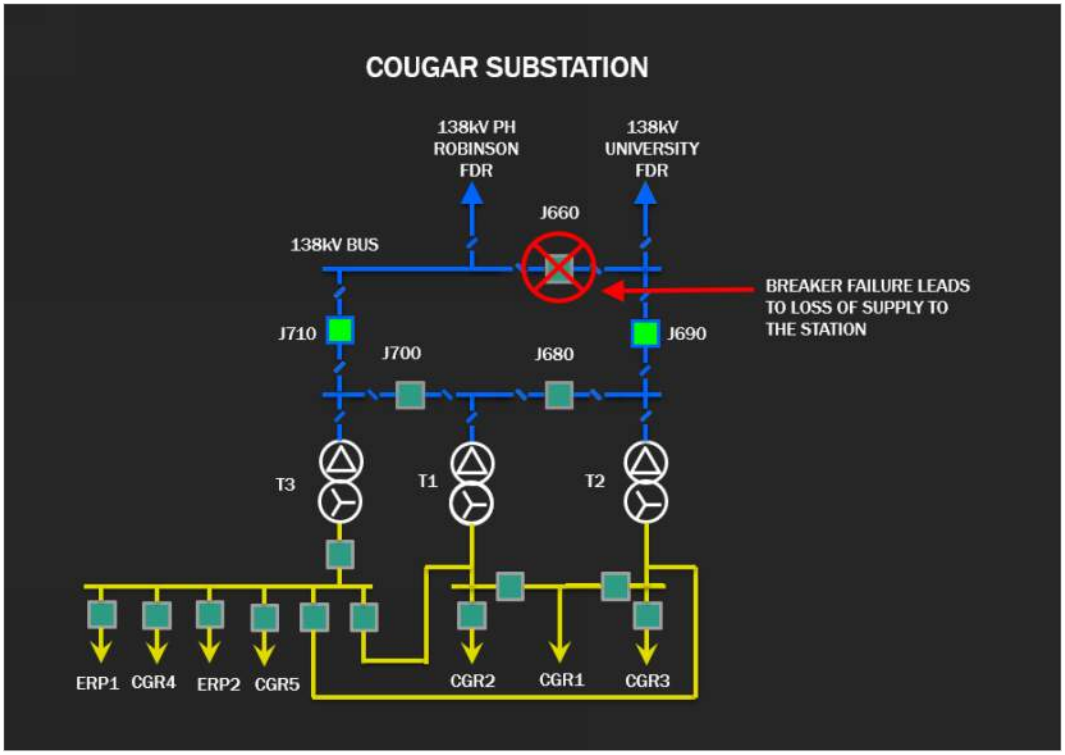


Figure 5-6. Cougar Substation One-Line Showing Loss of Supply for Breaker Failure Condition

Figure 5-7 shows the proposed solution for the failed breaker condition.

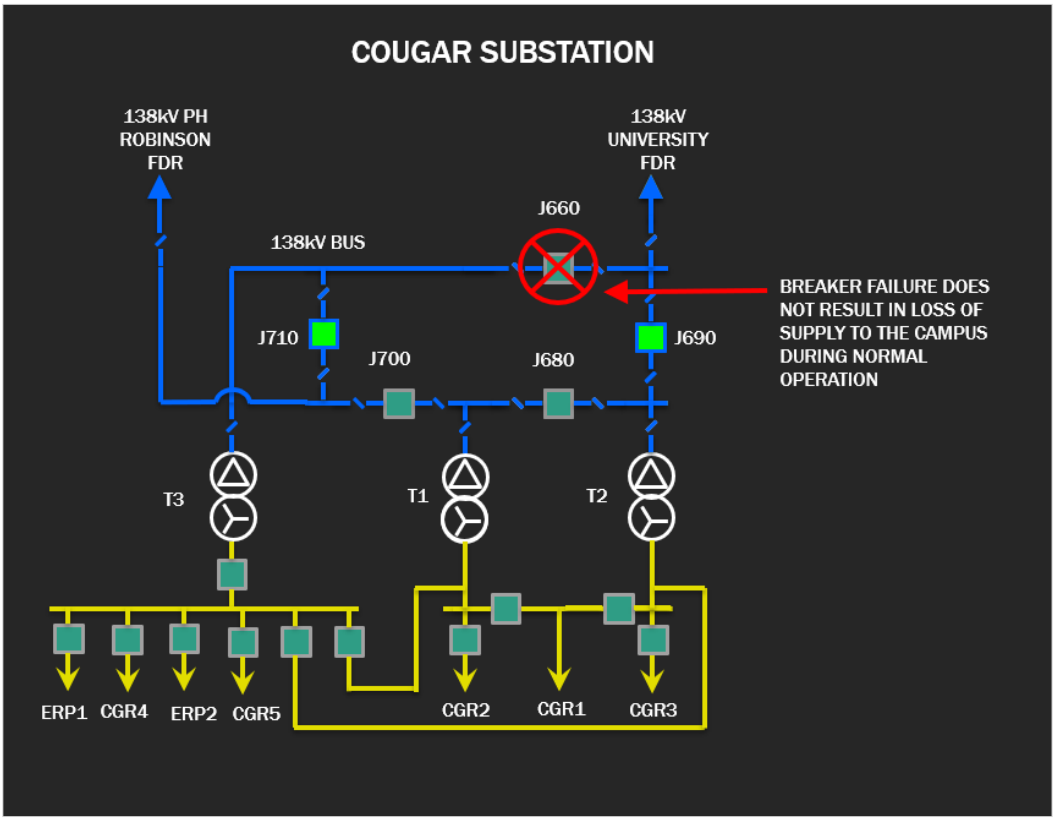


Figure 5-7. Cougar Substation One-Line Showing Proposed Reconfiguration

5.4.2 Cougar Substation Transformers

The three 138/12.47-kV transformers at Cougar Substation serve the majority of campus loads. With the current peak demand of 39 MW and an estimated additional future peak demand of 20 MW (Section 5.2.2), any two transformers would be able to support campus loads. However, based on information shown in Table 5-4, Transformers T1 and T2 are 23 years old. According to information collected during interviews with UH staff, these transformers have been subjected to frequent overloading during certain system conditions. Loading transformers beyond the nameplate rating affects transformer life expectancy. Institute of Electrical and Electronic Engineers (IEEE) Standard C57.91-2011, *IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators* (IEEE 2012) details the influence of transformer loading on normal transformer life expectancy, defining basic loading of the transformer for normal life expectancy as continuous loading at rated output when operated at a condition equivalent to average ambient temperature of 30 degrees Celsius (^{o}C) with a winding hotspot temperature of 110^{o}C. With continuous hotspot temperature of 110^{o}C, the normal transformer life expectancy is 20.55 years or 180,000 hours, varying with the loading cycle and operating conditions. Given that some transformers at Cougar Substation are 23 years in service, and frequently subjected to overloading, their insulation might have deteriorated, considerably affecting the life expectancy.

With three transformers in service, loss of one transformer may not impact continuity of supply to campus loads, but concurrent outage of two transformers would compromise the capacity of the substation to support all campus electrical loads. Jacobs recommends testing the transformers to determine their remaining lifespan. This would facilitate planning the end-of-life replacement process. For the purpose of this EMP, Jacobs assumes that these two transformers will require replacement within the next 10 to 15 years if Cougar Substation is not retired.

5.4.3 Cougar Substation Feeders

Cougar Substation has five feeders that serve the main campus. As noted in Table 5-6, some sections of Cougar Feeders 1 and 2 are more than 40 years old. According to Shah Smith (2012), Cougar 1 was installed in the 1970's, Cougar 2 and Cougar 3 in the 1980s. The typical design life of underground cables is between 30 and 40 years; therefore, the cables on these circuits might have exceeded their useful life. These feeders have already experienced multiple failures. Shah Smith (2015) identified some of these failures which are summarized below.

- Phase conductors are not grouped appropriately in the duct banks and conduits which might affect the thermal rating of the cables and might result in overheating.
- Multiple failures of lightning arrestors have occurred, requiring equipment replacement
- Failure of cable splices have occurred, requiring repairs
- Burned neutral conductors have occurred requiring replacement of failed cable sections
- Tripping of circuits due to cable faults have occurred
- Long circuit outages have occurred because of repair and maintenance activities.

If Cougar Substation is not retired, Jacobs recommends implementing an end-of-life replacement scheme in the near future to ensure continuous operation. When replacing cables, Jacobs recommends redesigning the cables using a cable thermal analysis modeling tool to determine cable temperatures based on loading conditions and circuit arrangements in the duct banks.

During installation of the new feeders, Jacobs recommends considering diverse paths and spatial separation to improve reliability. At present, Cougar 1, 2 and 3 circuits are routed overhead on two separate sets of poles (Section 5.3.3). However, the cable sections of the three circuits are routed in the same duct bank under railroad and Spur 5. Jacobs recommends considering a new duct bank running

parallel to existing duct banks with adequate spatial separation to route Cougar 1 and provision to add new circuits in the future. It is possible that the existing duct bank can be reused for Cougar feeders 2 and 3. However, a condition assessment should be performed to confirm whether it is suitable for reuse. If unsuitable, a new duct bank should be considered for installation south of the existing duct bank. During installation, crossing the railroads and, Spur 5will be challenging. For the purposes of cost estimating, Jacobs has assumed that directional drilling could be done under both the railroad and Spur 5 to mitigate impact to rail operations or freeway traffic.

The new 15-kV indoor switchgear in Cougar Substation has one feeder space for future additions, as indicated in Table 5-6. Jacobs recommends considering additional spare feeders to support future growth and improve redundancy and resiliency. This can be done by installing a new switchgear adjacent to the existing and connecting buses from the new and existing switchgear through tie breakers.

5.4.4 Campus Medium-Voltage Distribution

Medium-voltage distribution from the Health District plant and the CUP varies in age from 30 to 40 years. The UH electric shop reports there have been multiple feeder related failures/events in the past 12 years that have required repairs to the cables, splices and surge arresters. However, Jacobs has not been provided with documentation of these events to verify. Regardless, system age combined with the heavy load on some feeders and planned future expansion could create failure points in the system. Jacobs recommends testing each medium-voltage feeder to determine if there are any immediate issues. Jacobs also recommends developing a replacement plan for all feeders over 30 years old or found to be deficient.

5.4.5 Plant Switchgear in Central Utility Plant

The CUP switchgear is an integral part of the campus distribution system. As the campus has grown, this switchgear has been expanded to accommodate the additional loads. However, should the campus continue to grow, there is no additional space in the existing electrical room for further expansion of this switchgear. While the switchgear is of sufficient capacity for the existing connected load, should UH want to add additional load, either a new switchgear will need to be installed or load will need to be taken off this switchgear and placed onto another.

5.5 Electrical System Upgrades

5.5.1 New Campus Substation

The existing Cougar Substation has reliability concerns as described in Section 5.4.1. If this substation is not retired, the 12.47-kV Cougar Feeders 1, 2, and 3 require end-of-life replacement as described in Section 5.4.3. A new duct bank is also recommended under Spur 5 and the railroad during the cable replacement work. In addition, transformers T1 and T2 are expected to require replacement within the next 10 to 15 years as detailed in Section 5.4.2. These replacement projects will need to be carried-out in multiple phases to maintain the continuity of power supply to the campus. However, much of this work could be avoided if UH instead decides to replace Cougar Substation with a new 138/12.47 kV substation.

All campus power loads are on the west side of State Highway 5 except for Technology Bridge, which is on the east side of Spur 5. Locating a new substation west of State Highway 5 would avoid multiple feeder crossings under the railroad and Spur 5. One possible location for a new substation would be in existing Parking Lot 4A south of Wheeler Avenue and west of Martin Luther King Boulevard. Section 9 of this EMP contains additional information regarding the site location. For the new substation, the 138-kV bus could be configured as a six-breaker ring to improve reliability in comparison to the existing bus configuration in Cougar Substation. However, the new substation would be designed to prevent loss of both CPE feeders

during a breaker failure by not connecting to the adjacent feeder positions in the ring as described in Section 5.4.1. It may be possible to feed the substation from the existing double circuit high-voltage transmission lines routed adjacent to Parking Lot 4A. However, the voltage rating of lines near the parking lot is unknown. Alternatively, the existing 138-kV feeders from Cougar Substation could also be rerouted to the new substation location. Jacobs recommends consulting with CPE to study the feasibility of both options.

The new substation could have three transformers connected to the ring with a provision to add one more in the future to support additional campus growth. From this substation, three new 12.47-kV underground cable feeders could be routed via duct banks to connect Campus Switchgear A in the CUP, replacing the existing Cougar 1, 2 and 3 feeders. Similarly, two additional feeders could be routed to the Campus Switchgear B in the Health District Plant, replacing the Cougar 4 and 5 feeders. For feeding Technology Bridge campus, the existing 1,200-A Cougar 4 and 5 feeders could be repurposed by disconnecting from Campus Switchgear B and rerouting to the new substation. At the Cougar Substation end, the Cougar 4, Cougar 5, Energy Technology Bridge 1, and Technology Bridge 2 feeders could be disconnected from the existing switchgear and spliced following a cable sizing design. Figure 5-8 shows the proposed location of the new substation and approximate feeder routing to Campus Switchgear A and B and the Technology Bridge campus. A larger image of this figure is in Appendix H. Reusing existing Cougar 4 and 5 feeders will introduce two new splicing points, one near the Campus Switchgear B and another near the Cougar Substation along the proposed cable route between the new substation and the existing Cougar Substation. A detailed study is recommended to confirm the ratings and reliability of the feeder, taking the new feeder length and existing splices into account.

With the construction of a new substation, the existing Cougar Substation and Cougar feeders 1, 2, and 3 could be decommissioned and Cougar feeders 4 and 5 could be used to back feed the Technology Bridge campus.

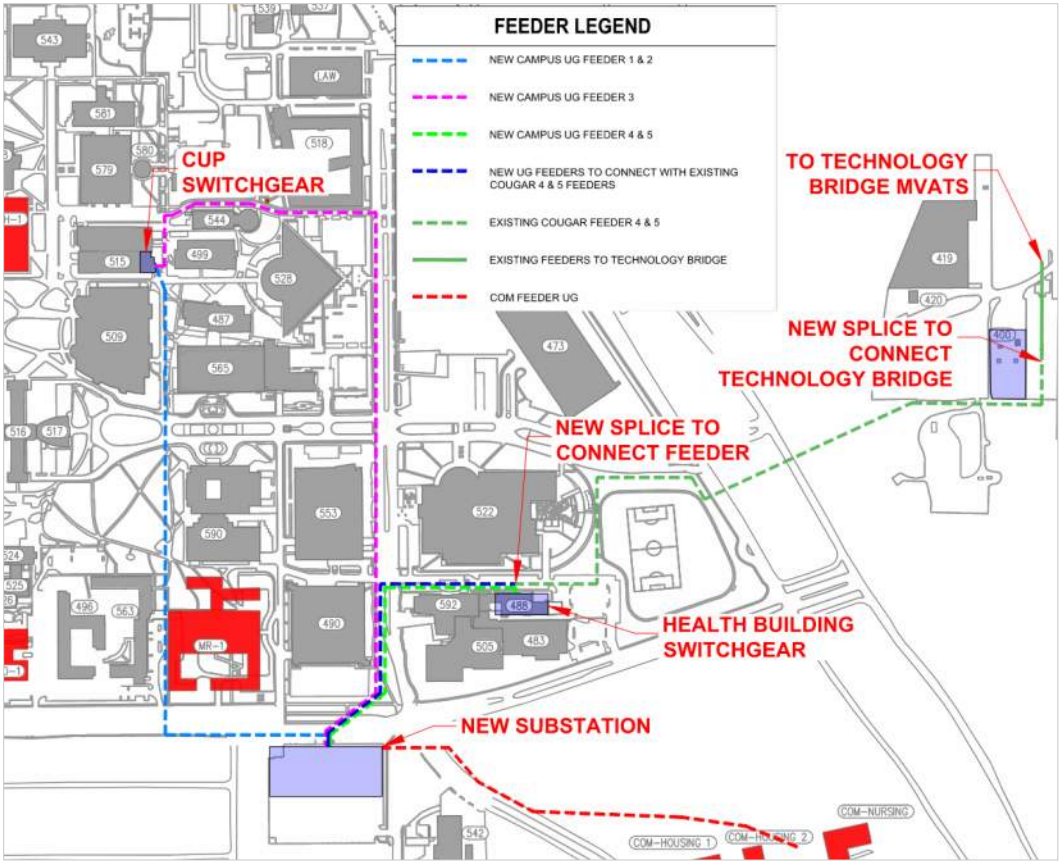


Figure 5-8. Proposed New Substation and Campus Primary Feeders

5.5.2 Microgrid Study

A microgrid system allows for a group of interconnected electrical loads to operate as a single entity. This is particularly useful when a campus has power generation resources and seeks to operate independently from the utility grid (commonly called island mode) in the event of an emergency or grid outage.

The first step in implementing a microgrid at the university is by evaluating how the building and plant electrical loads are served from the existing distribution network. The next important step is to identify the critical loads which should remain operational if the campus was not connected to the utility grid and also if the electrical demand is higher than the generation capacity. Based on this evaluation, the existing switchgear may need to be modified or upgraded to allow non-critical buildings or loads to be automatically disconnected while critical loads remain energized. Identification of critical building and plant loads would help in sizing the power generating equipment such as a CHP plant. Jacobs recommends undertaking a microgrid study prior to detailed design of any new CHP plant.

5.5.3 Photovoltaic Arrays and Energy Storage

5.5.3.1 Photovoltaic Sizing

Photovoltaic (PV) arrays with energy storage systems are an attractive solution for facilities in Texas due to the state's abundance of sunshine. The sizing of a PV field depends on a variety of factors, including the type of PV system used, whether the system is fixed position or tracking, and the presence of obstacles such as air handlers on roofs that can occasionally block sunlight. The National Renewable Energy Laboratory provides a basic tool for determining PV capacity with an online program called the PVWatts

Calculator.[1] This tool offers preliminary guidance on potential PV capabilities, but a detailed analysis using dedicated engineering software would be needed during detailed design. Table 5-11 gives a general overview of what a PV system could look like for the campus and the rough order-of-magnitude costs. It was assumed that the PV panels would be fixed position panels located on the roof of the existing buildings and face south.

Table 5-11. Photovoltaic Field Size

Item	Description	Value	Remarks
1	Module type	Premium	Approximate nominal efficiency of 19%
2	Cost Range [b]	$13–20 per square foot	Approximate PV panel costs. Does not include electrical connection costs
3	Building Roof Area	4,268,942 square feet	Maximum roof area available [a]
4	PV capacity	36.2 MW [c]	Theoretical maximum output assuming 48% of the building roof area is PV panels. Average daily output in July is approximately 14.6MWh.
5	Savings per year	$4,551,000	Based on total installation size
6	Rough order-of-magnitude costs	$85,379,000	Based on maximum roof area
7	Payback	19 years	Simple payback using a variable electric rate; refer to Section 8.4 for additional information regarding the electric rate
8	CO_2 offset	45,083 tons per year [d]	Assumes 818.6 lbs/MWh offset; refer to Section 8.9 for additional information about value used

Note:

[a] Does not consider existing rooftop equipment and represents a theoretical maximum. Area is for existing buildings.

[b] Approximate value from 2021 costs.

[c] Theoretical output is based on ideal conditions and does not take into consideration solar angles or losses from items such as converters.

[d] Standard U.S. ton = 2,000 pounds

Prior to the installing a PV system, Jacobs recommends performing a comprehensive review of campus buildings. If a PV project is for a new building, there are typically less issues during implementation, but for an existing building, installation can be more complex. In general, Jacobs recommends reviewing the following items

- Visual aesthetics of a possible PV system: If the building is historical with a roof that can easily be seen from the ground level, then the building is likely not a good candidate as a PV system could detract from the visual appeal of the building.
- The impact of additional structural loads caused by wind loading of the PV panels: The panels will create a significant load that will need to be resisted by the roof structure. These loads will not be trivial, and a structural analysis of the roof will be required prior to the completion of any design.
- Impacts to other systems such as air handlers and roof penetrations: This can affect the performance of air intakes for air handlers and the recirculation of hazardous air from exhaust systems such as lab fume hoods.
- Modifications to the electrical system: Typically, this is done before the building disconnect to allow the building to be de-energized and not served by the PV panels for safety.

[1] https://pvwatts.nrel.gov/

- Review of the building energy usage versus energy production by a PV system: While it is likely the PV system will not generate enough power to fully power the building during peak occupancy, evaluation may be required to determine how to handle excess generation during times when power consumption is low, such as a weekend.

5.5.3.2 Energy Storage Costs

One issue with PV technology is that production of energy during the entire day is not possible. For this reason, solar energy collection systems such as PV are sometimes combined with energy storage systems to allow for energy generated during sunlight hours to be stored for later usage. This is typically accomplished using batteries.

Battery technology is rapidly advancing, with many different entities actively researching different technologies. The *2020 Grid Energy Storage Technology Cost and Performance Assessment* (Energy Storage Report) (U.S. Department of Energy, Pacific Northwest National Laboratory 2020) lists the costs for different battery storage systems based on technology type. Costs shown in Table 5-12 were based on the 2020 values given in the Energy Storage Report for 100 MW of power supply for a 10-hour duration (1,000 MWh). The cost estimates are inclusive of all of the energy storage system costs, including the equipment, design, and integration of the technology into the power system. With the rapid advancements in technology and the changing costs of materials and construction, these costs should only be used for conceptual planning. Project-specific costing will be required if and when UH decides to proceed with detailed design.

Table 5-12. Battery Storage Costs

Item	Description	Cost ($/kWh)	Remarks
1	Lithium-ion phosphate	385	Lithium-ion iron phosphate battery.
2	Lithium-ion nickel manganese cobalt	395	Lithium-ion nickel manganese cobalt battery.
3	Lead-acid	356	Traditional lead-acid system for reference.
4	Vanadium redox	399	Cost data were estimated. Refer to the Energy Storage Report for additional information.

As campus energy use is higher than the generation capacity of PV systems on all campus roofs, Jacobs assumes that UH would likely utilize all solar power as it is generated and that battery storage would not be needed. For this reason, costs for battery storage are not included in the cost estimate for this EMP.

5.5.4 Buildings on CenterPoint Energy Service

Jacobs understands that UH is planning to connect the electrical loads for Woods Dining Hall, Cougar Village 2 and Cougar Place to campus power which are currently fed by direct services from CPE. Likewise, Football Indoor Practice Facility, Guy V Lewis Development Facility and TDECU Stadium might be transferred from CPE services to campus power. These loads are included in the future building load estimates to be connected to the Cougar Substation via campus distribution system, as noted Table 5-2.

5.5.5 Lighting Upgrades

A campus-wide lighting upgrade would help to reduce energy usage. The upgrade would include replacement of existing interior and exterior incandescent, fluorescent, and high intensity discharge (HID) lighting with equivalent light-emitting diode (LED) lighting.

Based on conversations with UH staff, it is thought that approximately 50% of the existing lighting has already been upgraded. Table 5-13 gives an overview of the carbon footprint reductions and rough order-of-magnitude costs associated with this upgrade.

Table 5-13. Lighting Upgrades

Item	Description	Value	Remarks
1	Cost Range [a]	$1–5 per square foot	Approximate costs. Assumes minimal lighting control upgrades are required.
2	Building Area	7,552,000 square feet	Existing building area minus parking garages.
3	Installation Size	3,776,000 square feet	--
4	Existing Lighting	0.99 watts per square foot	ASHRAE 90.1-2010 Table 9.5.1 lighting density for universities.
5	LED lighting	0.5 watts per square foot	Jacobs' experience with other similar institutions is that a value of 0.5 watts per square foot is an average number for LED lighting.
6	Rough order-of-magnitude costs	$7,552,000	Based on installation size and an average of $2 per square foot cost and average.
7	Savings per year	$334,930	Based on total installation size. Does not include HVAC savings due to reduced electrical power.
8	Payback [b]	23 years	Simple payback using a variable electric rate; refer to Section 8.4 for additional information regarding the electric ratel
9	CO_2 offset	3,308 tons	Assumes 818.6 lbs/MWh offset; refer to Section 8.9 for additional information about value used.

Note:

[a] Approximate costs based on other buildings Jacobs has upgraded.

[b] Payback duration is high due to low electric utility rate

5.5.6 Electric Metering

Electric metering of individual buildings is currently a priority for UH. Added metering will help to determine electricity use at campus buildings, and would also help to determine loads on medium- and low-voltage feeders serving the campus. The specific type of meter to be used will be dependent on the building service to comply with D5010 of *Section 12.0 Construction Systems and Assemblies Standards and Guidelines* (UH 2018).

5.6 Campus Load Transition

5.6.1 College of Medicine

COM electrical loads are currently served by a single 12.47-kV, 150-A service from CPE. However, loads served from the campus distribution system are considered to be more reliable and less likely to be interrupted by fault conditions on the CPE system, such as an overhead power line failure caused by a falling tree branch. As part of this EMP, Jacobs analyzed the feasibility of serving COM loads through the campus distribution system.

Table 5-14 lists buildings planned as part of the COM expansion and their estimated peak loads, based on the square footage and the power density for the building class. The total estimated peak load is 9.7 MW.

If a new campus substation was constructed as described in Section 5.5.1, the COM could easily be served from new switchgear in that location. As a temporary measure, before a new substation is constructed, Jacobs also evaluated the feasibility of feeding the COM from Campus Switchgear B.

Campus Switchgear B has two buses configured as main-tie-main with Buses 1 and 2 served by Cougar 4 and 5, respectively. Each incoming feeder from Cougar Substation is rated for 1,200 A. Campus Switchgear B has a 1,200-A spare feeder with the possibility of adding feeders in the future. For reliability, two fully rated underground feeders from each switchgear bus were considered for feeding COM loads. Jacobs derived existing peak loads on campus switchgear from peak current data for feeder pairs F1 and F2, F5 and F7 and F11 and F12 (Shah Smith 2012a). Table 5-15 lists peak loads on Campus Switchgear B before and after COM addition.

Table 5-14. College of Medicine Electrical Loads

Building	Building Name	Building Type	Peak Electrical Load (kW)
COM-Class	College of Medicine Building 1	Classroom	1,061
COM-Nursing	Nursing	Classroom	790
COM-Office	Office	Office	959
COM-Retail	Retail	Retail	674
COM-Lab	Lab, Research, Vivarium	Lab	2,382
COM-MOB	Clinic	Med. Office	639
COM-Housing 1	Housing	Housing	690
COM-Housing 2	Housing	Housing	690
COM-PG	Parking Garage	Parking Garage	87
		Total	7,972

Table 5-15. Estimated Load on Campus Switchgear B

Feeder Pairs	Estimated Load		Remarks
	Without COM (A)	With COM (A)	
F1/F2	137	137	Peak load from Shah Smith 2012a
F5/F7	224	224	Peak load from Shah Smith 2012a
F11/F12	165	165	Peak load from Shah Smith 2012a
Health and Biomedical Sciences 1 and 2	205	205	Based on Health and Biomedical Sciences 1 and 2 gross square footage of 480,000 and a power density of 8.32 watts per square foot
COM	--	410	Based on 7.972 MW at 0.9 power factor
Total	731	1141	--

Based on these estimates, the concurrent peak load on Campus Switchgear B with COM connected would be approximately 1141-A. Ideally, this should be shared between the two 1,200-A feeders from Cougar Substation. If either a Cougar feeder or a bus from Campus Switchgear B was out of service during this peak load condition, then the entire peak load would be carried by the feeder in service. However, the probability of concurrent peak demand is very low. If a diversity factor of 1.25 is applied, this would reduce peak demand to 913-A. Regardless, the addition of future loads should be monitored as the design of the planned future facilities advances.

Further study may be appropriate to consider the addition of suitably sized switchgear equipment at the COM. A single 600-A incoming feeder breaker is provided now and is not suitable to support all of the planned growth in this area.

One possible solution to feed the COM from the main campus power distribution system would be to route two underground feeders from Campus Switchgear B to the COM incoming switchgear with a short transition above ground to cross Brays Bayou via duct banks suspended from the existing bridge. However, the feasibility of this concept has not been verified with the Texas Department of Transportation or City of Houston. If feeders cannot be attached to the existing bridge, then a new structure would need to be constructed to cross the bayou. This would add cost to the project and would require regular maintenance.

An approximate cable route is shown on Figure 5-9. A larger version of this image can be found in Appendix H.

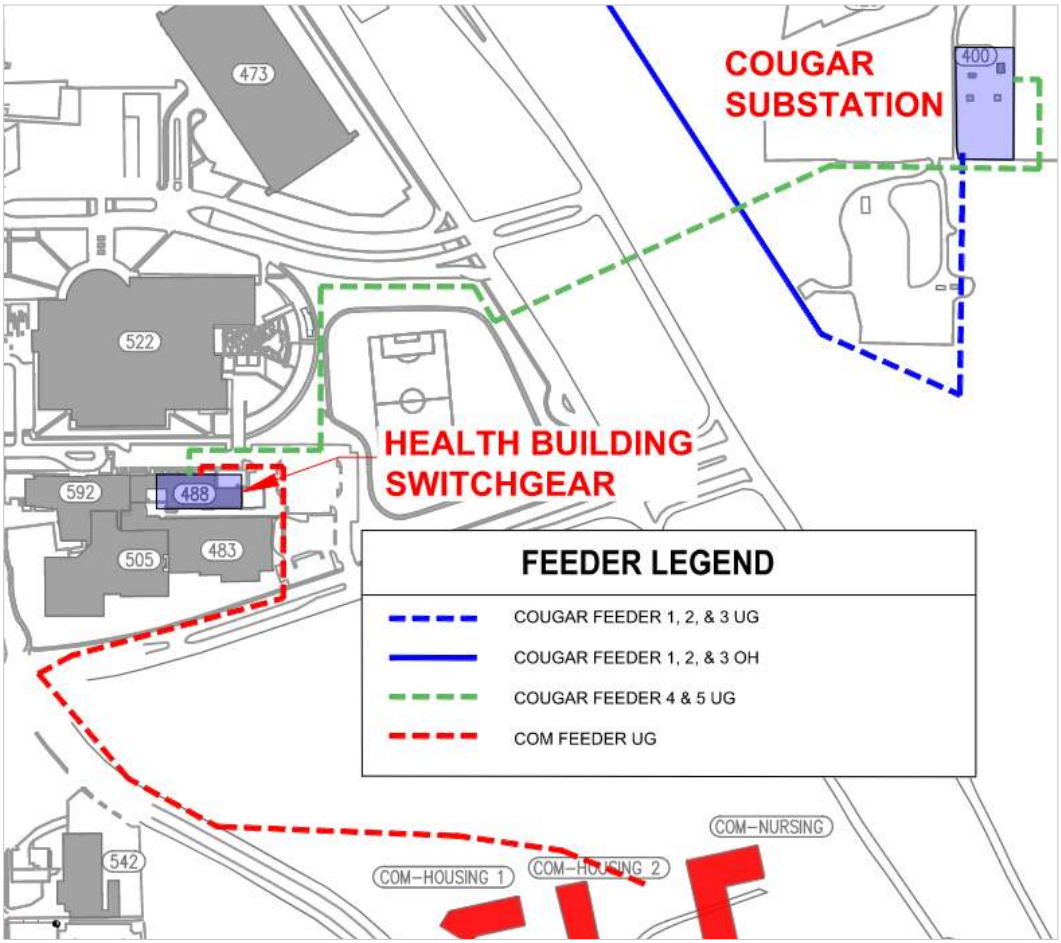


Figure 5-9. Health Building to College of Medicine Feeder Routing

Based on this analysis, connecting COM loads to Campus Switchgear B is feasible but would reduce the spare capacity available for other future building loads. For this reason, feeding COM from Campus switchgear B is not recommended.

As an alternative, direct feeders could be run from the Cougar Substation to the COM. Duct bank drawings prepared for the substation expansion project (Shah Smith 2016, 2016a, 2016b, 2016c) indicate there are two 6-inch spare conduits available in the duct banks between Cougar Substation and the Health Building Switchgear. These conduits can accommodate three1,250 thousand circular mil (kcmil) copper

cables with one conductor per phase, which could provide an ampacity rating of 600 A or more, subject to cable thermal analysis. These conduits could be intercepted outside the Health Building and extended down to COM for a direct 600-amp feed.

A new 15-kV switchgear added as part of the substation expansion project in 2018 has a 1200-A equipped spare feeder cubicle. However, UH has reported that there is no physical space available in the control room for any additional breaker cubicles to be added for a second redundant feeder or any other future load. Therefore, additional switchgear equipment would be required to facilitate dual feeders.

5.6.2 Interconnection of Campus Switchgear

During normal operation, Campus Switchgear A in the CUP is served by the Cougar 1 and 2 feeders from the Cougar Substation with incoming ring switchgear tie breakers open. If the Cougar1 or 2 feeder was out of service, one of the tie breakers would be closed to extend power from available feeders. During these switching operations, staff would ensure no two transformers were connected in parallel. This is mainly due to the fault rating of the campus switchgear. The fault duty of campus switchgear is 21.65 kA. If the Transformer T1 and T2 secondaries are paralleled, the symmetrical fault current would be 20.19 kA for a bus fault at the campus switchgear according to short circuit study data provided in Jonmar Electric Inc. (2011).

Campus Switchgear B is served by the Cougar 4 and Cougar 5 feeders, which are connected to Transformer 3 during normal operation. As the Cougar 1, 2 and 3 feeders have reliability concerns, Jacobs assessed whether it was possible to interconnect Campus Switchgear A and B to feed Campus Switchgear A loads through Campus Switchgear B.

Jacobs' analysis concluded that it is possible to interconnect the two switchgears using the spare feeders available on both switchgear after upgrading two spare feeders referred to in Tables 5-9 and 5-10. Two cable feeders with an approximate route length of 0.5 mile would be required to tie two sections into each switchgear. However, this arrangement would have the following limitations.

- When Campus Switchgear A is served from Campus Switchgear B, Campus Switchgear A cannot be connected to the Cougar 1, 2 or 3 feeders if these feeders are served by Transformer 1 or 2, as this would exceed the fault rating of Campus Switchgear A. In other words, transformers T1, T2 or T3 cannot be operated in parallel to meet campus electrical demand.
- The campus switchgear cannot be interconnected if either the Cougar 4 or Cougar 5 feeder is out of service. The existing peak load is 39 MW and the Cougar 4 and 5 feeders are each rated for 1,200 A. A single feeder would not be able to support the entire campus load.

The estimated cost for this interconnection is $4,684,000.

5.7 Substation Alternatives—Evaluation and Conclusions

Based on information in the preceding sections, UH must decide how to proceed with regard to power supply for the main campus. As discussed, Cougar Substation has sufficient capacity to support future load growth anticipated as a result of planned campus expansion. However, there are a number of challenges with regard to resiliency and expandability. Section 5.5.1 of this EMP also describes the option of constructing a new campus substation as an alternative to upgrading Cougar Substation and rectifying various deficiencies. To help UH determine the path forward, Jacobs evaluated three power supply options and ranked them using an evaluation matrix. Maximum scores were weighted to reflect the relative importance one option over another. The scores for each option were determined in coordination with UH. Options are described below.

5.7.1 Option 1—Business as Usual

Option 1 replaces only system components that have exceeded their useful service life without investing in any other improvements to increase reliability or resiliency. This option assumes UH would still have to maintain existing infrastructure, including replacing components such as feeder cables and transformers when they reach the end of their service life. Within the next 10–15 years, it is likely that major equipment such as transformers T1 and T2 and medium-voltage capacitor banks 1 and 2 in the Cougar Substation will need to be replaced. Similarly, cable sections of Cougar 1, 2 and 3 feeders will need to be replaced. Based on 2022 costs, it is anticipated that this work will cost $9,953,000. These costs would continue to escalate given market conditions for replacements performed at a later date.

5.7.2 Option 2a—Upgrade Cougar Substation to Improve Reliability and Expandability

Option 2a would include the work of Option 1 and add additional measures to improve the reliability of Cougar Substation and power distribution. These upgrades would include reconfiguration of the 138-kV buses as discussed in Section 5.4.1, installing a new duct bank in parallel to the existing Cougar 1, 2 and3 duct banks across the railroad and Spur 5 as discussed in Section 5.4.3, and installing an additional indoor 15-kV switchgear in the Cougar Substation to facilitate adding new feeders for future loads. The estimated total cost of work required for Option 2a is $15,104,000.

The Option 2a cost estimate does not include relocating overhead line sections in the Cougar 1, 2 and 3 feeders to underground. If UH considers this improvement as a way to mitigate the risk of outages caused by an overhead power line fault, additional study would be required to determine if a new underground easement would be feasible.

5.7.3 Option 2b— Upgrade Cougar Substation & Construct New Duct Banks

Option 2b is a variation of Option 2a; overhead sections of the Cougar 1 ,2 and 3 feeders would be eliminated by routing feeder cables from the Cougar Substation through new duct banks installed underneath the railroad and Spur 5. To improve reliability, two separate duct banks would be installed, with the Cougar feeder 1 in one duct bank and Cougar feeders 2 and 3 in the other duct bank. These two new duct banks would be run from Cougar Substation to the CUP. To cross the railroad and Spur 5, the new duct banks would be assumed routed to the south of the existing duct bank for the Cougar 4 and 5 feeders. Option 2b's estimated cost is $27,085,000.

5.7.4 Option 3—New Substation

Option 3 would replace Cougar Substation rather than upgrade it or upgrade existing feeders. Section 5.5.1 discusses Option 3 in more detail. Option 3 would require three new feeders to the Central Plant Switchgear, two new feeders to Campus Switchgear B, and reusing the existing Cougar 4 and 5 circuits as Technology Bridge feeders. Option 3 is estimated to cost $40,707,000. For comparison, should the Cougar Substation be upgraded, and all reliability projects undertaken, the estimated cost is $36,604,000 making Option 3 similar in cost.

5.7.5 Evaluation Criteria and Scoring

To support decision-making and further clarify the most appropriate solution for UH, Jacobs jointly developed with UH the evaluation options for the Substation and ranked them using an evaluation matrix. Tables 5-16 lists the evaluation factors Jacobs developed. As one factor may be more important than others, maximum scores were weighted to reflect the importance of each factor. The score for each option was determined using Jacobs' opinion as many of the factors do not have a defined cost associated with them.

Table 5-16. Evaluation Factors

Evaluation Factor	Description
Reliability	This factor covers substation bus configuration, campus feeders route separation and equipment age for both existing and new equipment up to campus switchgear. The most reliable option will be scored higher.
Cost	Equipment and Installation cost. Under this category, a base point will be allocated and every million dollars in cost will reduce the basepoint point by 1. If the base point is considered 50, then a $10 million cost would result in the allocation of 40 points to the option. Cost indicated for each option is an estimate of present-day costs.
Constructability	Review of the ease of construction with minimum outage of the services to the campus. The option that allows more pre-outage construction would have more weight.
Expandability	Flexibility to expand by adding new transformer or new feeders.
Footprint	Impact on available space in the campus for the construction any other building. The smaller the footprint, the higher the score.
Accessibility and Maintenance	Ease of accessing the assets for maintenance with less liaison or coordination with third parties. Feeders routed in university land will be scored higher over the feeders sharing a common easement or ROW with others.

After scoring the different options, the values were consolidated into Table 5-17.

Table 5-17. Substation Option Scoring

Evaluation Factor	Option Scoring				
	Weighted Maximum Score	Option 1 Business as Usual	Option 2a Upgrade Cougar Substation	Option 2b Upgrade Cougar Substation	Option 3 New Substation
Reliability	60	10	30	40	55
Cost	50	40	35	23	9
Constructability	40	5	15	20	35
Expandability	20	0	5	5	20
Footprint	10	10	7	7	5
Accessibility and Maintenance	30	5	10	15	25
Total	**210**	**70**	**102**	**110**	**149**

Table 5-18 compares the different evaluation factors for each option.

Table 5-18. Options Comparison

Evaluation Factor	Comparisons			
	Option 1 Business as Usual	Option 2a Upgrade Cougar Substation	Option 2b Upgrade Cougar Substation and Construct New Duct Banks	Option 3 New Substation
Reliability	While this option includes maintaining existing equipment in good working order, the high-voltage feeder position and routing of cable section of feeder in the same duct bank/route would still affect the reliability. Similarly, there is only one spare in the 15-kV switchgear for an additional power feeder.	This option would eliminate some of the most critical reliability concerns but much of the aging substation equipment would not be replaced, including the 145-kV circuit breakers and the 15-kV circuit breakers. Also, a section of Cougar 1, 2 and 3 feeders would remain as overhead lines and probability of fault on the overhead lines are higher than the underground cables.	This option would eliminate overhead line sections on Cougar 1, 2 and 3 feeders by constructing new duct banks and routing the circuits underground. This would improve reliability.	All substation equipment and feeders would be new, and would eliminate all deferred maintenance concerns. A six-breaker ringbus will be constructed to maximize reliability and all feeders to campus switchgear will be constructed below grade, with the possible exception of feeders over Brays bayou to the COM, which would be routed through ducts attached to the bridge.
Cost	This option would cost the least as only necessary end-of-life replacement work will be carried-out.	Additional investment would be required for upgrades to Cougar Substation	Two new duct banks from Cougar Substation to the CUP would increase cost.	The estimated cost to build a new substation would include new campus primary feeders, reuse of the existing Cougar 4 and 5 feeders for the Technology Bridge and an allowance for CPE's costs to provide 138-kV services to the new campus substation.

Table 5-18. Options Comparison

Evaluation Factor	Comparisons			
	Option 1 Business as Usual	Option 2a Upgrade Cougar Substation	Option 2b Upgrade Cougar Substation and Construct New Duct Banks	Option 3 New Substation
Constructability	Multiple outages of substation equipment and feeders would be required during the construction activity.	This option would reduce the outage on Cougar feeders as a new duct bank can be constructed pre-outage parallel to existing the duct bank to re-route Cougar 1 feeder across railroads and Spur 5	New duct banks could be constructed with less outage to Cougar Circuits. However, constructing new duct banks underneath the railroads and Spur 5 would be subject to risk evaluation by Texas DOT and railroad authorities before approval of the project as there are an existing duct bank crossing in the vicinity.	Majority of construction work can be performed without major outage on the existing substation or any campus primary feeders.
Expandability	Not applicable for this option.	A new pre-fabricated switchgear building would be installed and connected to T3 medium-voltage switchgear to allow for new feeders to support future loads.	Same as Option 2a.	Capacity of substation could be increased by adding a new transformer in the sixth feeder position in the 138-kV ring in the future. Also, the 138-kV ringbus could be converted into a breaker and a half if factored in the initial design and if the space is available to expand.
Footprint	No adverse change in the footprint and hence would be scored full.	This option would have marginal impact on the footprint of the existing substation.	The two new duct banks would have minimal impact to the footprint.	New substation would replace the existing Cougar Substation, but the footprint of the new substation will be slightly larger to allow for future expansion.

Table 5-18. Options Comparison

Evaluation Factor	Comparisons			
	Option 1 Business as Usual	Option 2a Upgrade Cougar Substation	Option 2b Upgrade Cougar Substation and Construct New Duct Banks	Option 3 New Substation
Accessibility and Maintenance	Accessing and maintaining the overhead conductor sections of Cougar feeders 1, 2 and 3 routed along railroad ROW and duct bank crossing under multiple railroads and the State Highway 35 would need coordination with the respective agencies. This would affect the preventive maintenance and repair activities	Same as Option 1	Removal of overhead lines on Cougar 1, 2 and 3 feeders would reduce the accessibility issues mentioned in Options 1 and 2a. But the new duct banks crossing under the railroad and Spur 5 would still restrict the access.	Exiting parking lot 4A is the proposed site for the construction of new substation. From here the primary feeders to Campus Switchgear A and B are proposed to be routed underground. The feeders would cross the light rail tracks and Wheeler Avenue near the substation, but the major sections of the circuit would be expected to be within the university easement. This would make access to the circuit easier. Also, no overhead conductors sections would be involved, which would reduce maintenance.

5.8 Recommended Electrical Projects

The electrical options described above have several distinct sub-projects that could be implemented in phases over the course of several years. Table 5-19 shows estimated costs for discrete components of recommended projects. Table 5-20 shows estimated costs for alternative sub-projects to improve Cougar Substation if it is not replaced and retired.

Table 5-19. Electrical System Cost Estimate Summary

Item	Identifier	Description	Estimated Cost ($)		Remarks
			Deficiency	Upgrade	
1	ELEC-01	New feeders from new substation to Campus Switchgear A in CUP and Campus Switchgear B in Health District Plant and repurpose Cougar 4 and 5 feeders for Technology Bridge	--	14,993,000	Alternatives ELEC-01A, 02A, and 03A could be done. Option 3 cost estimate provided under section 5.7.4 for new substation is a sum total of identifiers ELEC-01, and 02 cost.
2	ELEC-02	New 138-kV substation, six-position ring busbar configuration with two feeder and four transformer positions	--	25,714,000	Alternatives ELEC-01A, 02A, and 03A could be done. Utility interconnection cost of $6M assumed.
3	ELEC-03	Microgrid study	--	896,000	Required only if the new power generation sources are added such as reciprocating engines and combustion turbines to supply campus electrical load.
4	ELEC-04	Electric meters	--	527,000	--
5	ELEC-05	Photovoltaic system	--	85,379,000	--
6	ELEC-06	Lighting upgrade	--	7,552,000	--
Total			--	135, 061,000	--

Table 5-20. Electrical System Alternates

Item	Identifier	Description	Estimated Cost ($)		Remarks
			Deficiency	Upgrade	
1	ELEC-01A	Cougar Substation re-configuration to increase reliability.	1,408,000	--	Option 2a cost estimate provided under section 5.7.2 is a sum total of identifiers ELEC-01A,03A, 04A, and 05A cost.
2	ELEC-02A	Perform transformer testing to determine paper insulation condition and life of transformer through the degree of polymerization or furan testing using oil samples.	70,000	--	To confirm system deficiency and plan for upgrades.
3	ELEC-03A	Replace underground feeder sections for Cougar 1, 2 & 3 from Cougar Substation to the CUP. Includes new duct bank.	9,449,000	--	Upgrade to address identified system deficiency. Includes installed cost for an additional duct bank to cross Spur 5 and UP tracks to move Cougar 1 from the exiting duct bank. Potential 1.8 million cost reduction if existing duct banks casing reused.
4	ELEC-03B	Replace underground feeder sections for Cougar 1, 2 &3 from Cougar Substation to the CUP in the existing duct banks.	[7,643,000]		Alternate to ELEC-03A and not included in the total deficiency cost. Option 1 cost estimate provided under section 5.7.1 is a sum total of identifiers ELEC-03B, and 04A cost
5	ELEC-04A	Cougar Substation equipment replacement cost	2,310,000		Cost included for transformers T1 and T2 and MV capacitor banks1 and 2 end-of-life replacement.
6	ELEC-05A	Cougar Substation upgrade cost for an additional MV Switchgear		1,937,000	
7	ELEC-06A	Elimination of overhead lines for Cougar feeders 1,2 &3		21,430,000	Option 2a cost estimate provided under section 5.7.3 is a sum total of identifiers ELEC-01A, 04A, 05A, and 06A cost.
		Total	13,237,000	23,367,000	Total does not include ELEC-03B

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6. Utility Tunnels

6.1 Overview

Campus utility tunnels vary in age due to system expansions that have occurred since the original campus expansion in the1960s. The utility tunnels contain most of the distribution piping for the steam, condensate, and chilled water for the campus, as well as the campus medium-voltage feeders. There are approximately 3 miles of tunnels for distribution of utilities across the campus.

6.2 Utility Tunnel Conditions

According to a review of the images presented in the 2013 Shah Smith report, most of the tunnels are functional with minimal concrete spalling and cracking. Some exposed rebar did appear in some images. While exposed rebar is not uncommon in tunnels of this age, Jacobs recommends addressing this condition to prevent further deterioration. To better plan utility tunnel projects that address structural integrity issues not associated with the piping system, Jacobs also recommends developing an assessment report with a rating system to help prioritize tunnel section repairs.

In the past during weather events such as hurricanes, the utility tunnels have flooded, and water from the tunnels has flowed into buildings connected to the tunnel system. To prevent further flooding, many watertight tunnel access doors were added. These doors are closed and secured to prevent flooding. These watertight doors are monitored at the CUP operators' station. These watertight doors are relatively new, and for this EMP, Jacobs assumed no repair work was immediately necessary.

Also, according to the 2013 Shah Smith report, there appears to be standing water in some parts of the utility tunnels. This can be detrimental to both concrete and any ferrous metal. There are existing sump pumps installed in the utility tunnels; however, based on information collected during interview with UH staff, sump pump conditions are not known. Jacobs recommends placing the sump pumps on a regular maintenance schedule to ensure operation during weather events. Appendix E contains a map showing the location of existing sump pumps. In the cost estimate, Jacobs estimated an allowance for replacing existing sump pumps in the utility tunnels.

6.3 Pipe Supports

Pipe supports in the tunnel system have been showing signs of degradation or failure since the Shah Smith report was published in 2013. Many of the pipe supports appear to be a pre-manufactured system that is bolted together in the field for installation. These supports appear to be galvanized steel; however, the galvanized coating has failed and corrosion is occurring on the base metal.

Figure 6-1shows a failed pipe support in the tunnel system. The 2013 Shah Smith report noted that there were a significant number of supports that needed remediation almost 10 years ago. Based on interviews with UH staff, Jacobs understands that no significant projects have been undertaken to address the issues identified in the 2013 Shah Smith report and assumes that conditions have continued to deteriorate. Jacobs recommends developing a comprehensive support replacement program to address existing issues as soon as possible. For cost estimating purposes, Jacobs assumed tunnel supports would be replaced in their entirety and are spaced at an average interval of 12 feet.

Source: Shah Smith 2013

Figure 6-1. Corroded Pipe Support

6.4 Recommended Utility Tunnel Projects

The utility tunnel system has several distinct sub-projects to be implemented over the course of several years. Table 6-1 shows cost estimates for items detailed here.

Table 6-1. Utility Tunnel Cost Estimate Summary

Item	Identifier	Description	Cost ($)		Remarks
			Deficiency	Upgrade	
1	UT-01	Utility tunnel inspection report.	84,000	--	
2	UT-02	Utility tunnel structure repair.	800,000	--	Exact scope to be determined by inspection report.
3	UT-03	Sump pump replacement and maintenance program.	60,000	--	Assumed 20 pumps.
4	UT-04	Replace 500 feet of pipe supports per year. Does not include piping.	5,120,000	--	$214,000 per year for 16 years. Replaces approximately 50% of piping.
		Total	6,064,000	--	--

7. Control Upgrades and Emergency Water Storage

7.1 Overview

In addition to the steam, chilled water, and electrical system improvements discussed in the prior sections, Jacobs also recommends a number of other investments to support growth on campus and improve resiliency, efficiency and sustainability.

7.2 HVAC Control Upgrades

Heating, ventilation, and air-conditioning (HVAC) controls for many of the campus buildings have exceeded their useful life, which is typically 30 years. According to information collected during interviews with UH staff, some controls are non-operational. Additionally, several buildings have a mix of different control systems, some of which are not compatible and other systems which are still operational are technologically obsolete in comparison with modern control systems. Replacing and upgrading HVAC building controls would allow UH staff to better maintain and operate HVAC control systems efficiently.

While it is difficult to determine precise campus-wide energy savings if HVAC controls were upgraded, there would likely be a payback period. In the report from the Pacific Northwest National Laboratory *Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction*, Figure 6.33 shows that, for a large office building in Houston, energy efficiency could increase by 20% or more by having better HVAC controls. Assuming a peak campus load of approximately 17,600, tons this could be interpreted as an additional 3,520 tons of cooling through HVAC controls upgrades. To verify this value, a review of all campus buildings and their annual energy performance would need to be done. This review would require data generated by meters on both the thermal and electrical systems. Additional discussions about metering are in the utility sections of this EMP.

While a 20% savings could be possible, for the purposes of reducing the campus carbon footprint, Jacobs assumed that 70% of the buildings could be upgraded and that a 10% savings could be realized. Using these assumptions, CO_2 emissions could be reduced by 14,363 tons annually. These estimates are conservative and based on Jacobs' experience with similar large facility projects to show a rough order-of-magnitude estimate of CO_2 emissions reduction.

Replacing HVAC controls in an existing building can be a significant undertaking. Jacobs recommends prioritizing upgrades of buildings with the highest risk, such as high-end lab buildings or buildings with failed control systems. Jacobs also recommends evaluating each campus building to prioritize HVAC control upgrades and replacements. In the cost estimate, Jacobs assumes an average cost per square foot based on experience with similar projects completed.

7.3 Commissioning of Existing Buildings

Commissioning is the process of verifying a building is operating as intended. However, over the course of a building's life, it is not uncommon for problems such as temperature control to occur either from control system failures or control sequences no longer meeting the needs of the space. These problems create occupant discomfort and increase energy usage. There are two types of commissioning that are focused on addressing these problems. The first is re-commissioning. This applies to buildings that have been previously commissioned and is intended to maintain building performance.

The second is retro-commissioning. This applies to buildings that were either not commissioned properly or not commissioned after being constructed. Retro-commissioning is done by evaluating the building's original design parameters, typically by reviewing the original test and balance report, and then evaluating

how the building is currently operating. The controls setpoints and sequences are then updated and revised as needed to optimize the building's performance. This process also identifies control systems that may not be fully operational due to items such as failed dampers and stuck control valves. Retro-commissioning would reduce energy use and by extension reduce the campus carbon footprint without invasive modifications to existing HVAC systems. The EPA Energy Star *Building Upgrade Manual* (EPA 2008) has additional detail on the implementation of a commissioning program for existing buildings.

Jacobs has provided rough order-of-magnitude costs associated with the different building types and square footages. These estimated costs are based on Jacob's experience performing commissioning on other similar projects.

7.4 Existing Central Utility Plant Controls

The existing CUP has two primary control systems. The first system is for the boilers. The boiler control system is dedicated to the boilers only and is not interconnected with any network. This reduces the potential for any cyber intrusion, and Jacobs does not recommend any system modifications. This system was installed with the boilers in 2012 and does not have any known operational issues.

The second system is a JCI Metasys system that controls the chiller plant. This system was installed in 2019 and does not have any known issues. The CUP controls and campus system have not been integrated at this time. Integration of the CUP and building controls could be done; however, it would require significant upgrades to the buildings to operate efficiently. Jacobs recommends pursuing systems integration after a majority of campus buildings have undergone HVAC control upgrades. By integrating the CUP and building control systems, the campus chilled water system could be optimized for higher overall efficiency. An estimate of the potential energy savings for this integration should be performed after building level thermal and electrical energy metering data is available. Additional discussions about metering are in the utility upgrade sections of this EMP.

In addition to the JCI Metasys system, an Optimum Energy system was installed in 2019. The Optimum Energy system was integrated into the chilled water control to optimize chiller plant controls and energy performance. However, according to information collected during interviews with UH staff, this system is sometimes overridden to maintain setpoints chosen by operators. Jacobs recommends reviewing operational procedures to identify how to make better use of the Optimum Energy System and prevent the need for overrides.

7.5 Supervisory Control and Data Acquisition System

To collect data from various building meters, Jacobs recommends installing a supervisory control and data acquisition (SCADA) system. Information about the different meters can be found in Sections 3.5, 4.5, and 5.5. Rather than integrating new meters into the existing building management system, Jacobs recommends deploying a dedicated metering SCADA system. A dedicated SCADA system would create a single control platform to review all metering data without relying on a building management system to relay data back to a central collection system. In the cost estimate, the steam, condensate, chilled water, and electric meters are treated as separate items, and are included under their applicable sections of this EMP. Installation of the SCADA system would preferably be done prior to installation of meters at the buildings.

7.6 Emergency Water Storage

As demonstrated during winter storm Uri in February 2021, domestic water from the City of Houston may not be reliable during severe weather events. Other unplanned outages may also occur as a result of water

mains being punctured by construction activities or failing due to age. Any such outage can render the CUP inoperable and leave the campus without steam or chilled water until service is restored.

On campus, make-up water is required for the cooling towers to replace evaporation/drift losses and condensate losses from the steam system due to leaks and blowdowns. To create a more resilient campus energy system and allow for some disruption to water supply, Jacobs recommends installing an emergency water storage tank. The storage tank could be located either above or below grade. Table 7-1 lists approximate make-up water requirements for the existing CUP.

Table 7-1. Average Historical Make-Up Water Requirements

Item	Water Source	Average Winter Make-Up (gallons/month)	Average Summer Make-Up (gallons/month)
Boilers	City of Houston	695,000	545,000
Cooling Tower [a]	City of Houston	8,005,000	15,500,000
Chilled Water [b]	City of Houston	32,000	32,000
Total		8,732,000	16,077,000

Note:

[a] Data taken from 2014–2019 make-up water at the CUP.

[b] Make-up water requirements do not have a strong summer/winter correlation.

Based on the peak make-up water requirements for normal operations and a maximum city water outage duration of 3 days, Table 7-2 lists the storage volume requirements for an emergency water storage system. Listed numbers are for a non-potable water system that serves only the industrial water system.

Table 7-2. Emergency Water Storage

Season	Gallons	Approximate Tank Size (feet)	Remarks
Summer	1,607,000	13 x 90 x 100	740 gpm pumping system would be needed
Winter	873,000	24 x 90 x 100	400 gpm pumping system would be needed

For cost estimating purposes, Jacobs assumed the water tank would need to hold a sufficient amount of water for the summer season. In regard to space planning, Jacobs also assumed that the storage tank could be located under one of the planned parking structures, and could be added when the parking structure is constructed.

7.7 Booster Pump

During winter storm Uri, the UH campus was not able to keep the CUP boilers in operation because of low water pressure in the City of Houston system. As the make-up water softeners and deaerator tank operate at a pressures above atmospheric, any reduction in city water pressure below approximately 20 psig could cause the boiler make-up water system to fail, or not function at a sufficient flow to meet demand. A potential solution to this issue would be install booster pumps between the City of Houston water main and the CUP. This would allow the CUP to operate when the City of Houston's water pressure was normally insufficient for operating boiler make-up water equipment. For cost estimating, Jacobs assumed the larger of the two pumps shown in Table 7-2 would be appropriate for this application.

7.8 Recommended Projects

Table 7-3 shows the cost estimate for items detailed here.

Table 7-3. Chilled Water System Cost Estimate Summary

Item	Identifier	Description	Cost ($)		Remarks
			Deficiency	Upgrade	
1	MISC-01	Emergency water storage tank of 1,600,000 gallons	--	4,568,000	
2	MISC-02	HVAC building controls study	1,229,000	--	
3	MISC-03	Existing building HVAC control upgrades	50,455,000	--	
4	MISC-04	Commissioning of existing buildings	--	21,524,000	Includes both re-commissioning and retro-commissioning
5	MISC-05	SCADA system	--	978,000	
6	MISC-06	CUP booster pump	--	89,000	
		Total	51,684,000	27,159,000	--

8. Project Alternatives to Meet Future Energy Demands

As described in the prior sections, additional chilled water capacity is needed to accommodate planned campus growth. Energy resiliency, efficiency and sustainability are also of paramount importance. This section focuses on a number of possible solutions and compares the relative benefit of each across a range of criteria. The options evaluated include CHP and Non-CHP options for evaluation and comparison.

8.1 Methodology

8.1.1 Screening Analysis

This preliminary screening analysis has been performed to evaluate the feasibility of utility plant solutions for the UH campus. For this screening, Jacobs utilized baseline and projected average monthly electrical and thermal load profiles. System options have been identified based on system configurations deemed appropriate for the campus's operational needs.

Where available, historical data prior to 2020 was used. This was done to account for anomalies in campus activity caused by the COVID-19 pandemic. The following sections describe the different systems, both thermal and electric, and the methodology Jacobs used to develop the load profiles.

8.1.1.1 Chilled Water Load Profile Development

Jacobs developed the campus chilled water load profile using data provided by UH. Figure 8-1 represents monthly chilled water demand from March 2021 through February 2022. Jacobs used 2021–2022 data because no monthly load data in the form of monthly tonnages was available prior to March 2021. To account for the chilled water load increases from 2022–2030, a 118% scaling factor was applied. This is the ratio of the calculated peak cooling load for 2030 divided by the peak cooling load for 2018.

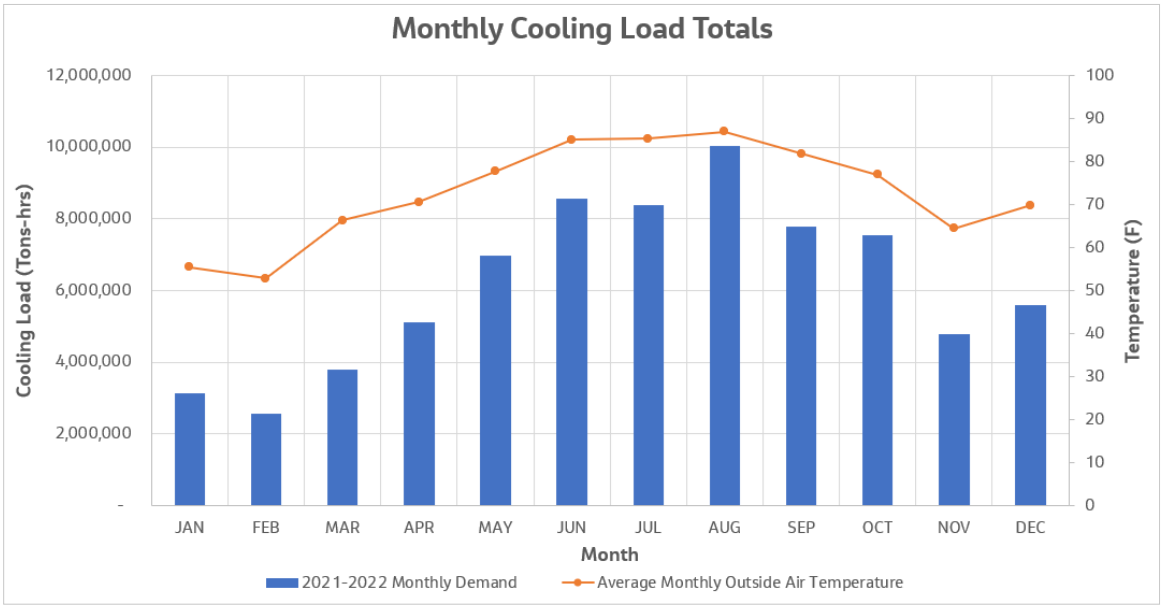

Figure 8-1. Chilled Water Load Profiles vs Outside Air Temperature

8.1.1.2 Steam Load Profile Development

Jacobs developed the campus steam load profile using data provided by UH. Figure 8-2 represents average 2018 steam demand. Jacobs used 2018 as a typical year because the average monthly temperatures more closely match historical averages than averages from 2019. To account for the steam load increases from 2022–2030, a 105% scaling factor was applied. This is the ratio of the calculated peak steam load for 2030 divided by the peak steam load for 2018.

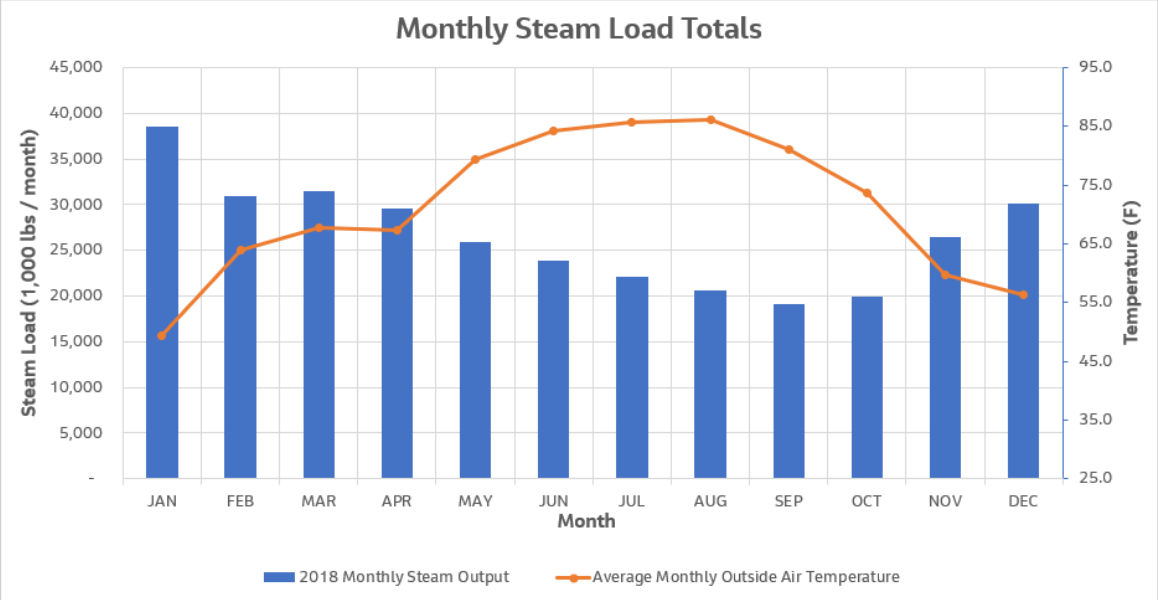

Figure 8-2. Steam Load Profiles for 2018 vs Outside Air Temperature

8.1.1.3 Electrical Load Profile Development

To determine the electrical loads, Jacobs developed a composite profile using data from February to December 2019 and from January 2022. Figure 8-3 shows the composite yearly electrical load profile used for analysis. There are some measurements below 20,000 kVA that Jacobs assumes are not related to campus demand, and can be discarded from consideration. To account for the electric load increases from 2022–2030, a 113% scaling factor was applied. This is the ratio of the peak electrical load for 2030 divided by the peak electrical load from 2019.

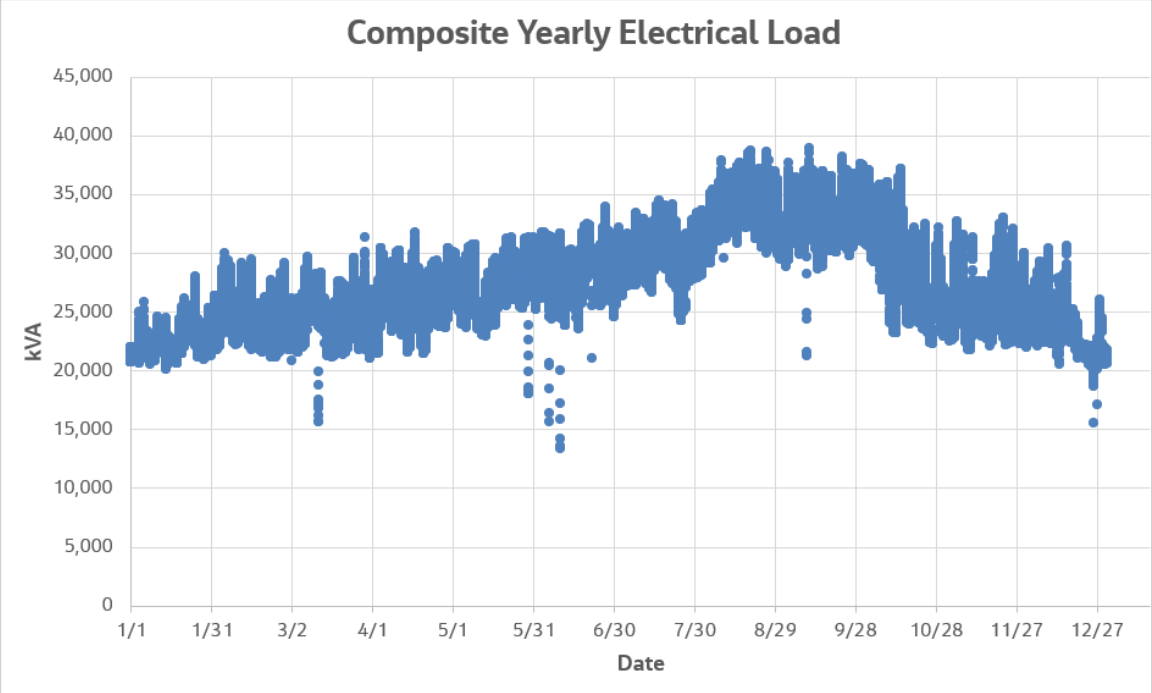

Figure 8-3. Composite Electrical Load Profile

8.1.2 Analysis Tools and Methods

Jacobs developed performance simulation/heat balance models for the CHP plant options using Thermoflex software. Thermoflex, part of the Thermoflow software suite, is a graphical heat balance software package that allows users to create a component-by-component model of virtually any type of power plant or thermal system and simulate its performance under varying load and ambient conditions. Thermoflex allows for initial design point definition of plant equipment performance, and subsequent part-load analysis of as-designed components, taking into account the associated efficiency impacts of part-load operation.

Once the Thermoflex models were developed, Jacobs ran simulations using a select set of ambient conditions and thermal and electric demands to characterize each option's performance. Model variables requiring adjustment to meet campus thermal demands included the following:

- Cooling requirements for combustion air intakes on combustion turbine generators
- Combustion turbine generator load as a percentage of base load capacity (where part-loading is required)

While Thermoflex is a powerful tool for simulation of plant performance over a wide range of operating conditions, the software is designed to provide snapshot-type performance data for discrete operating scenarios. On its own, Thermoflex does not lend itself to load-following simulations, which are required to fully evaluate the comparative annual performance of a particular set of plant design and operating strategies.

Jacobs used average dry bulb and wet bulb temperatures to determine equipment efficiency, natural gas consumption rates, and other necessary data. Natural gas consumption rates, steam generation rates, and efficiencies were put into a spreadsheet to model monthly thermal and electrical loads for both the CHP and existing CUP. To simulate both the CHP and CUP being operational in a parallel configuration, the

loads were separated into CHP and non-CHP loads. This methodology allowed the evaluation team to consider the overall efficiency of the CHP and CUP operating in parallel to satisfy campus demand.

8.2 Combined Heat and Power Screening Criteria

Jacobs used the screening criteria in Table 8-1 to select equipment for the screening analysis. These metrics were used as a starting point to begin equipment selections and analyses.

Table 8-1. Screening Criteria

Metric	Quantity	Units	Remarks
Minimum electrical demand [a]	24	MW	Refer to Section 5.2 for additional information
Maximum electrical demand [b]	44	MW	Peak demand from 2019 data with future loads from 2022 until 2030
Minimum steam demand [d]	30,000	lbs/hr	Based on historical minimum. Scaling factor not applied as this is a minimum value.
Maximum steam demand [d]	63,000	lbs/hr	Based on historical maximum with scaling factor
Minimum chilled water demand	4,214	Tons	From Optimum Energy report, January 2022
Maximum chilled water demand [c]	20,852	Tons	Based on historical maximum with loads future loads from 2022 until 2030
Minimum chilled water expansion to meet 2030 chilled water loads	1,053	Tons	Assumes existing CUP firm capacity does not change. Additional loads beyond 2030 not included. Load increase of 1,930 beyond current CUP capacity required to meet 2040 chilled water loads.

Note:

[a] Excludes some data points that appear to be brief events.

[b] Excludes integration of buildings on CPE service into the campus grid.

[c] Assumes 10°F water temperature differential.

[d] Data provided by UH.

8.3 Equipment Efficiencies and Assumptions

Jacobs used equipment efficiencies based on available manufacturer data or typical industry metrics. The efficiencies reviewed did not look at hourly thermal and electrical load changes and were instead based on monthly averages. For a high-resolution analysis, Jacobs recommends using hourly loads and corresponding part-load efficiencies to determine energy consumption and potential cost savings. Table 8-2 lists equipment efficiencies and assumed consumption rates.

Table 8-2. Equipment Efficiencies and Assumptions

Equipment	Quantity	Units	Remarks
Chilled water auxiliary equipment	0.4	kW/ton	Includes pumps and cooling towers
Heat exchanger efficiency for heat recovery	80	%	Typical of heat exchangers for this type of application
Lithium bromide chillers	0.04	kW/ton	Electrical consumption for chiller only

Table 8-2. Equipment Efficiencies and Assumptions

Equipment	Quantity	Units	Remarks
Lithium bromide chillers using steam	18.70	lbs steam/ ton-hour	Steam consumption for chiller only. For combustion turbine alternates.
Lithium bromide chillers using hot water	18,500	Btu/ton-hr	Thermal consumption for chiller only. For reciprocating engine alternates.
Existing boiler plant efficiencies [a]	76	%	Assumes 80% efficient boilers with 5% auxiliary loads
Cooling tower approach temperature differential	5	°F	Temperature difference between leaving condenser water and wet bulb temperature; typical value for high performance towers. For performance of new cooling towers.

Note:

[a] Pumping energy for the feedwater pumps was assumed negligible for this analysis and was not taken into account.

Efficiency data for the existing chilled water plant was taken from the Optimum Energy monthly reports provided to Jacobs. Table 8-3 shows the efficiencies that were used for the analysis. Efficiencies include pumping energy, cooling towers, and chillers. Data prior to 2021 were not available.

Table 8-3. Existing Chilled Water Plant Efficiencies

Month	Year	Efficiency (kW/ton)	Remarks
January	2022	0.850	
February	2022	0.938	Value appears high compared to January and March values.
March	2021	0.799	
April	2021	0.752	
May	2021	0.709	
June	2021	0.783	
July	2021	0.822	
August	2021	0.671	Value appears low compared to July and September values.
September	2021	0.728	
October	2021	0.677	
November	2021	0.666	
December	2021	0.705	

8.4 Utility Rates

Natural gas and electric utility rates vary throughout a typical year. The natural gas rate has two main components. The first is a fixed-volume rate for gas provided to campus. This rate does not change from month to month; the fixed-volume quantity varies based on a contract calculation method. The second component is an index rate. The index rate changes from month to month, and is applied to the difference between the fixed-volume rate and the actual volume gas amount.

Electric utility rates are pre-negotiated with utility provider but vary slightly from month to month. Charges such as meter charges, distribution charges, and other fees are included in the total rate.

Jacobs calculated steam costs using a combination of natural gas use logged by CUP staff, typical boiler efficiencies for industrial water tube boilers, and a composite natural gas price using a ratio of fixed and index rates. Table 8-4 shows the rates that were used per month. These rates are currently being re-negotiated between UH and the utility providers. Changes to the rates will affect the life cycle costs for the different alternatives as discussed in Section 8.8.

Table 8-4. Utility Rates

Month	Natural Gas [a, b] ($/MMbtu)	Electric (¢/kWh) [c]	Steam ($/lb_steam) [b]
January	3.15	4.3	0.00412
February	3.19[d]	4.5	0.00417
March	3.19	4.2	0.00418
April	3.21	4.1	0.00420
May	3.26	4.1	0.00426
June	3.31	4.0	0.00432
July	3.41	4.0	0.00446
August	3.42	4.0	0.00447
September	3.58	4.1	0.00468
October	3.45	4.2	0.00452
November	3.60	4.2	0.00471
December	3.18	4.1	0.00416

Note:

[a] Rate shown includes items such as distribution rates and contract maintenance costs. Data from 2021.

[b] Based on a composite gas rate of both fixed and index rates from 2021.

[c] Based on 2021 electric rates.

[d] Index gas rates were abnormally high due to winter storm Uri. Average of January and March index rates was used to remove abnormal rate.

8.5 Utility Interconnection

For any alternative that produces electric power, Jacobs assumes that UH will normally operate in parallel with the utility grid. Jacobs further assumes that UH will make less power than they consume at all times such that excess power is never exported to the grid. An interconnection agreement that permits the sale of power, effectively designating the University as an Independent Power Producer, would introduce a much higher level of regulation and operational complexity. Furthermore, we assume that operating as a public utility is not in alignment with the core mission or energy goals of the University.

8.6 Environmental Permitting

Natural gas-fired power plants produce greenhouse gasses and other hazardous air pollutants as a product of fossil fuel combustion and as such require construction and operating permits per EPA and Texas Commission on Environmental Quality regulations. The permitting process will entail evaluating new emissions rates, stack heights, and operating parameters for all emissions sources, including the existing CUP. New sources for evaluation include any new boilers, turbines, or reciprocating engines. Note that federal and state permitting can be time-consuming and can often drive the scheduling of construction and operation of new central plants.

Depending on the scale of the power generation equipment, this may include a prevention of significant deterioration major source construction permit under Title 40 Code of Federal Regulations Section 52.2.1. Environmental permit analysis for the combined heat and power project alternatives considered in this report has not been performed at this time but is recommended prior to proceeding with detailed design activities.

The campus' existing federal, state, and local environmental permits will also need to be updated to reflect any changes to areas that are currently not built upon. As most of the campus is no longer considered a greenfield site (that is, an area of land that has never been disturbed by humans), the complexity of environmental permitting for the site will likely be less than that of building on a greenfield site. This gives the campus additional flexibility when locating new facilities such as CHPs or satellite chilled water plants.

8.7 Description of Alternatives

Different utility plant alternatives were explored as part of this EMP. These alternatives included CHP and non-CHP cases to compare the relative economic benefit and overall value of each option. Each alternative is briefly described below. Section 8.7.11 lists the capacities for each alternative.

8.7.1 Alternative 0A—Non-CHP: CUP Expansion with Electric Chillers

One potential option for accommodating the future campus chilled water demands is expansion of the chilled water capacity in the existing CUP. The new chillers for this alternative were assumed to be electric, similar to the existing chillers installed. As the existing CUP does not have space to expand outside of the existing footprint, a new larger chiller was assumed to replace one of the existing chillers 2A or 2B. A new cooling tower would also be needed to support the increased cooling load. This could be accomplished by relocating the natural gas main that is to the east of the existing cooling towers. Relocating the gas main would be challenging as there are utility tunnels and buried infrastructure surrounding the site.

This project would add no new steam production or power generation equipment. As such, it would not improve the resiliency of the electric power or steam utilities on campus. The location of the CUP in the heart of the campus would also make any significant expansions challenging and disruptive. Figure 8-4 shows how the CUP could potentially be expanded inside of the existing footprint.

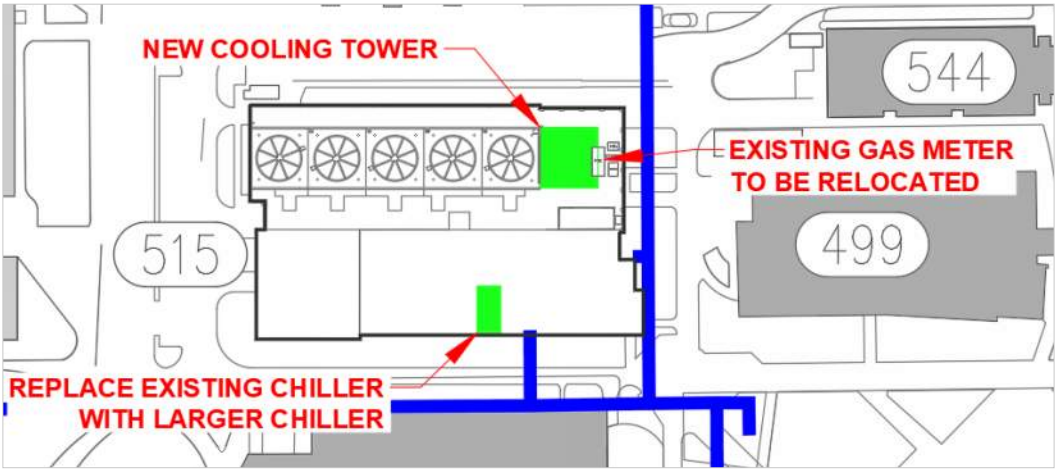

Figure 8-4. Existing CUP Expansion

The existing CUP electrical areas have limited capacity to accommodate projected campus growth. The electrical rooms are either near or at-capacity with equipment, leaving limited options for new configurations. For costing purposes, Jacobs has assumed the electrical room would be reconfigured or expanded into the existing plant to provide the room necessary for new equipment. It was also assumed that this work would be challenging and expensive due to space constraints and phasing challenges to prevent utility outages.

Piping inside the CUP would also need to be revised to accept the new chiller and cooling tower arrangement. Similarly, piping flow models show that velocities in piping would be excessive, exceeding 12 feet per second. As a result, this alternative would likely require enlargement of the existing chilled water lines to prevent excessive pressure drops and potential pipe erosion. Appendix F contains piping flow modeling results.

Table 8-5 lists estimated costs for expanding the existing CUP. These estimates include costs to upgrade the existing electrical room and increase chilled water capacity to meet only the main campus requirements. Future loads from the COM are not considered. The cost estimates are approximate and based on concepts described in this EMP. If selected, additional design work is recommended to further refine the cost estimates.

Jacobs assumed the piping, pumps, and electrical systems would be upgraded to support campus growth until 2040. New equipment is limited to pumps, chiller, and cooling tower upgrades.

Table 8-5. CUP Expansion Cost Estimates

Description	Estimated Cost ($)	Remarks
Relocate electrical utilities	1,105,000	Assumed 10 electrical utility relocates to accommodate new electrical room layout
Renovate plant area	6,758,000	Does not include new chillers or modification to piping
Concrete cooling tower	4,458,000	Includes excavation, concrete, structural steel, sump, and fan
Temporary power for electrical room work	2,193,000	Assumed 10MW of rented generators for 6 months. Fuel cost not included.
Electrical room renovation	1,987,000	--
New Electrical Equipment	10,067,000	Includes additional costs for project complexity
New Chillers and Pumps	11,724,000	Does not included chilled water piping upgrades necessary to support new expansion
Piping Revisions in plant	13,768,000	Does not include tunnel piping revisions
Total	52,060,000	--

8.7.2 Alternative 0B—Non-CHP: Satellite Chilled Water Plant with Electric Chillers

A satellite plant operating in parallel with the existing CUP was analyzed. The new electric chillers for this alternative were assumed to operate at a fixed output and the chillers at the CUP modulated to meet the campus chilled water demand. The initial chiller plant would be designed to allow for additional chilled water equipment to be installed to meet the 2040 chilled water load.

Electrical power for a new satellite chilled water plant could be accomplished using several different methods. For cost estimating purposes, Jacobs assumed that the electrical service for a new chilled water plant would be accomplished by connecting into the existing campus electrical grid, and not served directly by CPE. This would improve the reliability of power supply but could limit campus expansion on

the existing switchgear for new buildings if the campus electrical system upgrades discussed in Section 5 were not implemented.

This project would add no new steam production or power generation equipment. As such, it would not improve the resiliency of the electric power or steam utilities on campus.

Jacobs reviewed two different satellite plant alternatives. The first alternative was a 3,000-ton plant selected under the assumption that the COM was not added to the campus chilled water system. The second alternative was a 7,000-ton plant and assumed the COM was added to the campus chilled water system. Both options contained a reserve chiller for redundancy.

Table 8-6 shows estimated costs for the two plant options considered.

Table 8-6. Satellite Plant Cost Estimates

Description	Estimated Cost ($)	Remarks
3,000-ton Satellite Plant	35,606,000	2,000-ton firm capacity. Initial buildout of plant using 1,000-ton firm capacity (2,000-ton total capacity) is 2.91M less than full buildout
7,000-ton Satellite Plant	47,784,000	6,000-ton firm capacity

8.7.3 Alternative 0C – Non-CHP: New Utility Plant with Electric Chillers, 24MW Backup Power and Backup Steam Boiler

This system is a variation of Alternative 0B. However, this alternative has 24 MW of backup power and a backup steam boiler. The steam boiler would provide an additional level of redundancy for the CUP should an unexpected outage occur. It was assumed that the boiler would have an efficiency similar to the existing boilers. For the life cycle costing, it was assumed that the generators would be exercised for maintenance approximately 2 hours per month.

8.7.4 Alternative 1A—Non-CHP: New Utility Plant with Electric Chillers, 24 MW Continuously Operated Power Plant (No Boilers)

This system consists of multiple reciprocating engine generators with one redundant reciprocating engine generator to allow for an engine to be offline for maintenance. Alternative 1 does not recover any of the waste heat generated and uses an electric chiller to meet the chilled water demand. The output power selected was based on the approximate minimum campus power requirements as described in Section 8.2. This would allow the reciprocating engine generators to run continuously at maximum load, where they are the most efficient.

Electrical integration of power generation equipment into the campus power distribution system could require substantial changes or upgrades. As discussed in Section 5.5.2, a microgrid study is recommended to evaluate the modifications that may be required. The cost of such upgrades has not been identified and were not included in this screening level analysis.

8.7.5 Alternative 1B—Non-CHP: New Utility Plant with Electric Chillers, 24MW Backup Power Only (No Boilers)

This alternative would be designed and constructed like Alternative 1A. However, this alternative was evaluated assuming that the plant is only permitted to operate during an emergency situation. For life

cycle costing, it was assumed that the generators would be exercised for maintenance approximately 2 hours per month.

8.7.6 Alternative 2—CHP: Reciprocating Engine Generator, 24 MW with Absorption Chillers

Similar to Alternative 1A, this system uses multiple reciprocating engine generators to produce power with one redundant reciprocating engine. However, Alternative 2 would differ by including waste heat recovery from the engine's cooling water jacket and exhaust gases to produce chilled water for the campus. Absorption chillers were selected for this alternative, as they do not require steam and instead can use lower grade waste heat energy from the reciprocating engines that would otherwise be rejected to the atmosphere.

8.7.7 Alternative 3—CHP: Combustion Turbine, 9 MW with Heat Recovery Steam Generator and Electric Chillers

Combustion turbine generators can produce a significant amount of power and heat in a relatively compact footprint. Combustion turbine generators can also be configured with other equipment, making them flexible in terms of system configuration. For Alternative 3, Jacobs reviewed combustion turbine generators with a heat recovery steam generator. For redundancy, a reserve combustion turbine generator was assumed. Alternative 3 uses electric chillers to meet the chilled water demand. Cooling of the combustion air was taken into consideration by raising the peak cooling requirement for the electric chiller.

Jacobs selected this turbine and HRSG configuration based on the campus' average monthly steam load. This could potentially simplify the CHP equipment by eliminating an exhaust bypass damper and maximize the overall efficiency of the CHP process by utilizing all waste heat for campus steam production.

8.7.8 Alternative 4—CHP: Combustion Turbine, 26 MW with Heat Recovery Steam Generator and Absorption Chillers

Alternative 4 uses combustion turbine generators with heat recovery steam generators and steam absorption chillers. Excess steam not used by the campus was instead used by absorption chillers. Like Alternative 3, combustion air cooling was taken into consideration.

8.7.9 Alternative 5—CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following

Alternative 5 expanded on Alternative 2 to allow for the CHP to provide power for the entire campus at anytime throughout the year, including summertime peak load conditions. As the campus load varies, Jacobs assumed reciprocating engine generators would be staged on and off to better match the load. If selected, the economic performance of this alternative should be validated using a high-resolution analysis to consider the impact of part-loading on an hourly basis before proceeding into detailed design.

8.7.10 Alternative 6—CHP: Combustion Turbine, 44 MW with Absorption Chillers, Load Following

Like alternative 5, Alternative 6 would allow the CHP to provide power to the entire campus at any time throughout the year, including summertime peak conditions, but would do so with combustion turbine generators. If selected, the economic performance of this alternative should be validated using a high-resolution analysis to consider the impact of part-loading on an hourly basis before proceeding into detailed design.

8.7.11 Equipment Summary

Table 8-7 lists the equipment quantities for each alternative described above for ease of comparison. Appendix G contains additional discussion about individual pieces of equipment.

Table 8-7. Equipment Summary

Alternative	Reciprocating Engine Generators		Combustion Turbine Generators		Steam Generators		Absorption Chillers		Electric Chillers		Cooling Towers
	Qty [c]	Total Power Output (MW) [b]	Qty [c]	Total Power Output (MW) [a]	Qty [e]	Total Steam Output (kpph)	Qty	Total Chilled Water Output to Campus (tons) [d]	Qty	Total Chilled Water Output to Campus (tons)	Qty
0A	NA	NA	NA	NA	NA	NA	NA	NA	1	3,303 [j]	1
0B	--	--	--	--	--	--	--	--	2 [c]	1,053	2 [c]
0C	7	24.3	--	--	1	90.0	--	--	2 [c]	1,053	2 [c]
1A	7	24.3	--	--	--	--	--	--	2 [c]	1,053	2 [c]
1B	7	24.3	--	--	--	--	--	--	2 [c]	1,053	2 [c]
2	7	24.3	--	--	--	--	4	3,531	--	--	4
3	--	--	3	8.9	1	51.9	--	--	2 [c]	1,053 [g]	2 [c]
4	--	--	7	26.7	2	77.8	5 [f]	2,248 [h]	--	--	5
5	12	44.0	--	--	--	--	7 [i]	5,297 [h]	--	--	7
6	--	--	11	44.0	3	138,965	6 [i]	3,768 [h]	--	--	6

Note:

[a] Nominal capacity of 4.6 MW. Actual capacity varies with inlet conditions such as temperature and humidity. Actual output at site conditions ~4.2 MW.

[b] Nominal capacity of 4.0MW.

[c] Quantity shown includes one unit in standby.

[d] Capacity based on heat recovered in August.

[e] Backup heat recovery steam generators are not assumed as steam from the existing CUP could be used for absorption chillers.

[f] Quantity of chillers based on excess steam capacity in January.

[g] Output to campus 1,053 tons. Turbines require 143 tons of inlet air cooling. Total cooling 1,196 tons.

[h] Capacity shown is for monthly average in August and not maximum plant output.

[i] Quantity of chillers based on plant maximum. High resolution analysis must be done to confirm assumption.

[j] Replaces existing chiller with new larger capacity chiller

8.8 Life Cycle Cost Analysis Results

Jacobs performed a Life Cycle Cost Analysis (LCCA) on the alternatives described in this EMP to evaluate the total cost of ownership of each, taking into account capital construction, design, management, and operating cost for the facility. Based on a 50-year life cycle, LCCA results are shown in Table 8-8. Non-CHP alternatives have been included to evaluate purchased utility savings and provide a benchmark to rank the CHP alternatives. O&M costs for new equipment in the CUP as part of Alternative 0 have been included in the analysis; however, O&M costs for existing equipment in the CUP have not been included as they are the same for every alternative. Negative values shown in Table 8-8 indicate that the alternative does not produce economic savings compared to Alternative 0A, which is considered the baseline for how UH operates today.

Table 8-8. Life Cycle Cost Analysis Results

Alternative	Alternative Description	CHP (Y/N)	Initial Plant Cost ($)	Annualized Purchased Utility Costs ($)	Annualized O&M Costs ($)	Life Cycle Cost ($)	Life Cycle Savings ($)	Life Cycle Cost Rank
0A	CUP Expansion with electric chillers	N	52,060,000	12,650,495	61,960	638,260,210	Base Case	Base Case
0B	Satellite chilled water plant with electric chillers	N	32,692,000	12,669,740	551,120	644,778,663	(6,518,452)	1
0C	New utility plant with electric chillers, 24MW backup power with backup steam boiler	N	81,543,000	12,641,435	1,284,350	727,769,885	(89,509,675)	3
1A	New utility plant with electric chillers, 24MW continuously operated power plant (no boilers)	N	71,494,000	9,349,040	3,649,700	751,305,143	(113,044,932)	4
1B	New utility plant with electric chillers, 24MW backup power only (no boilers)	N	71,494,000	12,641,435	901,710	698,881,574	(60,621,364)	2
2	Reciprocating engine generator, 24MW with absorption chillers	Y	88,773,000	9,497,033	4,393,260	811,905,289	(173,645,078)	6
3	Combustion turbine, 9MW with heat recovery steam generator and electric chillers	Y	68,729,000	11,231,054	3,620,280	787,330,943	(149,070,733)	5
4	Combustion turbine, 26MW with heat recovery steam generator and absorption chillers	Y	154,190,000	11,006,842	7,921,440	1,141,063,083	(502,802,873)	8
5	Reciprocating engine generator, 44MW with absorption chillers, load following	Y	138,455,000	8,877,203	7,008,320	976,986,706	(338,726,496)	7
6	Combustion turbine, 44MW with absorption chillers, load following	Y	207,894,000	10,317,001	12,197,600	1,385,628,215	(747,368,004)	9

Based on LCCA results, all of the non-CHP options perform similarly economically. The CHP options, on the other hand, do not provide economic benefit. This is largely a result of the very favorable rate UH receives for electric power. These findings demonstrate that UH will incur more cost annually to produce power than to purchase it from CPE. Additional considerations with regard to O&M, sustainability, resiliency, and constructability need to be considered in addition to the cost and are considered in the following sections.

8.9 Carbon Emission Analysis

8.9.1 Carbon Emission Factors

Estimates for CO_2 emissions were determined using EPA rates based on the fuel and prime mover type. Values are based on EPA AP-42, *Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Source* (EPA 1997) or as noted. Table 8-9shows the CO_2 emissions for different prime mover types.

Table 8-9. CO_2 Emissions for Different Power Options

Power Source	Fuel	CO_2 Emissions
Four-Stroke Reciprocating Engine	Natural Gas	110 lbs/MMBtu $_{input}$
Combustion Turbine	Natural Gas	110 lbs/MMBtu $_{input}$
Steam Boiler	Natural Gas	110 lbs/MMBtu $_{input}$
City of Houston Grid [a]	Various	818.6 lbs/ MWh

Note:

[a] Reference from EPA.gov/eGrid for the Houston Electric Reliability Council of Texas (ERCOT) subregion for all input emission rates for all fuels in 2020. Data retrieved March 21, 2022. More current data is not available from the EPA.

Fuel use mixture for the Houston ERCOT region in Figure 8-5 shows carbon neutral energy is approximately 32% of electricity production. This percentage is of note because it reduces the CO_2 emission rate for purchased electricity for the region, which in turn affects the CO_2 calculation for each system type reviewed. Furthermore, carbon emissions from electric power in the ERCOT region are expected to continue dropping throughout the life of the new utility plant as Texas continues to add more sustainable sources of energy.

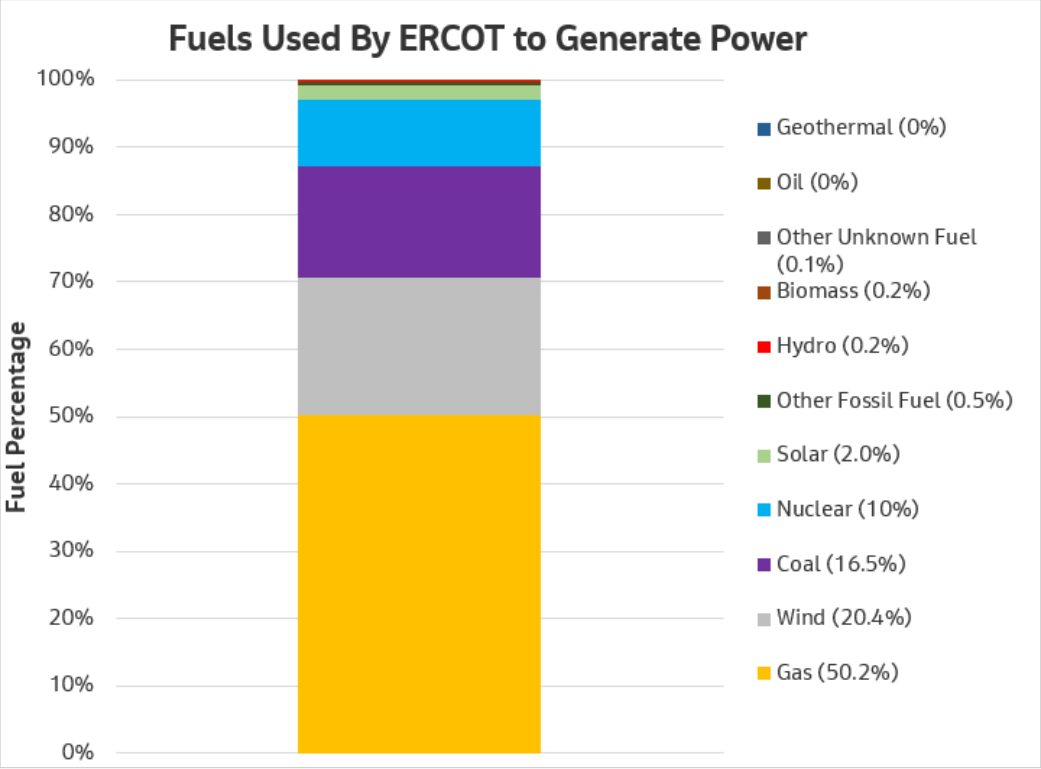

Figure 8-5. Fuel Mix for ERCOT Region from EPA eGRID for 2020

8.9.2 Combined Heat and Power Alternate Carbon Emissions

Table 8-10 lists resulting CO_2 emissions using the calculated purchased power and the associated fuel use for each alternative. In Table 8-10, a positive value for carbon reduction indicates an increase of CO_2 emissions versus the baseline.

Table 8-10. CO_2 Emissions (Tons per Year)

Alternative	Electrical Carbon Emissions	Natural Gas Carbon Emissions [a]	Total Emissions [c]	Carbon Reduction	Rank
0A	110,844	24,033	134,877	Baseline	Baseline
0B	111,039	24,033	135,072	195	5
0C [d]	110,605	24,284	134,888	11 [e]	2
1A	23,717	115,325	139,042	4,165	6
1B [d]	110,605	24,284	134,888	11 [e]	2
2	19,617	115,325	134,943	66	3
3	80,658	50,597	131,255	(3,622)	1
4	16,053	146,670	162,723	27,846	8
5	1	135,039	135,039	163 [b]	4
6	2	159,958	159,960	25,083 [b]	7

Note:

[a] Includes fuel for both the power generating equipment and existing steam boilers as applicable

[b] Value is an estimate as an hourly load analysis was not undertaken

[c] Standard U.S. ton = 2,000 pounds

[d] Assumed 2 hours of runtime per month. Emergency operation not included.

[e] Tie between two plant alternatives as generators operate as backup power only

Based on the analysis, none of the options considered are likely to have a significant impact on the carbon footprint of the university. Alternative 3 is the only option considered that is likely to reduce carbon emissions at all. This is largely because it limits the amount of waste heat produced to only that which can be efficiently utilized.

8.10 Evaluation and Conclusions

To support decision-making and further clarify the most appropriate utility plant solution for UH, Jacobs evaluated the proposed utility plant options and ranked them using an evaluation matrix. Table 8-11 lists the evaluation factors Jacobs developed. As one factor may be more critical than others, maximum scores were weighted to reflect the relative importance of each. The scores for each site option were determined in coordination with UH.

Table 8-11. Evaluation Factors and Assigned Points

Evaluation Factor	Description
Life Cycle	Weighted score of the life cycle costing using a linear weighting of points. Section 8.8 contains additional information on the life cycle costs.
Constructability	Review of the ease of construction for each utility plant option. For all new plant options, the maximum score was given. Expansion of the existing CUP will be challenging and was given the least number of points.
Footprint	Review of the overall size of the plant. The CUP expansion was given maximum points as it was within the footprint of the existing CUP and would not require any new land use on campus. The largest plants, Alternatives 5 and 6, were given the least number of points.
Refrigerant (HCF's)	Greenhouse gas reduction, specific to chiller refrigerants. For the combined heat and power plants, lithium bromide chillers were assumed. For a satellite chilled water plant, a low-GWP refrigerant was assumed.
CO_2 Reduction	Impact of each alternative on the carbon footprint for the campus. For utility plants that had a net carbon increase above Alternative 0A, the value was set to zero.
Air Quality	Review of the potential issues related to emissions from new equipment. Based on Jacobs' experience with other CHP installations, and the regulatory issues encountered, CHP's larger than approximately 12MW may encounter more scrutiny by regulatory agencies than smaller CHP's.
Steam System Resiliency	Maximize the resiliency of the campus steam system. For the combined heat and power facilities, power generation capacities were also taken into account because campus power is required to operate the air handling equipment in buildings. In other words, both steam and electric power are required for building heat.
Chilled Water System Resiliency	Maximize the resiliency of the campus chilled water system by reviewing how the new utility plant alternative will integrate with the existing campus. A lower value was given to alternatives with smaller CHP's as there would be less available electricity to generate chilled water during a power outage.
Electrical System Resiliency	Minimize electrical system disruptions by making the campus less reliant on the CPE power grid. A higher electrical output system scores higher as it decreases the likelihood of a power disruption.

Table 8-12 lists the different utility plant alternatives scores.

Table 8-12. Utility Plant Configuration Scoring

Evaluation Factor	Utility Plant Configuration Scoring										
	Weighted Maximum Score	CUP Expansion (0A)	Satellite CHW Plant (0B)	Satellite Utility Plant (0C)	Alternative						
					1A	1B	2	3	4	5	6
Life Cycle	50	50	50	44	42	46	38	40	16	27	0
Constructability	30	0	30	30	30	30	30	30	30	30	30
Footprint	20	20	10	10	10	10	5	10	5	0	0
Refrigerant (HFC's)	10	0	5	5	0	0	5	0	5	10	10
CO_2 reduction	10	0	0	0	0	0	0	10	0	0	0
Air Quality/Permitting	30	30	30	30	15	30	15	20	15	0	0
Steam system Resilience	10	0	0	10	10	0	10	5	10	10	10
CHW system resilience	30	3	6	12	12	12	24	9	24	30	30
Electrical system resilience	50	0	0	40	40	40	40	20	40	50	50
Total	**240**	**103**	**131**	**181**	**159**	**168**	**167**	**144**	**145**	**157**	**130**

Two conclusions can be drawn from this evaluation. First, alternatives that include power generation and a second source of steam and chilled water outside the existing CUP score highest in the categories of improving energy resilience. Constructing a second utility plant would ensure that campus energy systems would not be completely lost as the result of an accident or emergency at the CUP. These alternatives would also improve flexibility and reduce the cost of maintenance activities, as major utility systems at either location could be taken offline without disrupting utility service to campus.

Secondly, Jacobs' evaluation demonstrates that alternatives including backup power generation equipment score higher in resiliency than a continuously-operated CHP or a simple cycle power generation system. From the perspective of life cycle cost, the cost of fuel and equipment maintenance for a continuously-operated power plant would exceed the relatively low cost paid by UH for electricity from CPE. Over the life of a facility, making power on site even with a CHP, would increase the total cost of electric energy. In terms of carbon footprint, continuously operated power generation options offer minimal opportunities for footprint reduction. As discussed in Section 8.9, this is partially due to the growing percentage of carbon-neutral generation systems available on the Texas power grid today. In addition to carbon emissions, generation plants also produce other hazardous air pollutants as a product of fossil fuel combustion and require construction and operating permits per the U.S. Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality regulations. Plants that are permitted for continuous operation are likely to require more complex emission control systems and a more extensive permitting process.

8.11 Next Steps

The purpose of a screening analysis as documented in this EMP was to assess the feasibility of systems quickly and to rule out any alternatives that would likely not be viable for further analysis. Jacobs findings indicate that a continuously operated CHP will offer little or no economic or environmental benefit to UH. Improving the reliability and resiliency of electric power would be more economically accomplished through the addition of backup generators in a satellite utility plant.

If UH elects to pursue a CHP system, a more rigorous, high-resolution analysis is highly recommended prior to proceeding with detailed design. Such an analysis requires a substantial engineering effort and should consider hourly performance across at least two years of operation (17,520 data points) and account for factors such as equipment part-load efficiencies and future gas/electric rate escalation to better analyze future economic performance. This two-step approach, with the screening analysis included in this EMP constituting the first step, is the most reliable and economical way to select and size a CHP plant.

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9. Utility Plant Site Locations

9.1 Overview

The UH campus has limited site locations available to construct a new utility plant. This section discusses the site options that were reviewed and the pros and cons of each.

9.2 Site Locations Reviewed

Jacobs reviewed three potential locations for either a chilled water plant or a new CHP. Each of the sites has advantages and disadvantages and are discussed below. Figure 9-1 below shows the overall campus and the site locations that were reviewed. A larger version of this image can be found in Appendix H.

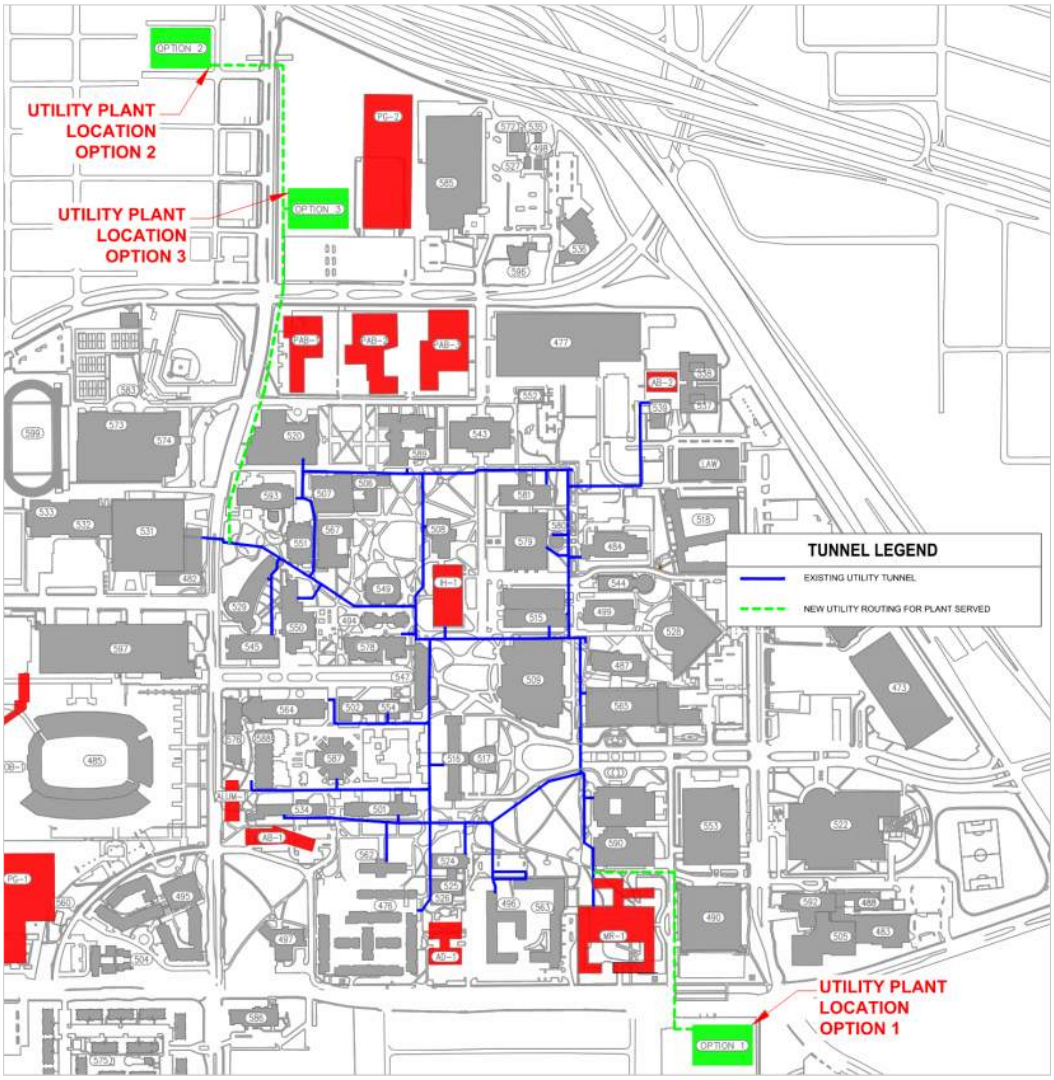

Figure 9-1. Site Options

9.2.1 Site Option 1

Site Option 1 is currently parking lot 4A, owned by UH on the southeast corner of campus. This site was selected because of its proximity to both the existing campus and new COM campus, and the existing high-voltage distribution lines owned by CPE. Figure 9-2 shows Site Option1. A larger version of this image can be found in Appendix H.

Figure 9-2. Site Option 1

Table 9-1 shows the advantages and disadvantages for integrating Site Option 1 into the campus.

Table 9-1. Site Option 1 Advantages and Disadvantages

System	Advantage	Disadvantage
Electrical	▪ A secondary substation could be built at this site to allow for more redundancy.	▪ Any piping or electrical feeders would have to cross under Wheeler Avenue and under the light rail tracks. ▪ This site is also considered in Section 5 as a possible location for a new substation and is not large enough for both.
Chilled Water	▪ Would provide chilled water near some of the major cooling loads on campus. ▪ Can serve the COM if desired and would reduce piping upgrades in the existing tunnel system.	▪ Does not provide good solution to pressure and flow issues in the northwest part of campus. ▪ There is a residential neighborhood to the west of the parking lot. Equipment noise and cooling tower drift could be a concern.
Steam and Condensate	▪ Connection to the existing campus steam and condensate system relatively close.	--
Other Utilities and Considerations	▪ Likely close to an existing water and sanitary sewer main for service.	▪ Not known if a natural gas pipe is located near the site. ▪ Need to either construct a new tunnel for utility systems to connect into existing tunnel or do direct buried pipe. Double wall direct buried pipe was assumed for the cost estimate. ▪ Connecting utilities from site option to the rest of campus requires going under a road and light rail tracks. This area of campus likely has significant buried utilities that will have to be coordinated and rerouted.
Resiliency and Sustainability	▪ Existing grayfield site, reducing impact to local environmental habitat. ▪ Could provide secondary substation as a backup to Cougar Substation.	▪ Close to Brays Bayou and existing flood plains. Could be impacted by extreme weather events.

Table 9-2 lists the integration costs for the different plant configurations. These estimates do not include any costs directly related to the utility plants which are discussed elsewhere in this EMP.

Table 9-2. Site Option 1 Integration Costs

Alternative	Steam and Condensate Piping ($)	Chilled Water Piping ($)	Electrical Systems ($)	Total ($)
Alternative with Steam, Chilled Water, and Electrical Power Generation	3,824,000	7,060,000	8,400,000	19,284,000
Alternative with Chilled Water and Electrical Power Generation	--	7,060,000	8,400,000	15,460,000
Alternative with Chilled Water Generation Only	--	7,060,000	4,800,000	11,860,000

9.2.2 Site Option 2

Site Option 2 is on the north side of campus and is currently occupied by an abandoned building owned by UH. The 2027 Centennial Plan does not show this area being used for any new facilities. Figure 9-4 shows Site Option 2. A larger version of this image can be found in Appendix H.

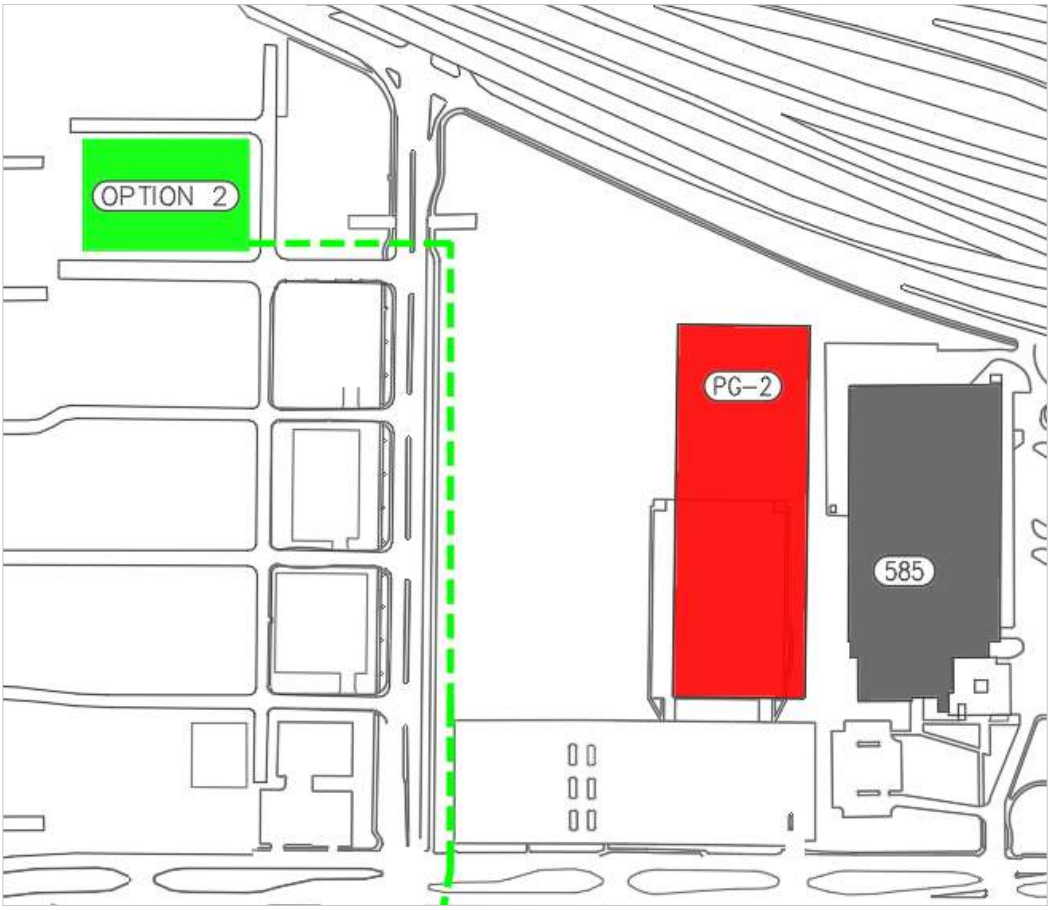

Figure 9-3. Site Option 2

Table 9-5 shows the advantages and disadvantages for Site Option 2.

Table 9-3. Site Option 2 Advantages and Disadvantages

System	Advantage	Disadvantage
Electrical	▪ Potential to place existing facilities served by CPE onto campus system.	▪ High-voltage CPE service not close to site. If UH desires to place a new substation at this location it would be the least desirable of the 3 sites.
Chilled Water	▪ Would provide chilled water near some of the new major buildings scheduled to be constructed. ▪ Would help to reduce chilled water pressure issues in the Athletics Area.	▪ Long distance to connect piping into campus system.
Steam and Condensate	--	▪ Remote from large steam loads. ▪ Connection to existing steam and condensate system is not close.
Other Utilities and Considerations	▪ Low likelihood of existing utilities in area.	▪ Water, sewer, or gas pipes of the size needed to serve a plant of this size might not be nearby.
Resiliency and Sustainability	▪ Existing brownfield site with minimal impact to local environmental habitat. ▪ Not close to any floodplains.	▪ Close to some local businesses. ▪ Possibly in a nonattainment area as it is close to the highway.

Table 9-6 lists the integration costs for the different plant configurations. These estimates do not include any costs directly related to the utility plants which are discussed elsewhere in this EMP. The cost to demolish the existing building and any potential remediation costs are not included.

Table 9-4. Site Option 2 Integration Costs

Alternative	Steam and Condensate Piping ($)	Chilled Water Piping ($)	Electrical Systems ($)	Total ($)
Alternative with Steam, Chilled Water, and Electrical Power Generation	7,323,000	8,504,000	14,880,000	30,707,000
Alternative with Chilled Water and Electrical Power Generation	--	8,504,000	14,880,000	23,384,000
Alternative with Chilled Water Generation Only	--	8,504,000	5,640,000	14,144,000

9.2.3 Site Option 3

Site Option 3 is on the north side of campus and is currently occupied by intramural sports fields and associated surface parking. The 2027 Centennial Plan shows that a new parking structure will be built in this area; however, sufficient space exists to construct both facilities. Figure 9-4 shows Site Option 3. A larger version of this image can be found in Appendix H.

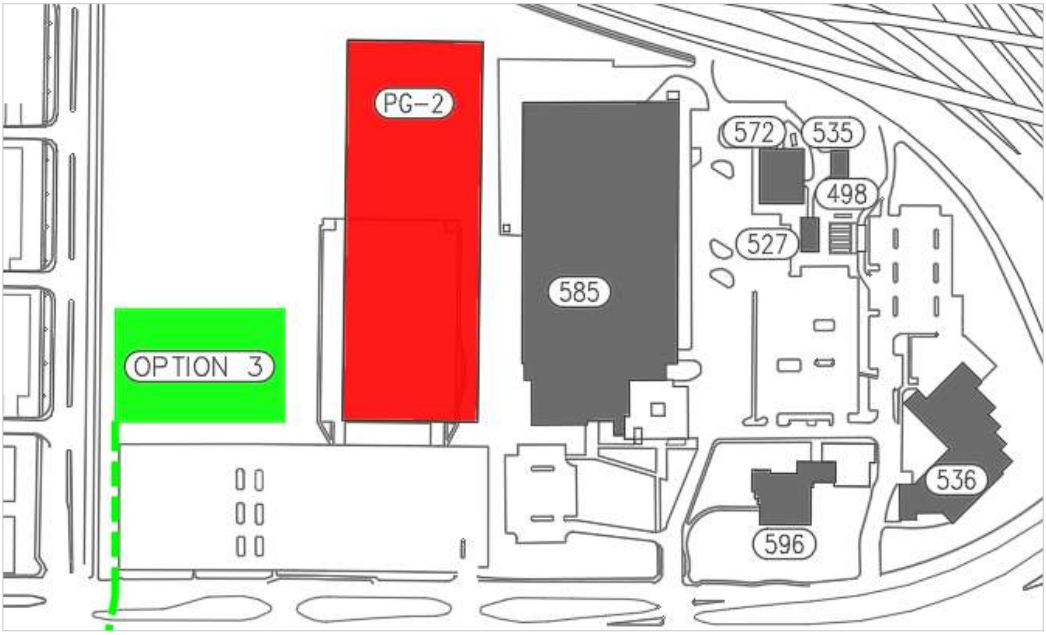

Figure 9-4. Site Option 3

Table 9-5 shows the advantages and disadvantages for Site Option 3.

Table 9-5. Site Option 3 Advantages and Disadvantages

System	Advantage	Disadvantage
Electrical	▪ Potential to place existing facilities served by CPE onto campus system.	▪ High-voltage CPE service not close to site. If UH desires to place a new substation at this location it would be the least desirable of the 3 sites.
Chilled Water	▪ Would provide chilled water near some of the new major buildings scheduled to be constructed. ▪ Would help to reduce chilled water pressure issues in the Athletics Area.	▪ Long distance to connect piping into campus system.
Steam and Condensate	--	▪ Remote from large steam loads. ▪ Connection to existing steam and condensate system is not close.
Other Utilities and Considerations	▪ Low likelihood of existing utilities in area.	▪ Water, sewer, or gas pipes of the size needed to serve a plant of this size might not be nearby.
Resiliency and Sustainability	▪ Existing brownfield site with minimal impact to local environmental habitat. ▪ Not close to any floodplains.	▪ Removes some grassy area. ▪ Possibly in a nonattainment area as it is close to the highway.

Table 9-6 lists the integration costs for the different plant configurations. These estimates do not include any costs directly related to the utility plants which are discussed elsewhere in this EMP.

Table 9-6. Site Option 3 Integration Costs

Alternative	Steam and Condensate Piping ($)	Chilled Water Piping ($)	Electrical Systems ($)	Total ($)
Alternative with Steam, Chilled Water, and Electrical Power Generation	4,201,000	5,037,000	12,000,000	21,238,000
Alternative with Chilled Water and Electrical Power Generation	--	5,037,000	12,000,000	17,037,000
Alternative with Chilled Water Generation Only	--	5,037,000	4,200,000	9,237,000

9.3 Site Location Analysis

To support decision-making and further clarify the most appropriate site location for UH, Jacobs evaluated the proposed site options and ranked them using an evaluation matrix. Table 9-7 lists the evaluation factors Jacobs developed. As one factor may be more critical than others, maximum scores were weighted to reflect the importance of each factor. The score for each site option was determined using Jacobs' opinion as many of the factors do not have a defined cost associated with them. Other significant factors influencing site selection are possible but are not known at this time.

Table 9-7. Evaluation Factors

Evaluation Factor	Description
Space available for plant	Review of the surrounding site and required space for the proposed plant including necessary support spaces to facilitate reliable operation and maintenance.
Community and neighborhood impact	Minimize impacts to the surrounding neighborhood. Specifically related to noise, emissions, and visual aesthetics.
Existing utility challenges	Review of exiting utilities and how the placement of the plant could impact both existing and future utilities. Based on conversations with UH staff, for the 3 new sites this is thought to be minimal in nature.
Resilience	Review of building placement to strategically maximize system resiliency with respect to campus growth and environmental changes (such as weather).
Minimize Impact to Natural Environment	Minimization of environmental impacts such as tree removal, erosion, water diversion, excavation, soil removal/disposal, and ecological changes to immediate surrounding environment.
Future Facility Construct	Review of how the site location could influence expansion of the new plant in the future. This includes items such as new substations or additional chillers.
Energy	Minimize energy consumption related to equipment sizing.
Construction Logistics	Minimize impacts to campus traffic and transportation during construction. Reduce safety concerns due to large equipment and construction requirements. Minimize contractor parking impacts with the existing parking lots. Minimize impact to sensitive labs adjacent to construction areas.

After scoring the different sites selected for review, the values were consolidated into Table 9-8.

Table 9-8. Selection Scoring

Evaluation Factor	Maximum Score	Site Option 1	Site Option 2	Site Option 3
Space available for plant	50	20	50	50
Community and neighborhood impact	30	10	20	10
Existing utility challenges	10	10	10	10
Resilience	50	30	40	40
Minimize impact to natural environment	30	20	20	20
Future facility construction	20	10	20	20
Energy	50	50	30	30
Construction logistics	10	5	10	10
Total	**250**	**155**	**200**	**190**

Based on the total score in the table above Site Option 2 offers the best value, even if the location had a higher capital investment. For this analysis, Jacobs assumed that the COM would not be integrated into the existing campus utility systems.

10. Phasing Schedule Planning

Jacobs determined a phasing plan using several factors; this plan is conceptual in nature and will require additional refinement when detailed design begins. Key factors are listed below.

- **Near-term campus growth 2022–2030.** Near-term campus growth is focused on buildings that are planned for construction between 2022 and 2030. The investments that are made in the near-term, such as a new chilled water plant, will have impacts on long-term growth. Other items to support near-term campus growth include the upgrading of existing systems that have deficiencies to increase the reliability of the campus electrical and thermal infrastructure. Additional campus growth will continue until 2040 per the 2027 Centennial Plan, but precise information about the size and location of buildings beyond 2030 is not available.
- **Long-term campus growth 2031–2040.** Long-term campus growth is focused on buildings that are planned for construction between 2031 and 2040. Upgrades done previously will allow for this campus expansion to occur without significant modifications to the campus electrical and thermal systems. Long-term planning also includes larger multi-year upgrade projects such as the installation of photovoltaic systems on buildings.
- **Contractor responsibilities.** For a conceptual phasing plan projects with similar system types, such as electrical feeder replacements and testing of transformers, were lumped together so that a single contract could be given to a single contractor. This would make a single contractor responsible for a system, and may help to mitigate coordination conflicts that can arise when multiple contractors are working on a single system. Alternatively, a master contract could be given to a general contractor who would oversee multiple sub-projects.
- **Long-lead items.** Jacobs typically recommends long-lead items for a CHP or a satellite chilled water plant be purchased by the owner and not by the contractor. This allows for the architectural and engineering teams to design for the exact equipment purchased, thereby reducing design rework and avoiding contractor equipment markup costs.

10.1 Proposed Phasing Plan

The proposed phasing plan takes into consideration the campus as a whole and looks to best optimize capital costs for energy improvements across campus. Some items, such as metering upgrades in Phase 1, could overlap with building upgrades in Phase 2; phases and their planned implementation can be adapted to meet funding requirements.

10.1.1 Phase 1—Improve System Monitoring

Phase 1 would install meters as part of a campus-wide metering upgrade program at the building level. Installed meters would first focus on gathering data about electrical consumption, then about chilled water, and finally about steam and condensate. Initially, these data would be collected using the building management system until a SCADA system could be implemented. Jacobs recommends a dedicated SCADA system as a more reliable long-term solution. Metering data would then be used to strategically target buildings that have high energy use as part of Phase 2. Metering data would also be important for a microgrid study, which could then be used to optimize the size of a new CHP plant.

10.1.2 Phase 2—Upgrade Systems and Reduce Demand

Phase 2 would use data collected during Phase 1 to reduce demand at individual buildings. Based on UH data provided to Jacobs, it appears some campus buildings are not optimized as the steam and chilled water peak and trough respectively, do not occur in the same month. This could be due to a range of factors from mechanical failures, obsolete/non-functional systems or control sequences not being

optimized. This should be resolved by performing commissioning, either re-commissioning or retro-commissioning, on the existing buildings. By reducing demand at the building level, system load would decrease, also decreasing the campus carbon footprint, and increasing cost savings.

10.1.3 Phase 3—Expand System

Phase 3 would expand the energy systems via either modification to the CUP, a new satellite plant, or new CHP. A critical portion of Phase 3 entails increasing pipe sizes and new electrical feeders to accommodate new electric and thermal loads. To accurately size a new CHP, the electrical and thermal system loads must be accurately known. Refer to Section 8.11 of this EMP for additional information.

10.1.4 Phase 4—Deploy Production Efficiency

Phase 4 would be a campus-wide optimization of the chilled water system and installation of photovoltaic systems. Phase 4 would establish a system that would continuously monitor all buildings and holistically review campus energy use to ensure that the campus as a whole was operating as efficiently and reliably as it could.

10.1.5 Phasing Schedule

Figure 10-1 shows a preliminary phasing schedule. This preliminary schedule is conceptual and based on projected campus growth from 2022 to 2040. Appendix J contains a larger version of this schedule.

Task Name	Duration Rounded	Lower Cost	Upper Cost
Proposed Funding Schedule	**200 mons**	**$362,997,000**	**$544,495,500**
Phase 1 - Improve System Monitoring	**18 mons**	**$3,431,000**	**$5,146,500**
Chilled Water Meters	18 mons	$679,000	$1,018,500
Steam Meters	18 mons	$652,000	$978,000
Condensate Meters	18 mons	$595,000	$892,500
Electric Meters	18 mons	$527,000	$790,500
SCADA System	18 mons	$978,000	$1,467,000
Phase 2 - Upgrade Systems and Reduce Demand	**200 mons**	**$101,225,000**	**$151,837,500**
Studies & Inspections	**48 mons**	**$3,143,000**	**$4,714,500**
Tunnel Upgrades	**200 mons**	**$24,739,000**	**$37,108,500**
CUP Upgrades	**30 mons**	**$1,364,000**	**$2,046,000**
HVAC Upgrades	**120 mons**	**$71,979,000**	**$107,968,500**
Phase 3 - Expand System	**70 mons**	**$165,364,000**	**$248,046,000**
New Satellite CHW plant or CHP	60 mons	$120,000,000	$180,000,000
New substation	36 mons	$25,714,000	$38,571,000
New feeders from new substation	18 mons	$14,993,000	$22,489,500
Emergency water storage	12 mons	$4,568,000	$6,852,000
CUP Booster pump	12 mons	$89,000	$133,500
Phase 4 - Production Efficiency	**180 mons**	**$92,977,000**	**$139,465,500**
Optimize CHW system	12 mons	$76,000	$114,000
PV System - 15 years	180 mons	$85,349,000	$128,023,500
Lighting upgrades - 15 years	180 mons	$7,552,000	$11,328,000

2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039
H2 H1 H2 H1 H2 H1

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11. Carbon Footprint

Based on analysis, there are opportunities for UH to make improvements in this sustainability metric. Projects to achieve carbon footprint reduction are identified in this EMP. Figure 11-1 illustrates the overall carbon footprint reduction that could be achieved by 2040 assuming all recommended system upgrades are completed.

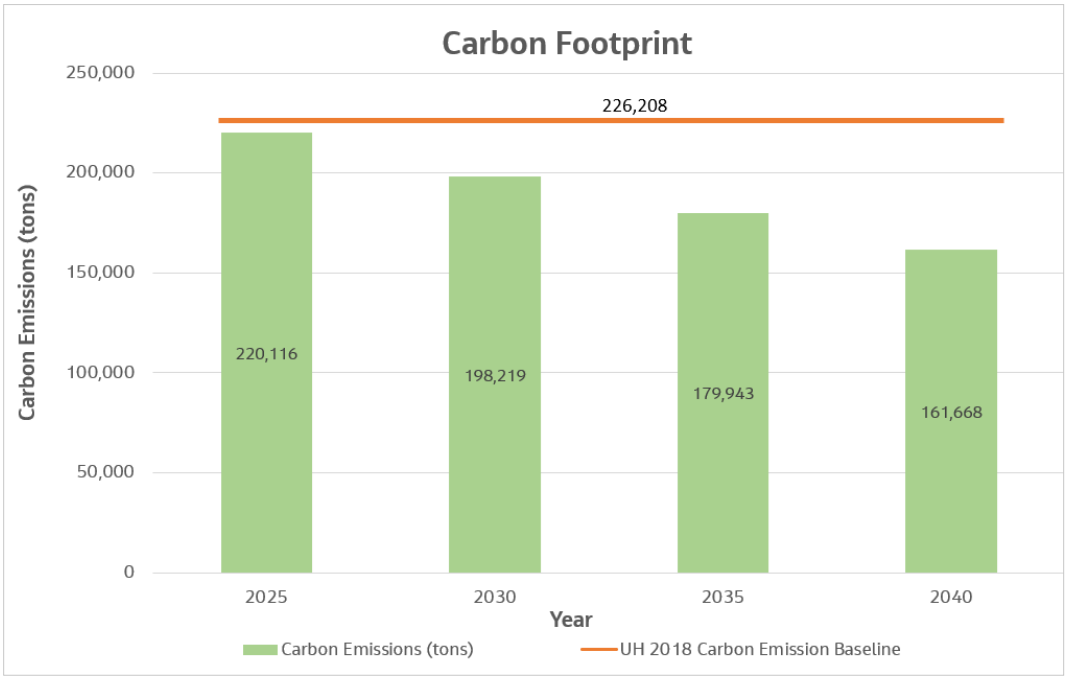

Figure 11-1. Projected Carbon Footprint Reduction 2022–2040

Figure 11-2 shows an approximate reduction by system that could be possible by 2040 if all system upgrades are completed. This figure also assumes that photovoltaic cells are mounted on the roofs of all the buildings on campus. Additional information regarding the solar photovoltaic reductions and lighting upgrades can be found in Section 5, HVAC reductions in Section 7, and combined heat and power reductions in Section 8. The carbon emissions for the different energy sources, and additional information, can be found in Section 8.9.

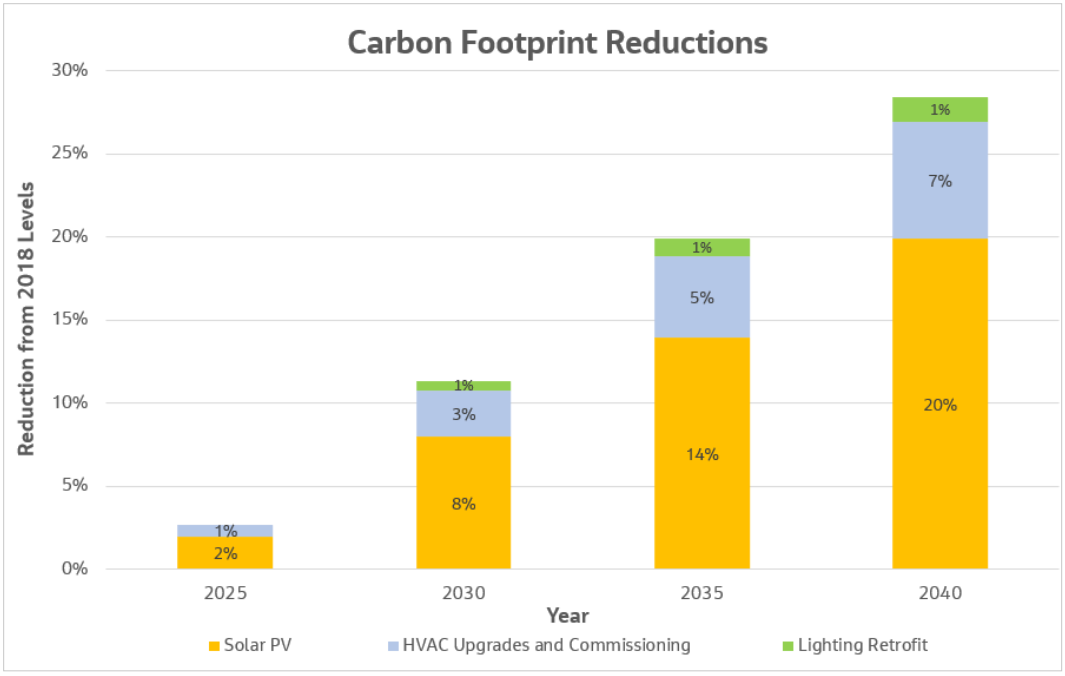

Figure 11-2. Carbon Footprint Reduction from 2022–2040

Carbon footprint per square foot is an important metric for higher education campuses. Figure 11-3 estimates the carbon footprint per square foot for UH as compared to other peer institutions in Texas and the national average based on publicly available information. Data about carbon footprint at UH and other peer institutions was obtained from multiple sources including the State Energy Conservation Office's (SECO's) *SECO Utility Management Report* (2020), and the *Building Performance Database* (DOE 2022). Since information was prepared by and drawn from multiple sources, it may not represent a perfectly accurate comparison. Based on the available data, UH has a higher carbon footprint compared to other universities in Texas.

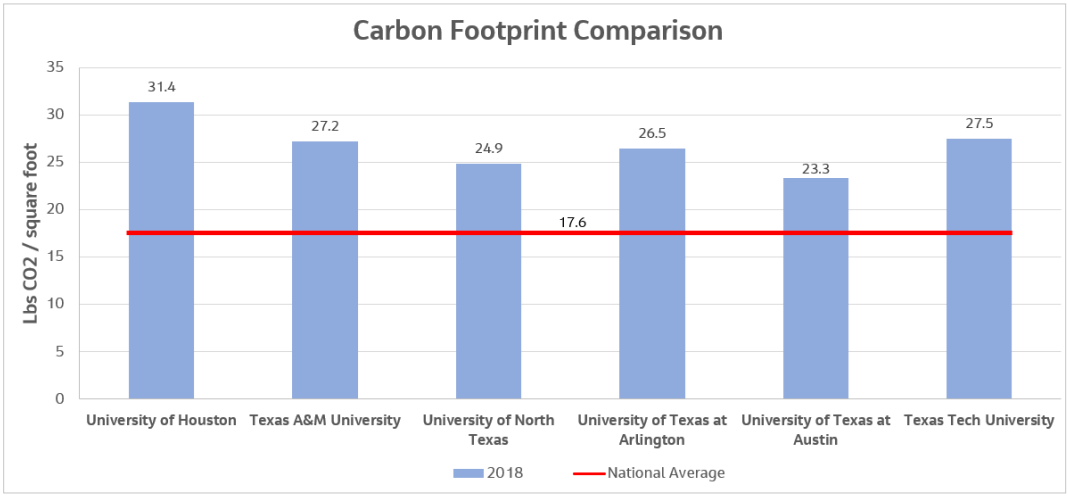

Figure 11-3. Carbon Footprint Comparison 2018

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Appendix A
Existing Building Chilled Water Loads

1. Chilled Water Loads and Flows for Existing Buildings

This appendix (Table A-1) lists the existing building chilled water loads and flows that were used for the piping flow models.

Table A-1. Chilled Water Loads for Existing Buildings

Building Number	Building Name	Diversified Load (tons) [b]	Peak Flow (gpm)	AFT Model Flow (gpm) [c]
476	The Quad [a]	397	1180	953
482	Guy V Lewis Development Facility [a]	197	586	473
484	Durga D and Sushila Agrawal Engineering Research [a]	865	2570	2075
487	Student Center North [a]	631	1875	1514
496	Cougar Village 2 [a]	404	1200	969
499	Classroom and Business Building [a]	396	1100	950
501	Roy G. Cullen	125	500	300
502	Science Building	150	600	360
503	Technology Annex	117	467	280
506	Jack J. Valenti School of Communications [d]	378	1512	908
508	College of Technology Building	102	407	244
516	Ezekiel W Cullen [e]	295	1180	709
518	University Lofts Apartments	870	3480	2089
520	Moores School of Music	225	900	541
524	Student Service Center 1 [f]	124	495	297
528	Leroy and Lucile Melcher Hall	430	1720	1033
529	Sci.& Engr. Classroom Building	93	370	222
531	Fertitta Center [g]	1197	4787	2874
534	Fred J. Heyne	77	308	185
537	Bates Law [h]	350	1400	841
543	Gerald D. Hines College of Architecture and Design	236	944	567
544	Michael J. Cemo Hall	70	278	167
545	Science and Engineering Research Center	1001	4000	2402

Table A-1. Chilled Water Loads for Existing Buildings

Building Number	Building Name	Diversified Load (tons) [b]	Peak Flow (gpm)	AFT Model Flow (gpm) [c]
547	Philip Guthrie Hoffman Hall	275	1100	660
549	Graduate School of Social Work	85	340	204
550	Science and Research 1	863	3450	2071
551	Science and Research 2	450	1800	1081
562	A. D. Bruce Religion Center	60	240	144
563	Cougar Village	300	1200	720
564	Lamar Fleming, Jr.	450	1800	1081
565	Student Center South	495	1980	1188
567	Student Center Satellite	150	600	360
568	Justin Dart, Jr. Student Accessibility Center	14	56	33
573	Alumni Center [i]	300	1200	720
576	Science Teaching Laboratory	650	2600	1561
578	Agnes Arnold Hall	309	1235	742
579	Cullen Coll of Engineering 1	1057	1660	2509
580	Engineering Lecture Hall			28
581	Cullen Coll of Engineering 2	205	820	492
584	Moody Towers Residence Halls	375	1500	901
587	Stephen Power Farish Hall	271	1084	651
588	Charles F. McElhinney Hall	118	470	282
589	Fine Arts Building	281	1125	675
593	UH Science Center	488	1950	1170
509A	Library Section A	192	766	460
509B	Library Section B	336	1345	808
509C	Library Section C	306	1225	735
590A	C. Hilton College of Hospitality and Restaurant Management Section A	383	1530	919
590B	C. Hilton College of Hospitality and Restaurant Management Section B	485	1940	1165
RP	Reflection Pool	5	20	12

[a] Diversity factors of 85% used.

[b] A 10°F temperature differential between the supply and return chilled water. Refer to Section 3 for additional information.

[c] Diversity factor of 95% used to adjust data from the Shah Smith report (2013) to match latest CUP chiller data

[d] Building 507 included in this load

[e] Building 517 included in this load

[f] Buildings 525, 526 included in this load

[g] Buildings 532, 533 included in this load

[h] Buildings 538, 539 included in this load

[I] Building 574 included in this load

Appendix B
Existing Building Steam Loads

1. Steam Loads and Flows for Existing Buildings

This appendix (Table B-1) lists the existing building steam loads and flows that were used for the piping flow models.

Table B-1. Steam Loads for Existing Buildings

Building Number	Building Name	Steam Load[b] (lb/hr)	AFT Model Flow[a] (lb/hr)
476	The Quad	14,846	2,735
482	Guy V. Lewis Development Facility	4,016	568
484	Durga D. and Sushila Agrawal Engineering Research	8,750	1,319
487	Student Center North	5,000	312
496	Cougar Village 2	--[i]	--[i]
499	Classroom and Business Building	3,520	843
501	Roy G. Cullen	1,693	324
502	Science Building	6,144	1,176
503	Technology Annex	2,050	392
506	Jack J. Valenti School of Communication [c]	2,655	508
508	College of Technology Building	462	89
516	Ezekiel W. Cullen[d]	2,142	410
520	Moores School of Music	4,850	928
524	Student Service Center 1[e]	2,340	--
528	Leroy and Lucile Melcher Hall	--	1,035
529	Science and Engineering Classroom Building	1,720	329
531	Fertitta Center[f]	21,200	4,057
534	Fred J. Heyne	1,680	322
537	Bates Law[g]	9,000	1,722
543	Gerald D. Hines College of Architecture and Design	2,700	516
544	Michael J. Cemo Hall	--	195
545	Science and Engineering Research Center	21,858	4,183
547	Philip Guthrie Hoffman Hall	2,920	559
550	Science and Research 1	17,000	3,253

Table B-1. Steam Loads for Existing Buildings

Building Number	Building Name	Steam Load[b] (lb/hr)	AFT Model Flow[a] (lb/hr)
551	Science and Research 2	15,501	2,966
562	A. D. Bruce Religion Center	1,120	215
563	Cougar Village	7,035	1,346
564	Lamar Fleming, Jr.	10,500	2,009
565	Student Center South	4,821	922
567	Student Center Satellite	1,694	324
573	Alumni Center[h]	11,300	2,300
576	Science Teaching Laboratory	13,000	2,488
578	Agnes Arnold Hall	5,230	1,001
579	Cullen College of Engineering 1	6,153	1,178
580	Engineering Lecture Hall	--	25
581	Cullen College of Engineering 2	1,410	270
584	Moody Towers Residence Halls	26,256	5,024
587	Stephen Power Farish Hall	2,980	570
588	Charles F. McElhinney Hall	1,700	325
589	Fine Arts Building	6,550	1,253
593	UH Science Center	7,600	1,454
509A	Library Section A	1,537	294
509B	Library Section B	6,106	1,169
509C	Library Section C	7,395	1,415
590A	C. Hilton College of Hospitality and Restaurant Management Section A	8,587	1,643
590B	C. Hilton College of Hospitality and Restaurant Management Section B	11,471	2,195

[a] Diversification factor calculated using a ratio of the peak plant load divided by the theoretical max load

[b] Most of the building load data taken from the Shah Smith report (2013); buildings constructed after 2012 used a Btuh/ft^2 approximation

[c] Building 507 included in this load

[d] Building 517 included in this load

[e] Buildings 525, 526 included in this load

[f] Buildings 532, 533 included in this load

[g] Buildings 538, 539 included in this load

[h] Building 574 included in this load

[i] Building does not have steam connection. Listed for completeness of data only.

Appendix C
Pumping Systems

1. Pumping Systems

1.1 Variable Volume Primary

In this configuration, a single set of primary pumps circulate chilled water throughout the plant and the entire distribution system, overcoming the pressure drop of the chillers and distribution system to supply chilled water to each building's main mechanical room. The pumps are controlled via remote differential pressure sensors located at key locations in the distribution system and regulated by minimum chiller flow rates. Table lists the advantages and disadvantages to a variable volume pumping system.

Table C-1. Variable Volume Primary Advantages and Disadvantages

Item	Advantage	Disadvantage
1	Lowest pump energy consumption	Potentially difficult to properly control pressures and flows on both the plant and distribution (building point of use) sides
2	Fewest number of pumps	Improper operation can lead to increased energy consumption
3	--	Large pump horsepower requirements

1.2 Constant Volume Primary/Variable Volume Secondary

Constant speed primary pumps circulate chilled water through the plant internals and are sized to overcome the pressure losses in the chillers and plant piping. A decoupler balances the flow between the constant volume primary (CVP) and variable volume secondary (VVS) loops. The chillers are controlled to balance the capacity required in the secondary loop serving the campus, functioning like a traditional primary-secondary system.

Variable speed secondary pumps circulate chilled water from the plant throughout the campus distribution system, targeting the mechanical room of each building. Pump speed is controlled via remote differential pressure sensors located in key locations in the distribution system, modulating flow to match overall campus demand. Table lists the advantages and disadvantages to a CVP/VVS pumping system.

Table C-2. CVP/VVS Advantages and Disadvantages

Item	Advantage	Disadvantage
1	Simpler to control pressure and flow at both the plant and distribution system	Requires approximately twice as many pumps as variable primary
2	Similar arrangement to what is currently used on campus	Largest pump energy consumption
3	--	Potential for delta T problems (inefficient energy use)

1.3 Variable Volume Primary/Variable Volume Secondary

As technology has advanced over the years, more sophisticated and responsive controls have evolved that allow the benefits and efficiency gains of variable speed-driven equipment to be fully exploited.

In a variable volume primary (VVP)/VVS configuration, variable speed primary pumps circulate chilled water through the plant internals and are sized to overcome the pressure losses in the chillers and plant piping. Similar to the primary-secondary scheme, a decoupler balances the flow rates between the primary and secondary loops. Flow through the decoupler will be lower than the constant volume system as loop flows should match more closely.

Variable speed secondary pumps circulate chilled water from the plant throughout the campus distribution system, targeting the mechanical room of each building. Pump speed is controlled via remote differential pressure sensors located in key locations in the distribution system, modulating flow to match overall campus demand. Table lists the advantages and disadvantages to a constant VVP/VVS pumping system.

Table C-3. VVP/VVS Advantages and Disadvantages

Item	Advantage	Disadvantage
1	Isolated systems allow for easier flow and pressure control	Requires approximately twice as many pumps as variable primary
2	Low pump energy consumption, similar to variable primary	Chillers need to be capable of handling varying flow rates
3	Ability to integrate into the existing campus variable primary system	Additional controls required. Control sequence is also more complicated than other options.

Appendix D
Proposed Meter List

1. Proposed Utility Meter List

Meters will be installed on both the thermal and electric utilities as part of an overall energy conservation plan. These meters will be the first step in better defining individual building energy consumption which will then be used to determine which buildings should be targeted first for energy conservation projects. The meters listed in Table D-1 are for the entire University of Houston (UH) campus, including buildings that are not connected to the campus utility systems. Appendix H contains drawings shows a map of the campus and color codes the buildings with respect to metering requirements. Items with a "X" in them indicated a meter for the system shown is recommended, and in a few select instances already installed. Items with a "--" in them indicate a meter for the system is not required or not applicable.

Table D-1. Proposed Building Meter List

Building	Building Name	Electric	Chilled Water	Steam [c]	Remarks
104	KUHT Fiber Optics Building	--	--	--	d
105	KUHT Telephone Equipment	--	--	--	d
106	Texas Learning and Computational Center Annex	--	--	--	d
111	Dynamometer Test Laboratory	--	--	--	d
116	Safety, Human Factors, and Ergonomic Lab	--	--	--	d
199	Clinical Research Services Annex	--	--	--	d
400	Cougar Substation	--	--	--	g
401	Technology Bridge 1	X	--	--	a
402	Technology Bridge 2	X	--	--	a
403	Technology Bridge 3	X	--	--	a
404	Conference and Research Building	X	--	--	a
405	Technology Bridge 5	X	--	--	a
406	Technology Bridge 6	X	--	--	a
407	Technology Bridge 7	X	--	--	a
408	Technology Bridge 8	X	--	--	a
409	ConocoPhillips Petroleum Engineering	X	--	--	a
410	Technology Bridge 10	X	--	--	a
411	Technology Bridge 11	X	--	--	a
413	Technology Bridge 13	X	--	--	a
414	Technology Bridge 14	X	--	--	a
415	Energy Device Fabrication Lab	X	--	--	a
419	Technology Bridge Annex	X	--	--	a

Table D-1. Proposed Building Meter List

Building	Building Name	Electric	Chilled Water	Steam [c]	Remarks
420	Technology Bridge Storage	X	--	--	[a]
421	Technology Bridge 21	X	--	--	[a]
468	Greenhouse	--	--	--	
473	University Gateway Garage	--	--	--	[d]
475	Softball Batting Facility	--	--	--	
476	The Quad	X	X	X	
477	Elgin Street Garage	X	--	--	[e]
479	Baseball Clubhouse	--	--	--	[d]
480	Football Indoor Practice Facility	--	--	--	[d]
481	Bayou Oaks Apartments Annex	--	--	--	[d]
482	Guy V. Lewis Development Facility	X	X	X	
482	Guy V. Lewis Development Facility	X	X	X	
483	Health 2 [f]	--	--	--	Part of Health Building system
484	Durga D. and Sushila Agrawal Engineering Research	X	X	X	
485	TDECU Stadium	--	--	--	[d]
486	Atmospheric Testing Lab	X	--	--	[e]
487	Student Center North	X	X	X	
488	Satellite Central Plant 1 [f]	--	--	--	Part of Health Building system
490	Welcome Center Student Garage	--	--	--	[d]
492	Cougar Softball Stadium Ticket Booth	--	--	--	[d]
493	Cougar Softball Stadium	--	--	--	[d]
494	Agnes Arnold Auditorium	X	X	X	
495	Cougar Place	--	--	--	[d]
496	Cougar Village 2	[d]	X	X	
497	Cougar Woods Dining Hall	--	--	--	[d]
499	Classroom and Business Building	X	X	X	

Table D-1. Proposed Building Meter List

Building	Building Name	Electric	Chilled Water	Steam [c]	Remarks
500	Bayou Oaks Apartments	--	--	--	[d]
501	Roy G. Cullen	X	X	X	[h]
502	Science Building	X	X	X	
503	Technology Annex	--	--	--	[b]
504	Child Care Center	--	--	--	[d]
505	J. Davis Armistead [f]	--	--	--	Part of Health Building system
506	Jack J. Valenti School of Communication	X	X	X	
507	C. W. Mitchell Center for the Arts	X	X	X	
508	College of Technology Building	X	X	X	
509	M. D. Anderson Library	X	X	X	
513	Visitor Information - Booth 2	X	--	--	[e]
514	Fire & Life Safety - Storage	--	--	--	[d]
515	Central Plant	X	X	X	[h]
516	Ezekiel W Cullen	X	X	X	
517	Cullen Performance Hall	X	X	X	
518	University Lofts Apartments	X	X	X	
519	DPS - UH Police	--	--	--	[b]
520	Moores School of Music	X	X	X	
521	Grounds Storage	--	--	--	[d]
522	Campus Recreation and Wellness Center	X	--	--	[f]
524	Student Service Center 1	X	X	X	
525	Human Resources Center	X	X	X	
526	Student Service Center 2	X	X	X	
527	EHRM1	X	--	--	[e]
528	Leroy and Lucile Melcher Hall	X	X	X	
529	Science and Engineering Classroom Building	X	X	X	
531	Fertitta Center	X	X	X	
532	Susanna Garrison Hall	X	X	X	

Table D-1. Proposed Building Meter List

Building	Building Name	Electric	Chilled Water	Steam [c]	Remarks
533	Melcher Life Sciences	X	X	X	
534	Fred J. Heyne	X	X	X	
535	EHRM2	X	--	--	e
536	Leroy and Lucile Melcher Center For Public Broadcasting	X	--	--	e
537	Bates Law	X	X	X	
538	Teaching Unit 2 Building	X	X	X	
539	Max Krost Hall	X	X	X	
540	John M. O'Quinn Law Library	--	--	--	b
542	South Park Annex	--	--	--	d
543	Gerald D. Hines College of Architecture and Design	X	X	X	
544	Michael J. Cemo Hall	X	X	X	
545	Science and Engineering Research Center	X	X	X	
546	East Parking Garage	--	--	--	d
547	Philip Guthrie Hoffman Hall	X	X	X	
548	Athletics Maintenance Building	--	--	--	d
549	Graduate School of Social Work	X	X	X	
550	Science and Research 1	X	X	X	
551	Science and Research 2	X	X	X	
552	B. Keeland Jr. Design and Exploration Center	X	--	--	
553	Welcome Center and Parking Garage	--	--	--	d
560	UH-DPS Parking Enforcement	--	--	--	d
561	Campus Recreation and Wellness Center Annex	X	--	--	Part of Building 522
562	A. D. Bruce Religion Center	X	X	X	
563	Cougar Village	X	X	X	
564	Lamar Fleming, Jr.	X	X	X	
565	Student Center South	X	X	X	
567	Student Center Satellite	X	X	X	
568	Justin Dart, Jr. Student Accessibility Center	--	--	--	b

Table D-1. Proposed Building Meter List

Building	Building Name	Electric	Chilled Water	Steam [c]	Remarks
569	Cullen Oaks Apartments	--	--	--	[d]
570	Athletics Batting Cage	--	--	--	[d]
572	General Services Storage Building	X	--	--	[e]
573	Alumni Center	X	X	X	
574	Athletic Center	X	X	X	
575	Cambridge Oaks Apartments	--	--	--	[d]
576	Science Teaching Laboratory	X	X	X	[h]
578	Agnes Arnold Hall	X	X	X	
579	Cullen College of Engineering 1	X	X	X	
580	Engineering Lecture Hall	X	X	X	
581	Cullen College of Engineering 2	X	X	X	
582	Darryl and Lori Schroeder Park	X	--	--	[e]
583	Cougar Baseball Field Ticket Booth	--	--	--	[d]
584	Moody Towers Residence Halls	--	--	--	[b]
585	General Services Building	X	--	--	[e]
586	Isabel C. Cameron	X	--	--	[e]
587	Stephen Power Farish Hall	--	--	--	[b]
588	Charles F. McElhinney Hall	X	X	X	
589	Fine Arts Building	X	X	X	
590	C. Hilton College of Hospitality and Restaurant Management	X	X	X	
591	Visitor Information Booth 1	X	--	--	[e]
592	Health 1 [f]	--	--	--	Part of Health Building system
593	UH Science Center	X	X	X	
596	Computing Center	X	--	--	[e]
597	Stadium Parking Garage	--	--	--	[d]
598	Clinical Research Services Center	--	--	--	[d]
LAW	LAW Building	X	X	--	[h]

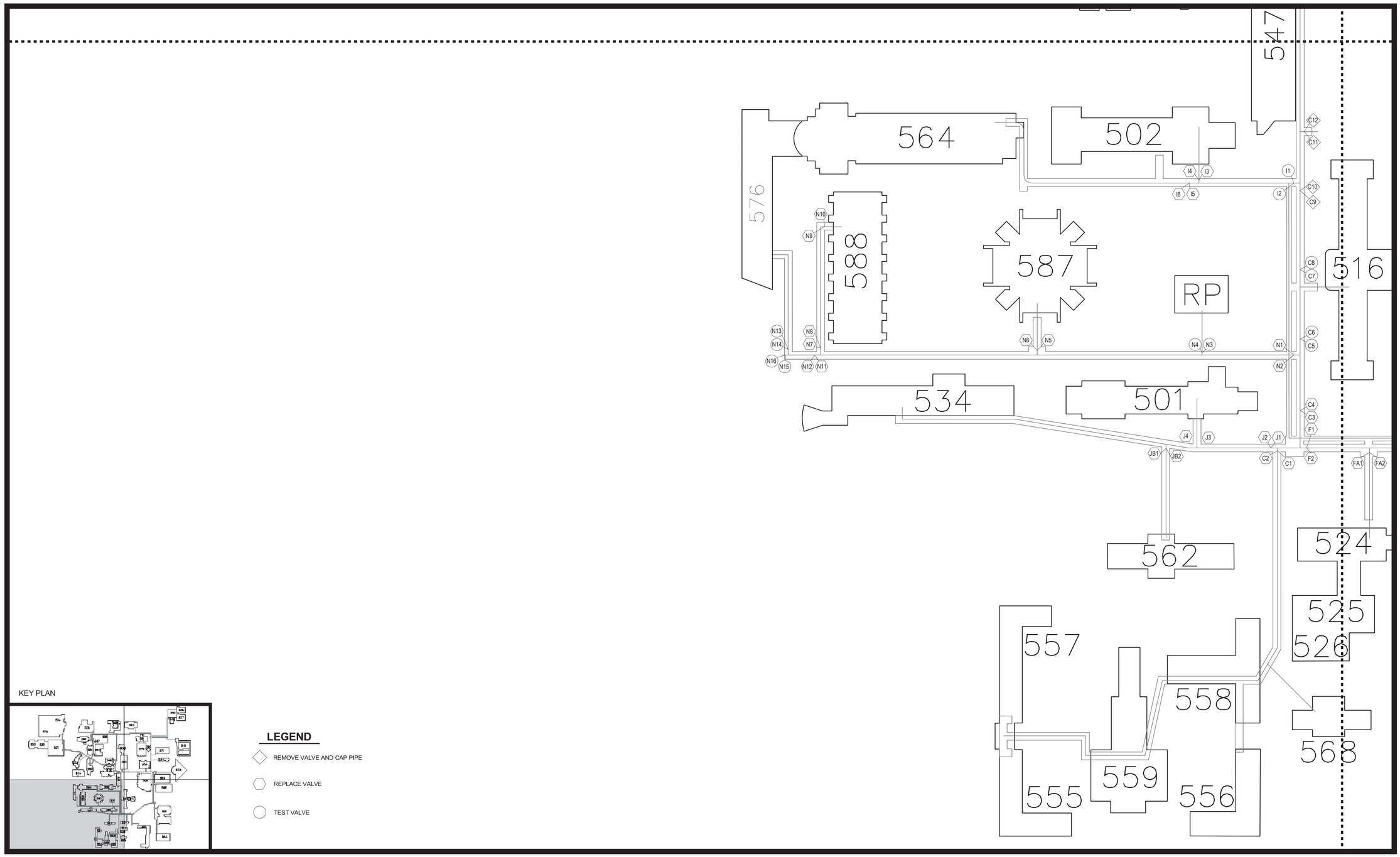
[a] Building part of Technology Bridge campus.
[b] Building to be demolished as part of Campus Master Plan.

[c] If a steam meter cannot be installed then a condensate meter might be a potential alternative.
[d] Building currently on CPE service and has an existing electrical meter
[e] No steam or chilled water service
[f] Standalone heating and cooling plant serves building
[g] Substation metered by CPE
[h] Building meters currently installed

Appendix E
Chilled Water Piping Data

Appendix 4 from *Chilled Water, Steam, and Condensate Distribution Study* (Shah Smith 2013)

NOT TO SCALE



KEY PLAN

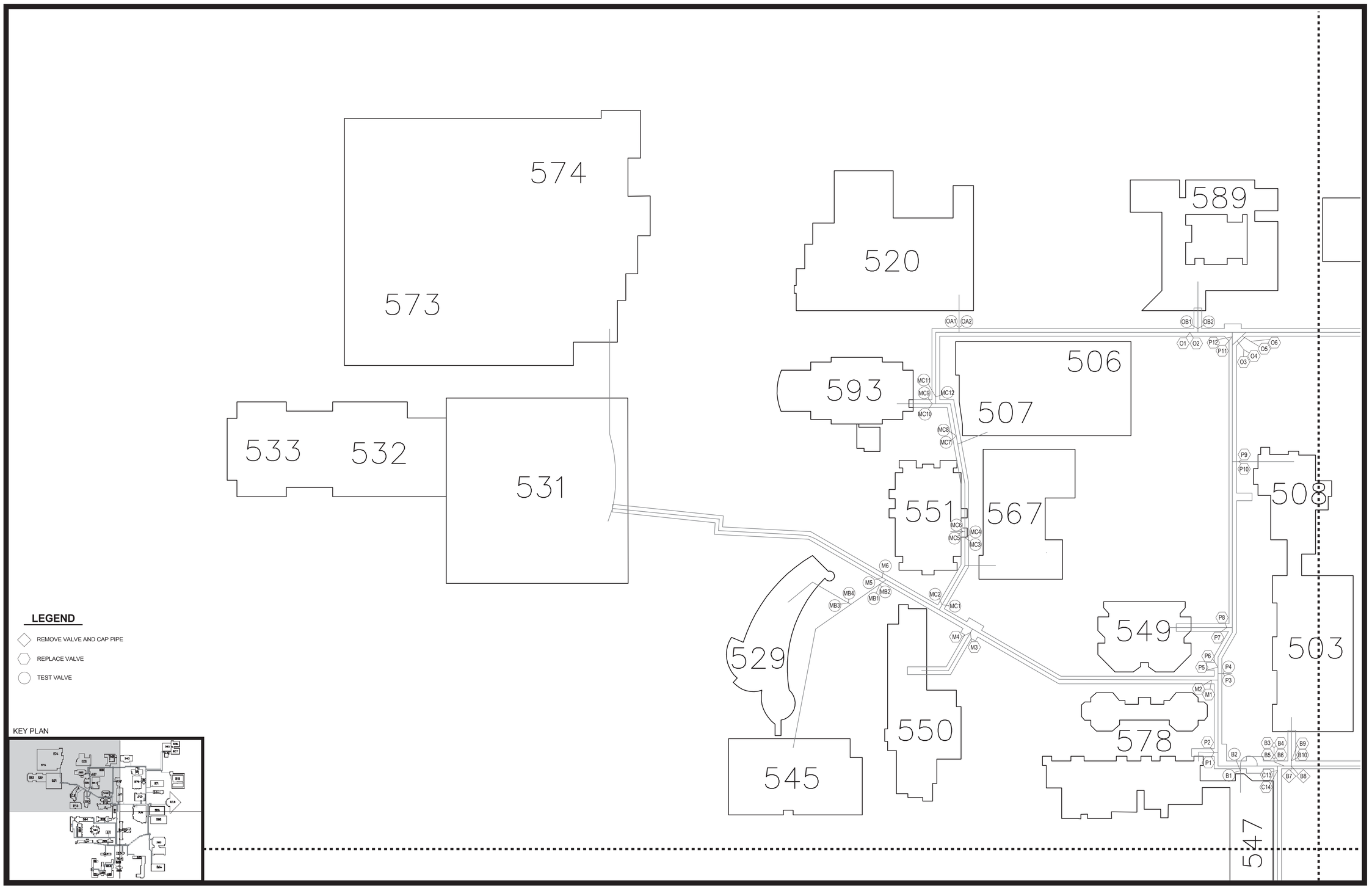
LEGEND

- REMOVE VALVE AND CAP PIPE
- REPLACE VALVE
- TEST VALVE

VALVE REPLACEMENT SCHEMATIC 1

Appendix 4 from Shaw Smith (2013) report

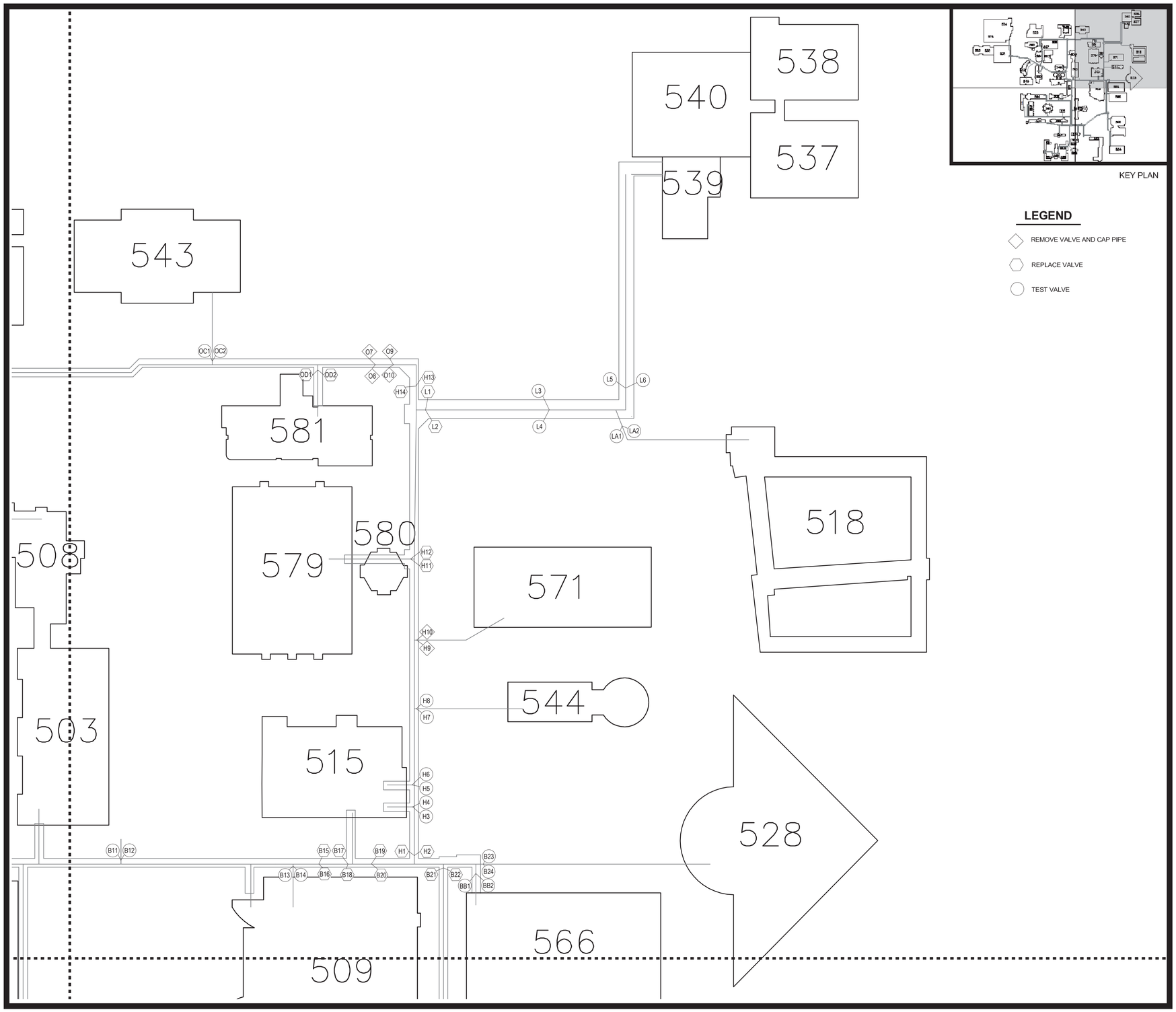
NOT TO SCALE



VALVE REPLACEMENT SCHEMATIC 2

Appendix 4 from Shaw Smith (2013) report

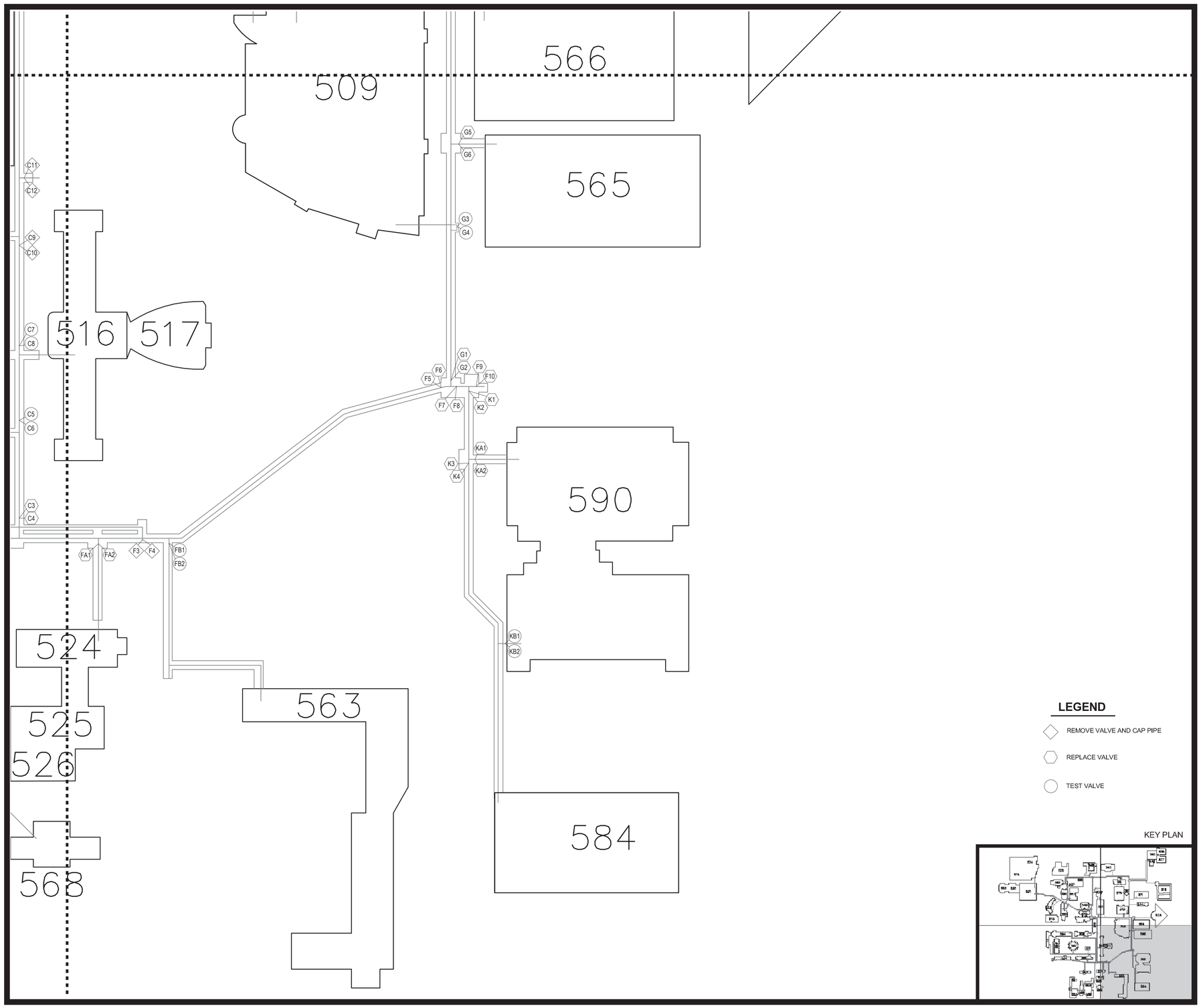
NOT TO SCALE



VALVE REPLACEMENT SCHEMATIC 3

Appendix 4 from Shaw Smith (2013) report

NOT TO SCALE



VALVE REPLACEMENT SCHEMATIC 4

UH Central Plant BAS Retrofit
8N83-0217

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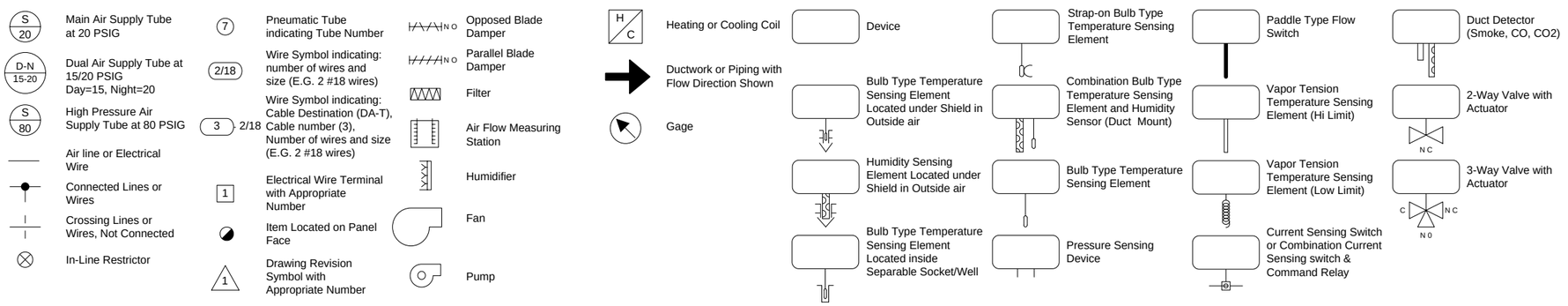
A01-12	CHILLER-2A,2B PANEL DETAIL DRAWING
A01-13	CHILLER-5,6,7 & TOWERS PANEL DETAIL DRAWING
BOM	BILL OF MATERIALS
PD-01	PRODUCT LITERATURE

LEGEND



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- ☐ Performance Contracting
- ☐ Planned Service Agreements

Air Conditioning
Heating
Diagnostic Services
Coil Cleaning
Refrigeration
Automatic Temperature Controls
Facility Management Systems
Fire Management
Security Management
Building Operations and Management
Water Treatment
Electrical Equipment
Emergency Generator / Lighting Equipment
Industrial Controls / Recording / Indication Equipment

PROJECT TITLE

UH Central Plant BAS Retrofit

ARCHITECT	ENGINEER
, **Phone:**	
MECHANICAL CONTRACTOR	ELECTRICAL CONTRACTOR
	, **Phone:**

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SALES ENGINEER	PROJECT MANAGER	APPLICATION ENGINEER	DATE	CONTRACT NUMBER
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	04/27/18	8N83-0217

METASYS NETWORK LAYOUT-PAGE 1

Ethernet
MSTP Trunk
SA Bus
Modbus

HUB OR SWITCH

ETHERNET

IT IS ASSUMED THAT THE ETHERNET SHOWN IS THE CUSTOMERS ETHERNET BACKBONE.

Printer
Work Station
ADX Server

NAME: NIE
DEVICE: NIE 2960-0
LOCATION: PLANT ROOM

MODBUS

CHILLER 3 INTEGRATION | CHILLER 4 INTEGRATION | RTU INTEGRATION | BOILER 1 INTEGRATION | BOILER 2 INTEGRATION | BOILER 3 INTEGRATION | SWITCH GEAR | POWER METER CH-2A | POWER METER CH-2B | POWER METER CH-3 | POWER METER CH-4 | POWER METER CH-5 | POWER METER CH-6 | POWER METER CH-7

NAME: NAE-1
DEVICE: NAE 4510-2
LOCATION: IT ROOM

MSTP

NAME: CHILLER-1,3,4
DEVICE: FAC 3611
MSTP ADD: 04

CHILLER 1 INTEGRATION — **MSTP ADD:** 05
CHILLER 2A INTEGRATION — **MSTP ADD:** 06
CHILLER 2B INTEGRATION — **MSTP ADD:** 07
CHWP 5 INTEGRATION — **MSTP ADD:** 08
CHWP 6 INTEGRATION — **MSTP ADD:** 09

SA BUS

NAME: CHILLER-1,3,4 **DEVICE:** IOM 4711 **SA BUS ADD:** 04
NAME: CHILLER-1,3,4 **DEVICE:** IOM 2721 **SA BUS ADD:** 05
NAME: CHILLER-1,3,4 **DEVICE:** IOM 2721 **SA BUS ADD:** 06
NAME: CHILLER-2A,2B **DEVICE:** IOM 4711 **SA BUS ADD:** 07
NAME: CHILLER-2A,2B **DEVICE:** IOM 2721 **SA BUS ADD:** 08
NAME: CHILLER-2A,2B **DEVICE:** IOM 2721 **SA BUS ADD:** 09

EOL

NAME: CHILLER-5,6,7 **DEVICE:** IOM 2721 **SA BUS ADD:** 13
NAME: CHILLER-5,6,7 **DEVICE:** IOM 2721 **SA BUS ADD:** 12
NAME: CHILLER-5,6,7 **DEVICE:** IOM 4711 **SA BUS ADD:** 11
NAME: CHILLER-5,6,7 **DEVICE:** IOM 4711 **SA BUS ADD:** 10

A

CHWP 10 INTEGRATION — **MSTP ADD:** 16
CHWP 9 INTEGRATION — **MSTP ADD:** 15
CHWP 8 INTEGRATION — **MSTP ADD:** 14
CHWP 7 INTEGRATION — **MSTP ADD:** 13
CHILLER 7 INTEGRATION — **MSTP ADD:** 12
CHILLER 6 INTEGRATION — **MSTP ADD:** 11
CHILLER 5 INTEGRATION — **MSTP ADD:** 10

NOTE: Units are integrated to Metasys system by the BACnet interface card provided by the Manufacturer.

Drawing Title: **NET RISER-PAGE 1**

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

Sales Engineer	Project Manager	Application Engineer	DRAWN		APPROVED	
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS	DATE 04/26/2018	BY	DATE

Project Title: **U of H Central Plant BAS Retrofit**

Johnson Controls

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CONTRACT NUMBER: **8N83-0217**

DRAWING NUMBER: **NR-01**

METASYS NETWORK LAYOUT-PAGE 2

Ethernet
MSTP Trunk
SA Bus
Modbus

A

NAME: COOLING TOWERS
DEVICE: FAC 3611
MSTP ADD: 17

CT 1 INTEGRATION — **MSTP ADD:** 18

CT 2 INTEGRATION — **MSTP ADD:** 19

CT 3 INTEGRATION — **MSTP ADD:** 20

CT 4 INTEGRATION — **MSTP ADD:** 21

CT 5 INTEGRATION — **MSTP ADD:** 22

CWP 1A INTEGRATION — **MSTP ADD:** 23

CWP 2A INTEGRATION — **MSTP ADD:** 24

SA BUS

NAME: COOLING TOWERS
DEVICE: IOM 3710
SA BUS ADD: 04

NAME: COOLING TOWERS
DEVICE: IOM 3710
SA BUS ADD: 05

NAME: CWPS & MUVs
DEVICE: IOM 4711
SA BUS ADD: 06

NAME: CHILLER-PRESSURE
DEVICE: IOM 4711
SA BUS ADD: 07

NAME: CHILLER-PRESSURE
DEVICE: IOM 2721
SA BUS ADD: 08

NAME: BASIN LEVELs
DEVICE: IOM 2721
SA BUS ADD: 09

EOL

NAME: MISC
DEVICE: IOM 2721
SA BUS ADD: 11

NAME: SUMP LEVELs
DEVICE: IOM 2721
SA BUS ADD: 10

EOL

NAME: EX FANs
DEVICE: FEC 2611
MSTP ADD: 28

CWP 5A INTEGRATION — **MSTP ADD:** 27

CWP 4A INTEGRATION — **MSTP ADD:** 26

CWP 3A INTEGRATION — **MSTP ADD:** 25

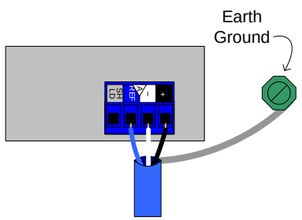
NOTE: Units are integrated to Metasys system by the BACnet interface card provided by the Manufacturer.

Drawing Title: **NET RISER-PAGE 2**							
REFERENCE DRAWING		NO.	REVISION-LOCATION		ECN	DATE	BY
Sales Engineer: R J Wagner Jr	Project Manager: Jacob Hall	Application Engineer: Anitha Selvaganeshan	DRAWN: BY AS DATE 02/26/2018		APPROVED: BY	DATE	
Project Title: **U of H Central Plant BAS Retrofit**	Johnson Controls	Branch Information: Johnson Conrols, Inc. 10644 West Little York, Suite 200 Houston, Texas 77041 Phone: 713-934-2400 Fax: 713-934-7865			CONTRACT NUMBER: **8N83-0217**		
					DRAWING NUMBER: **NR-02**		

METASYS MSTP NETWORK INSTALLATION DETAILS

The information in this document is not intended to replace the published Technical Product Literature for the Johnson Controls systems and products presented. The Installation Instructions that are packed with products, and the Technical Bulletins and Product Bulletins released with Johnson Controls systems and products supersede the information on this page. It is the responsibility of the product installer and product user to obtain and follow the product installation, operation, and safety procedures provided with the products or project specific information required by specification or local codes.

Category	Rules / Maximums Allowed
General	Typically daisy-chained; branch or star configuration acceptable when repeaters are used. See End of Line Switching and Repeater Guideline graphic.
Number of Devices	**When all of the devices connected on the FC Bus are Metasys FECs, VMAs, and/or IOMs, the device and bus segment limits are:** 100 devices total per FC Bus (maximum) 3 bus segments per FC Bus (maximum) 50 devices per bus segment (maximum, not to exceed 100 devices per FC Bus) **When one or more TEC26xx Series thermostat or third-party MS/TP device is connected on the FC Bus, the device and bus segment limits are:** 64 devices total per FC Bus (maximum) 3 bus segments per FC Bus (maximum) 32 devices per bus segment (maximum, not to exceed 64 devices per FC Bus) **Note:** Metasys MS/TP devices generate less data traffic than third-party MS/TP devices and TEC26xx thermostats. Connecting third-party devices or TEC26xx thermostats to the FC Bus increases data traffic, reduces bus performance, and reduces the number of devices that can be connected to the bus. Bus segments on an FC Bus are connected with repeaters (only). Up to two cascaded repeaters may be applied to an FC Bus (to connect three bus segments).
Line Length and Type	**When all of the devices connected on the FC Bus are Metasys FECs, VMAs, and/or IOMs, the cable length limits are:** Each bus segment can be up to 1520 m (5000 ft) in length (using 22 AWG 3-wire twisted, shielded cable). Each FC Bus can be up to 4750 m (15,000 ft) in length (using 22 AWG 3-wire twisted, shielded cable). **When one or more TEC26xx Series thermostat or third-party MS/TP device is connected on the FC Bus, the device and bus segment limits are:** Each bus segment can be up to 1220 m (4000 ft) in length (using 22 AWG 3-wire twisted, shielded cable) Each FC Bus can be up to 3660 m (12,000 ft) in length (using 22 AWG 3-wire twisted, shielded cable). When using fiber-optic connections: 2,010 m (6,600 ft.) between two fiber modems 22 AWG Stranded, 3-Wire Twisted, Shielded Cable
Cable	22 AWG stranded, 3-wire, twisted shielded cable
EOL Termination	End-of-Line (EOL) termination is required on the FC Bus to reduce signal reflection when data transmissions reach the end of a bus segment and bounce back. EOL termination is built into some Metasys FC devices and is enabled with a switch or jumper on the device. **EOL Termination on NAEs** An EOL switch on an NAE enables EOL termination. For those NAEs with two FC Bus connections, two EOL double-pole switches are provided. Set the EOL switch to the ON (up) position to set the controller as an EOL termination device. **EOL Termination on Switch-Terminating Devices** Some field controllers have an EOL switch or jumper. Such devices include FECs, IOMs, VMAs, ZFR1810s, and repeaters. Set the EOL termination to On for any of these devices when it is the last device on a bus segment. **EOL Termination on Devices Without EOL Provision** For the devices such as TECs and third-party controllers in which no EOL provision is provided, install the MS-BACEOL-0 RS485 End-of-Line Terminator at the device if at the end of the bus segment. **EOL Termination Across the FC Bus** The FC Bus may consist of up to three bus segments. Each bus segment on an FC Bus requires two EOL termination devices, one at each end of the bus segment. All other devices on the FC Bus should have their EOL termination disabled (EOL switches Off) . If only one device on an FC segment has an EOL termination, it must be set to On. **EOL on FC Bus Repeaters** When using repeaters in the FC Bus, set the EOL jumpers based on the position of the repeater in the run.



SHIELD GROUNDING

The shield should be earth grounded at one and only one point for the entire bus segment. (Preferably in the NAE Panel.) The shield screws on the controllers are simply a convenient way to continue the daisy chain of the bus. They are not attached to earth ground. You can use the shield terminal or twist together the shield and tape back at each controller.

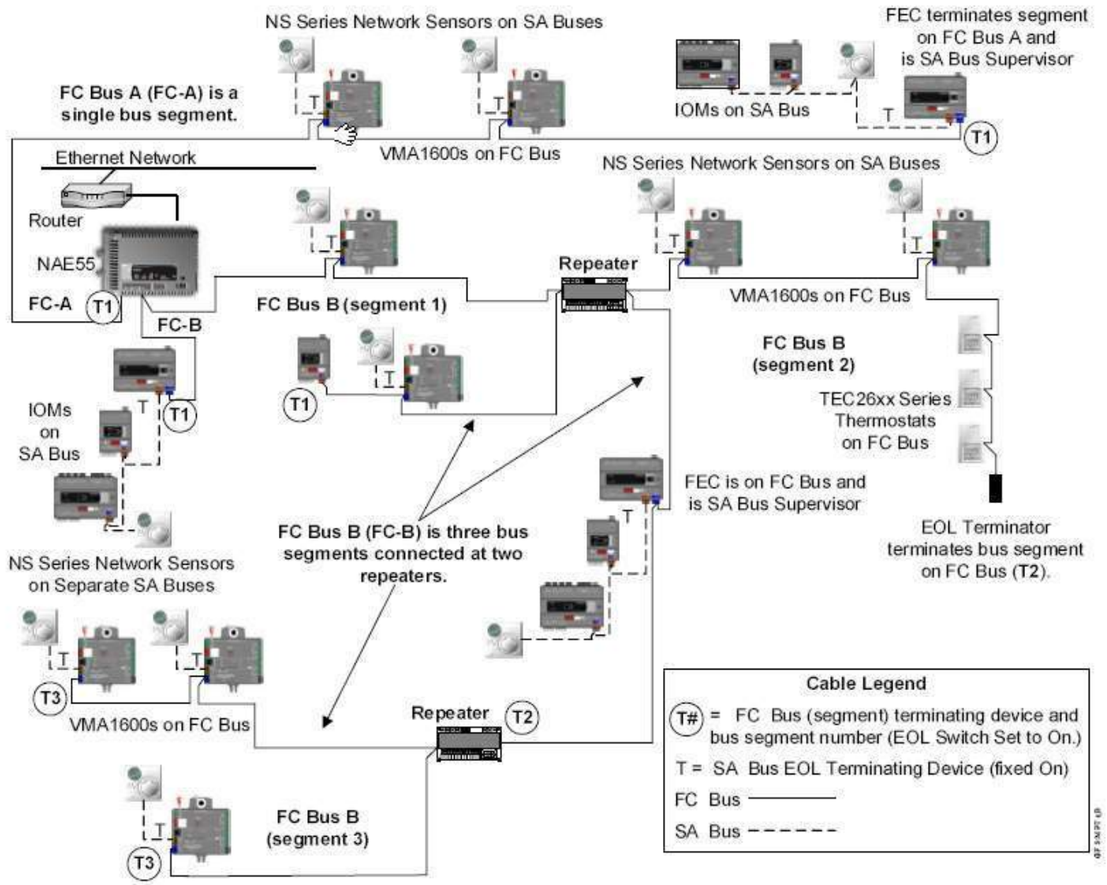
RECOMMENDED MSTP FIELD CONTROLLER BUS CABLE

Type	Typical Usage	Anixter #	Belden #	pF/ft	Area
22/3c Shielded Plenum	Open Plenum Installations. 38400+ Baud RS-485 Communication.	CBL-22/3-FC-PLN	6501FE	25	0.014
22/3c Shielded PVC	EMT (Raceway) Installations. 38400+ Baud RS-485 Communication.	CBL-22/3-FC-PVC	5501FE	31	0.015

RECOMMENDED MSTP SENSOR ACTUATOR BUS CABLE

Type	Typical Usage	Anixter #	Belden #	pF/ft	Area
22/2pr Shielded Plenum	Open Plenum Installations. 38400+ Baud RS-485 Communication.	CBL-22/2P-SA-PLN	6541FE	33	0.033
22/2pr Shielded PVC	EMT (Raceway) Installations. 38400+ Baud RS-485 Communication.	CBL-22/2P-SA-PVC	5541FE	31	0.034

END OF THE LINE SWITCHING AND REPEATER GUIDELINES



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Drawing Title

Net Riser Guidelines

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Sales Engineer	Project Manager	Application Engineer	DRAWN	APPROVED
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS DATE 04/27/2017	BY DATE

Project Title

U of H Central Plant BAS Retrofit

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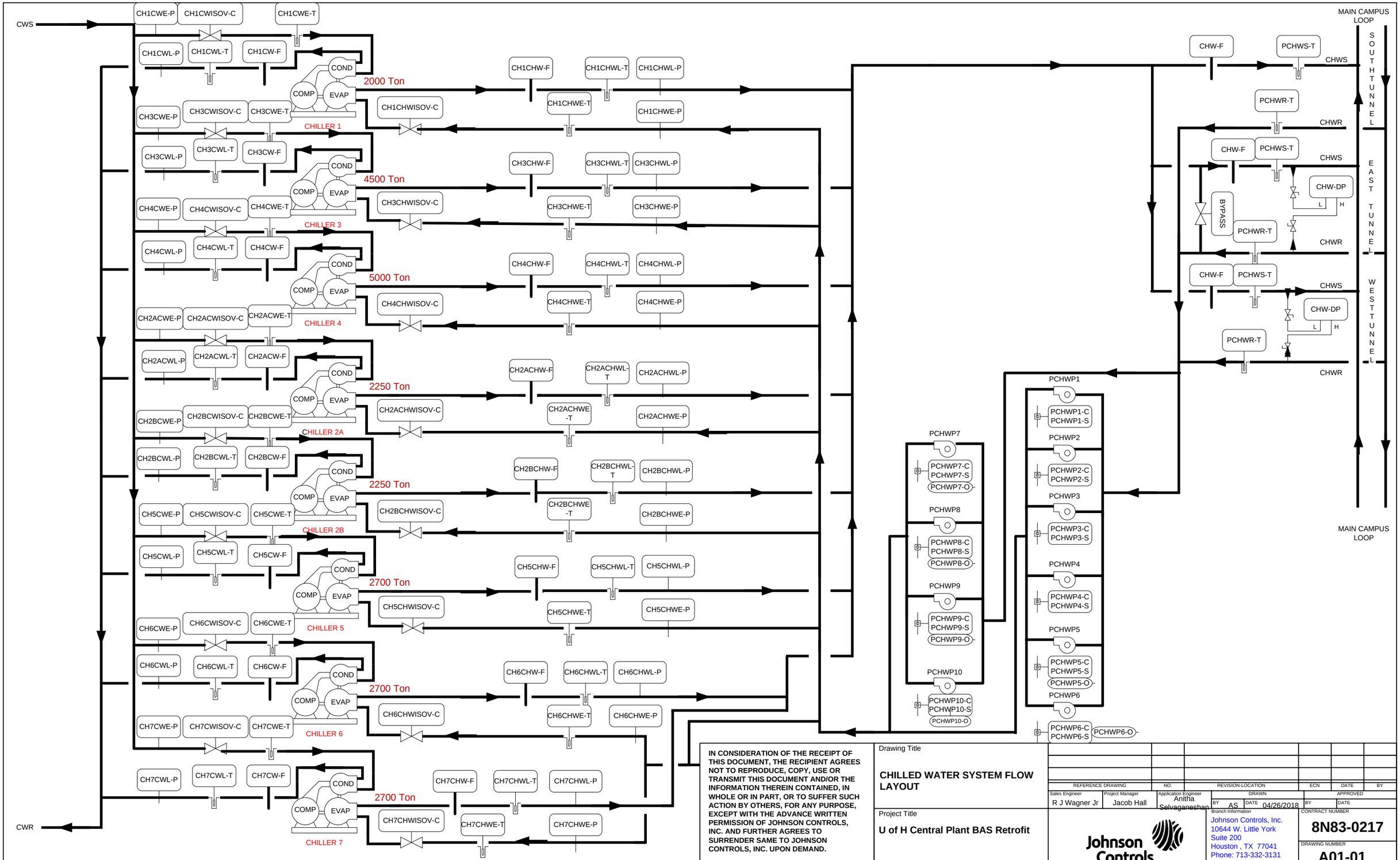
CONTRACT NUMBER **8N83-0217**

DRAWING NUMBER **NR-03**

CHILLED WATER SYSTEM FLOW LAYOUT



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Drawing Title

CHILLED WATER SYSTEM FLOW LAYOUT

Project Title

U of H Central Plant BAS Retrofit

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Sales Engineer	Project Manager	Application Engineer	DRAWN	APPROVED
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Fax: 713-332-3100

CONTRACT NUMBER

8N83-0217

DRAWING NUMBER

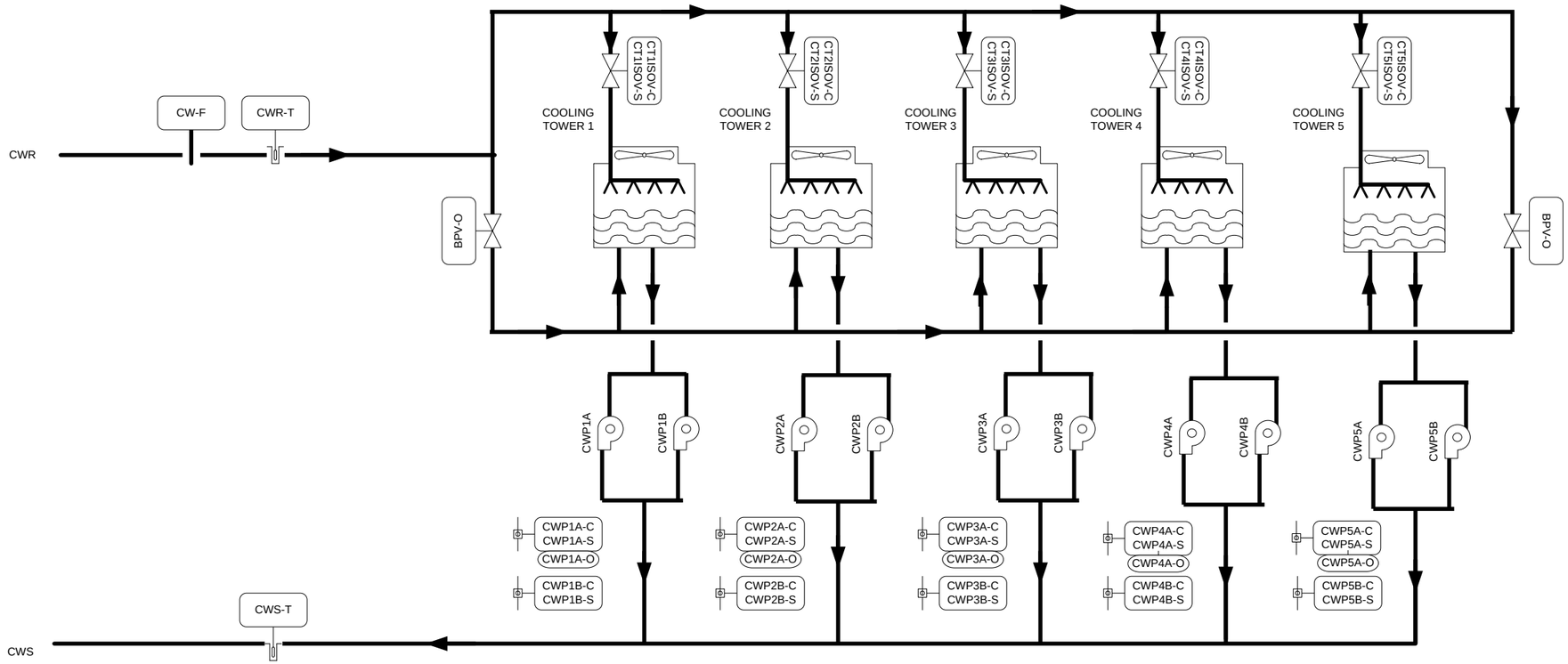
A01-01

CONDENSER WATER SYSTEM FLOW LAYOUT

OA-H

OA-T

LOCATED IN THE SHADE ON THE NORTH SIDE OF THE BUILDING



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Drawing Title

CONDENSER WATER SYSTEM FLOW LAYOUT

Project Title

U of H Central Plant BAS Retrofit

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Sales Engineer	Project Manager	Application Engineer	DRAWN		APPROVED	
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS	DATE 04/26/2018	BY	DATE

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CONTRACT NUMBER

8N83-0217

DRAWING NUMBER

A01-02

CENTRAL PLANT SEQUENCE OF OPERATION-PAGE 1

1.1. Purpose

1.1.1. This document is intended to provide a description of the plant operation and preliminary control sequences for the University Houston Chilled Water Plant.

1.1.2. The optimization control and interface are not included in this document. Certain parts of the control described here is limited to default operation (herein called General Plant operation) which will operate the plant when the optimization is not active.

1.2. Software Structure

1.2.1. Program execution is output oriented wherein various calculations and logic exercises are conducted and organized such that a single portion of the entire program is employed to command and operate each system output.

1.2.2. Except where greater frequency is required, calculation and control are executed once every 30 seconds.

1.3. University of Houston Chiller Plant Main Components

1.3.1. **Chillers:**

CH-1: York YK 2500 ton electric variable speed centrifugal chiller
CH-2A: York 2250 ton electric constant speed centrifugal chiller
CH-2B: York 2250 ton electric constant speed centrifugal chiller
CH-3: York 4500 ton Titan electric constant speed centrifugal chiller
CH-4: York 5000 ton Titan electric constant speed centrifugal chiller
CH-5: York YK 2750 ton electric variable speed centrifugal chiller
CH-6: York YK 2750 ton electric variable speed centrifugal chiller
CH-7: York YK 2750 ton electric variable speed centrifugal chiller

1.3.2. **Chilled Water Pumps:**

CHP-1: 4500 GPM constant speed chilled water pump
CHP-2: 4500 GPM constant speed chilled water pump
CHP-3: 6000 GPM constant speed chilled water pump
CHP-4: 9000 GPM constant speed chilled water pump
CHP-5: 6240 GPM variable speed chilled water pump
CHP-6: 6240 GPM variable speed chilled water pump
CHP-8: 6240 GPM variable speed chilled water pump
CHP-9: 6240 GPM variable speed chilled water pump
CHP-10: 6240 GPM variable speed chilled water pump

1.3.3. **Cooling Towers**:

CT-1: 5,000 tons, 15,000 GPM with variable speed fan
CT-2: 5,000 tons, 15,000 GPM with variable speed fan
CT-3: 5,000 tons, 15,000 GPM with variable speed fan
CT-4: 5,000 tons, 15,000 GPM with variable speed fan
CT-5: 5,000 tons, 15,000 GPM with variable speed fan

1.3.4. **Condenser Water Pumps**:

CWP1a: 7500 GPM variable speed condenser water pump
CWP1b: 7500 GPM constant speed condenser water pump
CWP2a: 7500 GPM variable speed condenser water pump
CWP2b: 7500 GPM constant speed condenser water pump
CWP3a: 7500 GPM variable speed condenser water pump
CWP3b: 7500 GPM constant speed condenser water pump
CWP4a: 7500 GPM variable speed condenser water pump
CWP4b: 7500 GPM constant speed condenser water pump
CWP5a: 7500 GPM variable speed condenser water pump
CWP5b: 7500 GPM constant speed condenser water pump

. General Control Parameters

2.1. This plant operations document describes the general control of the plant and its components. Optimization is provided separately and is not included in this description.

2.2. Main components of the chiller plant operate automatically. Operators employ setup screens to interact with system to place equipment in and out of service and to establish lead/lay sequencing.

2.3. Maximum rate of speed change limitations listed in this document do not necessarily apply when equipment is initially started or when equipment is switched to or from manual mode operation to automatic mode or to optimized mode.

2.4. All VFDs in the plant shall be set up with an initial setting of 90 second ramp up and ramp down (0% - 100% acceleration/deceleration times). VFDs are also set up to provide automatic current limiting via speed (RPM) reduction to eliminate faults due to motor overload conditions. Care shall be taken that all other fundamental setup parameters are the same for all plant VFDs

2.5. To protect the distribution infrastructure, chilled water pump speed is limited such that discharge pressure never exceeds an operator adjustable limit – initially set to ??? psi. Operators are notified that pressure limitation is in effect.

. Equipment Priority

3.1. All heating and cooling equipment (pumps, chillers, towers) are assigned a priority. Equipment is sequenced on and off as required based on priority with the highest priority unit in a group sequenced on first and the lowest priority unit in operation sequenced off first.

3.2. Priority can be established two ways.

3.2.1. Automatic priority is based on runtime which can be reset or adjusted by operators when equipment is serviced. Equipment in groups has priority ordered with lowest runtime as the highest priority when automatic priority is active.

3.2.2. Operators can also override priority in which case priority ordering is done by the operators.

3.2.3. Appropriate setup screen allows operators to easily view, set or adjust current priority settings for equipment groups as described in this document.

3.2.4. Sequencing can be changed at any time with no change in the current plant operation. Only when equipment is added or shed is the new sequencing applied.

4. Maintenance "Out of Service" and Equipment Failure

4.1. The Maintenance "Out of Service" designation can apply to all equipment in the plant. When the Maintenance "Out of Service" designation is active, the unit cannot be sequenced on line regardless of priority order until the designation is deactivated by an operator. When an "Out of Service" unit is scheduled to be added, it is bypassed and the next unit in sequence is added instead.

4.2. Equipment units can be designated as on Maintenance "Out of Service" by operators only when equipment is off line.

4.3. If a currently on-line component fails in operation, then it is shut down, alarmed, listed in Fault, and replaced in operation by the off-line component of the highest priority (if available). The alarm alerts the operator to the condition and the affected faulted unit cannot operate until the cause of failure is corrected and the alarm designation is reset by the operator.

5. General Plant Operation Overview

5.1. The chiller water plant equipment is sequenced as required to maintain a chilled water flow output that meets current campus cooling chilled water requirements.

5.2. The chilled water supply temperature can be reset such that in cool and cold weather with low loads the chilled water supply temperature can be adjusted upward slightly so long as all cooling loads are satisfied.

5.3. To achieve desired flow (capacity) requirements, chillers are sequenced on and off line as necessary in accordance with operator established sequencing schedules and Out of Service limitations.

5.4. When a unit or piece of equipment is designated to be added, the off-line unit or piece of equipment of the highest priority is started. When a unit or piece of equipment is designated to be shed, the on-line unit or piece of equipment with the lowest priority is shut down.

5.5. Chillers are sequenced on and off line to maintain loading between 50% and full load on each chiller. Chillers will also be added when chilled water flow rises above the maximum rated flow for the on-line chillers.

5.6. Condenser water pumps and cooling towers are sequenced on and off line in their priority order such that the on-line chillers operate as close as possible to their design flow.

5.7. The tower fan speed control maintains the operator preset leaving tower water temperature setpoint.

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Drawing Title: CENTRAL PLANT SEQUENCE OF OPERATION-PAGE 1

Project Title: U of H Central Plant BAS Retrofit

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

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DRAWING NUMBER: A01-03

CENTRAL PLANT SEQUENCE OF OPERATION-PAGE 2

5.8. Chilled water pumps are sequenced on or off line as needed to meet flow requirements and keep the on-line pumps operating above 50% of full speed.

5.9. Chilled water pump speed is controlled to maintain the desired chilled water header pressure setpoint.

6. General Plant Operation Chiller Add Criteria

6.1. A chiller is added with a pop-up notification when:

6.1.1. At all times, even in the instance of a plant shutdown, the lead chiller chilled water and condenser water isolation valves remain fully open.

6.1.2. If no chiller is operating, and the CHW flow becomes greater than the minimum flow for the lead chiller and the chilled water supply temperature is more than 5F above the chilled water temperature setpoint.

6.1.3. If current chillers are operating at greater than 90% (adjustable) of design tons loading for more than 5 (adjustable) consecutive minutes.

6.1.4. If current chillers are operating and flow setpoint becomes larger than the maximum flow for the on line chillers.

7. General Plant Operation Chiller Start Sequence

7.1. Once a chiller has been selected to start, the following sequence is followed to bring it on line

7.1.1. The CW isolation valve of the highest priority off line chiller is opened to 20% (adjustable) open and thereafter opened at the rate of 1% per second until fully open.

7.1.2. The CHW isolation valve of that chiller is opened concurrently with the CW isolation valve to 20% (adjustable) open and thereafter opened at the rate of 1% per second until fully open.

7.1.3. As soon as valves are fully opened, the chiller is commanded to start.

8. General Plant Operation Chiller Shed Criteria

8.1. A chiller is shed with a pop-up notification when:

8.1.1. The total chilled water flow is calculated to be less than 90% of the maximum flow of the remaining chillers and any one of the following is true:

8.1.2. If more than 2 chillers are on line, the average tons loading for the on line chillers has been less than 45% (adjustable) for 5 (adjustable) consecutive minutes.

8.1.3. If 2 chillers are on line, the average tons loading for the on line chillers will be less than 80% (adjustable) of the capacity of the remaining chillers for 5 (adjustable) consecutive minutes.

8.1.4. If only one chiller is on line and the flow becomes less than the chiller's minimum flow.

9. General Plant Operation Chiller Stop Sequence

9.1. Once a chiller has been selected to shed, the following sequence is followed to take it off line

9.1.1. The chiller is commanded to stop.

9.1.2. Both the CHW and CW isolation valves are closed to at the rate of 1% per second until 20% open at which time both are fully closed.

10. General Plant Operation Chilled Water Flow Control

10.1. The Chilled Water Flow is modulated to maintain the distribution header differential pressure setpoint is established by the Operations Staff.

11. General Plant Operation Chilled Water Pump Add or Shed Criteria and Control

11.1. A chilled water pump is added or shed with appropriate pop-up notification as follows:

11.1.1. Variable speed chilled water pumps that are in service are always the first in pump sequencing (CHP-5, 6, 8, 9, 10). The constant speed pumps (CHP-1, 2, 3, 4) always follow after all in-service variable speed pumps are on line.

11.1.2. Lead chilled water pump: The lead chilled water pump operates at all times unless the operators initiate a general plant shutdown.

11.1.3. A Chilled water pump is added anytime the on-line variable speed pump(s) is(are) operating at greater than 95% (adjustable) speed to meet the chilled water flow requirements for 2 (adjustable) consecutive minutes. The program starts the highest priority off line pump automatically.

11.1.4. A chilled water pump is shed when pump speed drops to less than 60% (adjustable) continuously for 2 (adjustable) consecutive minutes. The program stops the lowest priority on line pump automatically.

11.1.5. If an on line chilled water pump fails, then the highest priority off line chilled water pump available is automatically added.

12. General Plant Operation Chilled Water Pump Speed Control.

12.1. When multiple variable speed chilled water pumps are on line, all pumps operate at identical speed.

12.2. Chilled water pump speed is limited to a maximum (adjustable) pump discharge pressure

12.3. Minimum chilled water pump speed is 40% (adjustable). When a pump is started it is immediately set to the speed control of the existing pumps and speed of all pumps is controlled to maintain chilled water differential pressure setpoint.

12.4. When a pump is shut down, it's speed is first disconnected from the pump speed control, reduced to minimum speed and one minute later it is shut down.

13. General Plant Operation Condenser Water Pump Add or Shed Criteria and Control

13.1. A condenser water pump is added or shed with appropriate pop-up notification as follows:

13.1.1. Variable speed chilled water pumps (CWP-1a, 2a, 3a, 4a, 5a) in General Plant Operation are operated at full speed at all times when on line.

13.1.2. Condenser water pumps are added and shed in sequence set by operators. Condenser water pumps are sequenced in accordance with their design flow such that the condenser water flow is at all times at least the total of the design condenser flow for the on line chillers.

13.1.3. When a chiller is added, the design flow for that chiller is added to the condenser water flow requirement when its condenser water valve is 20% open.

13.1.4. When a chiller is shed, the design flow for that chiller is subtracted from the condenser water flow requirement when its condenser water valve closes to 20% open.

14. General Plant Operation Cooling Tower Cell Add or Shed Control

14.1. Cooling towers are sequenced on and off line in accordance with the operators' tower sequencing schedule.

14.2. A cooling tower is added or shed as follows:

14.2.1. The isolation valves for the lead cooling tower remain open at all times.

14.2.2. Cooling towers are sequenced on and off line such that the ratio of on-line condenser water pumps to on-line cooling towers is never greater than 2.0 (for example, if four CW pumps and two Towers are on-line, the addition of a fifth CW pump causes a third Tower to be added. Conversely, if three CW pumps and two Towers are on line and on CW pump is shut down, a Tower is shut down also.

15. General Plant Operation Cooling Tower Fan Control

15.1.1. Whenever one or more chillers are on line, the cooling tower fans for the active towers are started anytime the leaving tower water temperature is less than 1°F below the current leaving tower water temperature setpoint for 2 (adjustable) consecutive minutes.

15.1.2. Fans are shut down if the leaving tower water temperature falls to 3°F below the current leaving tower water temperature setpoint for 2 (adjustable) consecutive minutes.

15.1.3. Fan speed is controlled from 25% (adjustable) speed to 100% speed to maintain the operator set leaving tower water temperature setpoint. Fan speed shall change at a maximum rate of 1% per second (adjustable).

15.1.4. All on line tower fans shall operate at the same speed.

PRELIMINARY FOR DISCUSSION

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Drawing Title: CENTRAL PLANT SEQUENCE OF OPERATION-PAGE 2

Project Title: U of H Central Plant BAS Retrofit

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DRAWING NUMBER: A01-04

CHILLER-1,3,4 POINT SCHEDULE

Electrician/Fitter		Point Information			Controller Information							Panel Information					Intermediate Device				Field Device					
Tag	Point Type	System Name	Object Name	Expanded ID	Controller Details	Trunk Type	Trunk Nbr	Trunk Addr.	Cable Destination Bay/Terminal	Module Type	Termination Out	Panel	Panel Location	Slot Number	Reference Drawing	Cable Number	Wiring /Tubing	Termination In	Device	Termination Out	Location	Wiring /Tubing	Termination In	Device	Location	Ref Detail Shape	Comment
		Chillers-1,3,4			FAC 3611																						Power to Controller
		Chillers-1,3,4			FAC 3611	MS/TP	1	4						0													BacNet FC Bus
	UI IN-1	Chillers-1,3,4	CH1CHW-F	Chiller 1 CHW Flow	FAC 3611	MS/TP	1	4	UI IN-1		IN1, ICOM1, 24V HOT, 24V COM			0		4-UI IN-1						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-2	Chillers-1,3,4	CH1CW-F	Chiller 1 CW Flow	FAC 3611	MS/TP	1	4	UI IN-2		IN2, ICOM2, 24V HOT, 24V COM			0		4-UI IN-2						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-3	Chillers-1,3,4	CH3CHW-F	Chiller 3 CHW Flow	FAC 3611	MS/TP	1	4	UI IN-3		IN3, ICOM3, 24V HOT, 24V COM			0		4-UI IN-3						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-4	Chillers-1,3,4	CH3CW-F	Chiller 3 CW Flow	FAC 3611	MS/TP	1	4	UI IN-4		IN4, ICOM4, 24V HOT, 24V COM			0		4-UI IN-4						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-5	Chillers-1,3,4	CH4CHW-F	Chiller 4 CHW Flow	FAC 3611	MS/TP	1	4	UI IN-5		IN5, ICOM5, 24V HOT, 24V COM			0		4-UI IN-5						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-6	Chillers-1,3,4	CH4CW-F	Chiller 4 CW Flow	FAC 3611	MS/TP	1	4	UI IN-6		IN6, ICOM6, 24V HOT, 24V COM			0		4-UI IN-6						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-7	Chillers-1,3,4	CH1CHWE-T	Chiller 1 CHW Entering Tempe	FAC 3611	MS/TP	1	4	UI IN-7		IN7, ICOM7			0		4-UI IN-7						2/22	2-Wire	TE		F131	
	UI IN-8	Chillers-1,3,4	CH1CHWL-T	Chiller 1 CHW Leaving Tempe	FAC 3611	MS/TP	1	4	UI IN-8		IN8, ICOM8			0		4-UI IN-8						2/22	2-Wire	TE		F131	
	BI IN-9	Chillers-1,3,4	PCHWP1-S	Primary CHW Pump 1 Status	FAC 3611	MS/TP	1	4	BI IN-9		IN9, ICOM9			0		4-BI IN-9	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-10	Chillers-1,3,4	PCHWP2-S	Primary CHW Pump 2 Status	FAC 3611	MS/TP	1	4	BI IN-10		IN10, ICOM10			0		4-BI IN-10	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-11	Chillers-1,3,4	PCHWP3-S	Primary CHW Pump 3 Status	FAC 3611	MS/TP	1	4	BI IN-11		IN11, ICOM11			0		4-BI IN-11	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-12	Chillers-1,3,4	PCHWP4-S	Primary CHW Pump 4 Status	FAC 3611	MS/TP	1	4	BI IN-12		IN12, ICOM12			0		4-BI IN-12	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-13	Chillers-1,3,4			FAC 3611	MS/TP	1	4	BI IN-13					0		4-BI IN-13											
	BI IN-14	Chillers-1,3,4			FAC 3611	MS/TP	1	4	BI IN-14					0		4-BI IN-14											
	AO OUT-1	Chillers-1,3,4	CHWBYPV-O	Chilled Water Bypass Valve O	FAC 3611	MS/TP	1	4	AO OUT-1		OUT1, OCOM1			0		4-AO OUT-1						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-2	Chillers-1,3,4	CH1CHWISOV	Chiller 1 CHW Isolation Valve	FAC 3611	MS/TP	1	4	AO OUT-2		OUT2, OCOM2			0		4-AO OUT-2						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-3	Chillers-1,3,4	CH1CWISOV-(	Chiller 1 CDW Isolation Valve	FAC 3611	MS/TP	1	4	AO OUT-3		OUT3, OCOM3			0		4-AO OUT-3						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-4	Chillers-1,3,4			FAC 3611	MS/TP	1	4	AO OUT-4					0		4-AO OUT-4											
	AO OUT-5	Chillers-1,3,4			FAC 3611	MS/TP	1	4	AO OUT-5					0		4-AO OUT-5											
	AO OUT-6	Chillers-1,3,4			FAC 3611	MS/TP	1	4	AO OUT-6					0		4-AO OUT-6											
	BO OUT-7	Chillers-1,3,4	CH1-EN	Chiller 1 Enable	FAC 3611	MS/TP	1	4	CO OUT-4		OUT7, 24V COM			0		5-CO OUT-4	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-8	Chillers-1,3,4			FAC 3611	MS/TP	1	4	BO OUT-8		OUT8, 24V COM			0		4-BO OUT-8	2/22	COIL	Relay	COM, NO, NC		3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source		F595	
	BO OUT-9	Chillers-1,3,4			FAC 3611	MS/TP	1	4	BO OUT-9		OUT9, 24V COM			0		4-BO OUT-9	2/22	COIL	Relay	COM, NO, NC		3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source		F995	
	BO OUT-10	Chillers-1,3,4	PCHWP1-C	Primary CHW Pump 1 Comma	FAC 3611	MS/TP	1	4	BO OUT-3		OUT10, 24V COM			0		6-BO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	BO OUT-11	Chillers-1,3,4	PCHWP2-C	Primary CHW Pump 2 Comma	FAC 3611	MS/TP	1	4	BO OUT-11		OUT11, 24V COM			0		4-BO OUT-11	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	BO OUT-12	Chillers-1,3,4	PCHWP3-C	Primary CHW Pump 3 Comma	FAC 3611	MS/TP	1	4	BO OUT-12		OUT12, 24V COM			0		4-BO OUT-12											
		Chillers-1,3,4			IOM 4710																						Power to Controller
		Chillers-1,3,4			IOM 4710	SA Bus	1	4						0													BacNet SA Bus
	UI IN-1	Chillers-1,3,4	CH1CWE-T	Chiller 1 CW Entering Temper	IOM 4710	SA Bus	1	4	UI IN-1		IN1, ICOM1			0		4-UI IN-1						2/22	2-Wire	TE		F131	
	UI IN-2	Chillers-1,3,4	CH1CWL-T	Chiller 1 CW Leaving Tempera	IOM 4710	SA Bus	1	4	UI IN-2		IN2, ICOM2			0		4-UI IN-2						2/22	2-Wire	TE		F131	
	UI IN-3	Chillers-1,3,4	CH3CHWE-T	Chiller 3 CHW Entering Temp	IOM 4710	SA Bus	1	4	UI IN-3		IN3, ICOM3			0		4-UI IN-3						2/22	2-Wire	TE		F131	
	UI IN-4	Chillers-1,3,4	CH3CHWL-T	Chiller 3 CHW Leaving Tempe	IOM 4710	SA Bus	1	4	UI IN-4		IN4, ICOM4			0		4-UI IN-4						2/22	2-Wire	TE		F131	
	UI IN-5	Chillers-1,3,4	CH3CWE-T	Chiller 3 CW Entering Temper	IOM 4710	SA Bus	1	4	UI IN-5		IN5, ICOM5			0		4-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-1,3,4	CH3CWL-T	Chiller 3 CW Leaving Tempera	IOM 4710	SA Bus	1	4	UI IN-6		IN6, ICOM6			0		4-UI IN-6						2/22	2-Wire	TE		F131	
	BI IN-7	Chillers-1,3,4			IOM 4710	SA Bus	1	4	BI IN-7					0		4-BI IN-7											
	BI IN-8	Chillers-1,3,4			IOM 4710	SA Bus	1	4	BI IN-8					0		4-BI IN-8											
	BO OUT-1	Chillers-1,3,4	CH3-EN	Chiller 3 Enable	IOM 4710	SA Bus	1	4	BO OUT-1		OUT1, 24V COM			0		4-BO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-2	Chillers-1,3,4	CH4-EN	Chiller 4 Enable	IOM 4710	SA Bus	1	4	BO OUT-2		OUT2, 24V COM			0		4-BO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-3	Chillers-1,3,4	PCHWP4-C	Primary CHW Pump 4 Comma	IOM 4710	SA Bus	1	4	BO OUT-3		OUT3, 24V COM			0		4-BO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	CO OUT-4	Chillers-1,3,4			IOM 4710	SA Bus	1	4	CO OUT-4		OUT4, 24V COM			0		4-CO OUT-4											
	CO OUT-5	Chillers-1,3,4	CH4CHWISOV	Chiller 4 CHW Isolation Valve	IOM 4710	SA Bus	1	4	CO OUT-5		OUT5, OCOM 5			0		4-CO OUT-5						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-6	Chillers-1,3,4	CH4CWISOV-(	Chiller 4 CDW Isolation Valve	IOM 4710	SA Bus	1	4	CO OUT-6		OUT6, OCOM 6			0		4-CO OUT-6						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-7	Chillers-1,3,4			IOM 4710	SA Bus	1	4	CO OUT-7					0		4-CO OUT-7											
	AO OUT-8	Chillers-1,3,4	CH3CHWISOV	Chiller 3 CHW Isolation Valve	IOM 4710	SA Bus	1	4	AO OUT-8		OUT8, OCOM8			0		4-AO OUT-8						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-9	Chillers-1,3,4	CH3CWISOV-(	Chiller 3 CDW Isolation Valve	IOM 4710	SA Bus	1	4	AO OUT-9		OUT9, OCOM9			0		4-AO OUT-9						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
		Chillers-1,3,4			IOM 2721																						Power to Controller
		Chillers-1,3,4			IOM 2721	SA Bus	1	5						0													BacNet SA Bus
	UI IN-1	Chillers-1,3,4	CH3CHWE-T	Chiller 3 CHW Entering Temp	IOM 2721	SA Bus	1	5	UI IN-1		IN1, ICOM1			0		5-UI IN-1						2/22	2-Wire	TE		F131	
	UI IN-2	Chillers-1,3,4	CH3CHWL-T	Chiller 3 CHW Leaving Tempe	IOM 2721	SA Bus	1	5	UI IN-2		IN2, ICOM2			0		5-UI IN-2						2/22	2-Wire	TE		F131	
	UI IN-3	Chillers-1,3,4	CH3CWE-T	Chiller 3 CW Entering Temper	IOM 2721	SA Bus	1	5	UI IN-3		IN3, ICOM3			0		5-UI IN-3						2/22	2-Wire	TE		F131	
	UI IN-4	Chillers-1,3,4	CH3CWL-T	Chiller 3 CW Leaving Tempera	IOM 2721	SA Bus	1	5	UI IN-4		IN4, ICOM4			0		5-UI IN-4						2/22	2-Wire	TE		F131	
	UI IN-5	Chillers-1,3,4	CH4CHWE-T	Chiller 4 CHW Entering Temp	IOM 2721	SA Bus	1	5	UI IN-5		IN5, ICOM5			0		5-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-1,3,4	CH4CHWL-T	Chiller 4 CHW Leaving Tempe	IOM 2721	SA Bus	1	5	UI IN-6		IN6, ICOM6			0		5-UI IN-6						2/22	2-Wire	TE		F131	
	UI IN-7	Chillers-1,3,4	CH4CWE-T	Chiller 4 CW Entering Temper	IOM 2721	SA Bus	1	5	UI IN-7		IN7, ICOM7			0		5-UI IN-7						2/22	2-Wire	TE		F131	
	UI IN-8	Chillers-1,3,4	CH4CWL-T	Chiller 4 CW Leaving Tempera	IOM 2721	SA Bus	1	5	UI IN-8		IN8, ICOM8			0		5-UI IN-8						2/22	2-Wire	TE		F131	
	AO OUT-1	Chillers-1,3,4			IOM 2721	SA Bus	1	5	AO OUT-1					0		5-AO OUT-1											
	AO OUT-2	Chillers-1,3,4			IOM 2721	SA Bus	1	5	AO OUT-2					0		5-AO OUT-2											
		Chillers-1,3,4			IOM 2721																						Power to Controller
		Chillers-1,3,4			IOM 2721	SA Bus	1	6						0													BacNet SA Bus
	UI IN-1	Chillers-1,3,4	CH1CHWE-P	Chiller 1 CHW Entering Press	IOM 2721	SA Bus	1	6	UI IN-1		IN1, +15V			0		6-UI IN-1						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Chillers-1,3,4	CH1CHWL-P	Chiller 1 CHW Leaving Press	IOM 2721	SA Bus	1	6	UI IN-2		IN2, +15V			0		6-UI IN-2						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Chillers-1,3,4	CH3CHWE-P	Chiller 3 CHW Entering Press	IOM 2721	SA Bus	1	6	UI IN-3		IN3, +15V			0		6-UI IN-3						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-4	Chillers-1,3,4	CH3CHWL-P	Chiller 3 CHW Leaving Press	IOM 2721	SA Bus	1	6	UI IN-4		IN4, +15V			0		6-UI IN-4						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-5	Chillers-1,3,4	CH4CHWE-P	Chiller 4 CHW Entering Press	IOM 2721	SA Bus	1	6	UI IN-5		IN5, +15V			0		6-UI IN-5						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-6	Chillers-1,3,4	CH4CHWL-P	Chiller 4 CHW Leaving Press	IOM 2721	SA Bus	1	6	UI IN-6		IN6, +15V			0		6-UI IN-6						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-7	Chillers-1,3,4	CHWR-T South	South Tunnel CHW Return Te	IOM 2721	SA Bus	1	6	UI IN-7		IN7, ICOM7			0		6-UI IN-7						2/22	2-Wire	TE		F131	
	UI IN-8	Chillers-1,3,4	CHWS-T South	South Tunnel CHW Supply Te	IOM 2721	SA Bus	1	6	UI IN-8		IN8, ICOM8			0		6-UI IN-8						2/22	2-Wire	TE		F131	
	AO OUT-1	Chillers-1,3,4			IOM 2721	SA Bus	1	6	AO OUT-1					0		6-AO OUT-1											
	AO OUT-2	Chillers-1,3,4			IOM 2721	SA Bus	1	6	AO OUT-2					0		6-AO OUT-2											

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Drawing Title

CHILLER-1,3,4 POINT SCHEDULE

Project Title

U of H Central Plant BAS Retrofit

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

Sales Engineer	Project Manager	Application Engineer	DRAWN		APPROVED	
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS	DATE 04/26/2018	BY	DATE

Johnson Controls

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CONTRACT NUMBER
8N83-0217

DRAWING NUMBER
A01-05

CHILLER-2A,2B POINT SCHEDULE

Electrician/Fitter		Point Information			Controller Information							Panel Information					Intermediate Device					Field Device					
Tag	Point Type	System Name	Object Name	Expanded ID	Controller Details	Trunk Type	Trunk Nbr	Trunk Addr.	Cable Destination Bay/Terminal	Module Type	Termination Out	Panel	Panel Location	Slot Number	Reference Drawing	Cable Number	Wiring /Tubing	Termination In	Device	Termination Out	Location	Wiring /Tubing	Termination In	Device	Location	Ref Detail Shape	Comment
		Chillers-2A,2B			IOM 4710																						Power to Controller
		Chillers-2A,2B			IOM 4710	SA Bus	1	7						0													BacNet SA Bus
	UI IN-1	Chillers-2A,2B	CH2ACHW-F	Chiller 2A CHW Flow	IOM 4710	SA Bus	1	7	UI IN-1		IN1, ICOM1, 24V HOT, 24V COM			0		7-UI IN-1						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-2	Chillers-2A,2B	CH2ACW-F	Chiller 2A CW Flow	IOM 4710	SA Bus	1	7	UI IN-2		IN2, ICOM2, 24V HOT, 24V COM			0		7-UI IN-2						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-3	Chillers-2A,2B	CH2BCHW-F	Chiller 2B CHW Flow	IOM 4710	SA Bus	1	7	UI IN-3		IN3, ICOM3, 24V HOT, 24V COM			0		7-UI IN-3						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-4	Chillers-2A,2B	CH2BCW-F	Chiller 2B CW Flow	IOM 4710	SA Bus	1	7	UI IN-4		IN4, ICOM4, 24V HOT, 24V COM			0		7-UI IN-4						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-5	Chillers-2A,2B	CH2ACHWE-T	Chiller 2A CHW Entering Tem	IOM 4710	SA Bus	1	7	UI IN-5		IN5, ICOM5			0		7-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-2A,2B	CH2ACHWL-T	Chiller 2A CHW Entering Tem	IOM 4710	SA Bus	1	7	UI IN-6		IN6, ICOM6			0		7-UI IN-6						2/22	2-Wire	TE		F131	
	BI IN-7	Chillers-2A,2B	PCHWP5-S	Primary CHW Pump 5 Status	IOM 4710	SA Bus	1	7	BI IN-7					0		7-BI IN-7	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-8	Chillers-2A,2B	PCHWP6-S	Primary CHW Pump 6 Status	IOM 4710	SA Bus	1	7	BI IN-8					0		7-BI IN-8	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BO OUT-1	Chillers-2A,2B	CH2A-EN	Chiller 2A Enable	IOM 4710	SA Bus	1	7	BO OUT-1		OUT1, 24V COM			0		7-BO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-2	Chillers-2A,2B	CH2B-EN	Chiller 2B Enable	IOM 4710	SA Bus	1	7	BO OUT-2		OUT2, 24V COM			0		7-BO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-3	Chillers-2A,2B	PCHWP5-C	Primary CHW Pump 5 Comma	IOM 4710	SA Bus	1	7	BO OUT-3		OUT3, 24V COM			0		7-BO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	CO OUT-4	Chillers-2A,2B	PCHWP6-C	Primary CHW Pump 6 Comma	IOM 4710	SA Bus	1	7	CO OUT-4		OUT4, 24V COM			0		7-CO OUT-4	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	CO OUT-5	Chillers-2A,2B	CH2BCHWISO	Chiller 2B CHW Isolation Valv	IOM 4710	SA Bus	1	7	CO OUT-5		OUT5, OCOM 5			0		7-CO OUT-5						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-6	Chillers-2A,2B	CH2BCWISOV	Chiller 2B CW Isolation Valve	IOM 4710	SA Bus	1	7	CO OUT-6		OUT6, OCOM 6			0		7-CO OUT-6						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-7	Chillers-2A,2B			IOM 4710	SA Bus	1	7	CO OUT-7					0		7-CO OUT-7											
	AO OUT-8	Chillers-2A,2B	CH2ACHWISO	Chiller 2A CHW Isolation Valv	IOM 4710	SA Bus	1	7	AO OUT-8		OUT8, OCOM8			0		7-AO OUT-8						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-9	Chillers-2A,2B	CH2ACWISOV	Chiller 2A CW Isolation Valve	IOM 4710	SA Bus	1	7	AO OUT-9		OUT9, OCOM9			0		7-AO OUT-9						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
		Chillers-2A,2B			IOM 2721																						Power to Controller
		Chillers-2A,2B			IOM 2721	SA Bus	1	8						0													BacNet SA Bus
	UI IN-1	Chillers-2A,2B	CH2BCHWE-T	Chiller 2B CHW Entering Tem	IOM 2721	SA Bus	1	8	UI IN-1		IN1, ICOM1			0		8-UI IN-1						2/22	2-Wire	TE		F131	
	UI IN-2	Chillers-2A,2B	CH2BCHWL-T	Chiller 2B CHW Leaving Temp	IOM 2721	SA Bus	1	8	UI IN-2		IN2, ICOM2			0		8-UI IN-2						2/22	2-Wire	TE		F131	
	UI IN-3	Chillers-2A,2B	CH2BCWE-T	Chiller 2B CW Entering Tempe	IOM 2721	SA Bus	1	8	UI IN-3		IN3, ICOM3			0		8-UI IN-3						2/22	2-Wire	TE		F131	
	UI IN-4	Chillers-2A,2B	CH2BCWL-T	Chiller 2B CW Leaving Tempe	IOM 2721	SA Bus	1	8	UI IN-4		IN4, ICOM4			0		8-UI IN-4						2/22	2-Wire	TE		F131	
	UI IN-5	Chillers-2A,2B	CH2ACWE-T	Chiller 2A CW Entering Tempe	IOM 2721	SA Bus	1	8	UI IN-5		IN5, ICOM5			0		8-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-2A,2B	CH2ACWL-T	Chiller 2A CW Leaving Tempe	IOM 2721	SA Bus	1	8	UI IN-6		IN6, ICOM6			0		8-UI IN-6						2/22	2-Wire	TE		F131	
	UI IN-7	Chillers-2A,2B	CHWR-T East	East Tunnel CHW Return Tem	IOM 2721	SA Bus	1	8	UI IN-7		IN7, ICOM7			0		8-UI IN-7						2/22	2-Wire	TE		F131	
	UI IN-8	Chillers-2A,2B	CHWS-T East	East Tunnel CHW Supply Tem	IOM 2721	SA Bus	1	8	UI IN-8		IN8, ICOM8			0		8-UI IN-8						2/22	2-Wire	TE		F131	
	AO OUT-1	Chillers-2A,2B	PCHWP5-O	Primary CHW Pump 5 VFD C	IOM 2721	SA Bus	1	8	AO OUT-1		OUT8, OCOM8			0		8-AO OUT-1						2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-2	Chillers-2A,2B	PCHWP6-O	Primary CHW Pump 6 VFD C	IOM 2721	SA Bus	1	8	AO OUT-2		OUT9, OCOM9			0		8-AO OUT-2						2/22	See VFD Detail	VFD Speed Control (Vdc)			
		Chillers-2A,2B			IOM 2721																						Power to Controller
		Chillers-2A,2B			IOM 2721	SA Bus	1	9						0													BacNet SA Bus
	UI IN-1	Chillers-2A,2B	CH2ACHWE-P	Chiller 2A CHW Entering Pres	IOM 2721	SA Bus	1	9	UI IN-1		IN1, +15V			0		9-UI IN-1						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Chillers-2A,2B	CH2ACHWL-P	Chiller 2A CHW Leaving Pres	IOM 2721	SA Bus	1	9	UI IN-2		IN2, +15V			0		9-UI IN-2						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Chillers-2A,2B	CH2BCHWE-P	Chiller 2B CHW Entering Pres	IOM 2721	SA Bus	1	9	UI IN-3		IN3, +15V			0		9-UI IN-3						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-4	Chillers-2A,2B	CH2BCHWL-P	Chiller 2B CHW Leaving Pres	IOM 2721	SA Bus	1	9	UI IN-4		IN4, +15V			0		9-UI IN-4						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-5	Chillers-2A,2B	CHW-DP-East	CHW Diff Pressure East Tunn	IOM 2721	SA Bus	1	9	UI IN-5		IN5, +15V			0		9-UI IN-5						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-6	Chillers-2A,2B	CHW-DP-Sout	CHW Diff Pressure South Tur	IOM 2721	SA Bus	1	9	UI IN-6		IN6, +15V			0		9-UI IN-6						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-7	Chillers-2A,2B	CHW-F-East	CHW Flow East Tunnel	IOM 2721	SA Bus	1	9	UI IN-7		IN7, ICOM7, 24V HOT, 24V COM			0		9-UI IN-7						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-8	Chillers-2A,2B	CHW-F-South	CHW Flow South Tunnel	IOM 2721	SA Bus	1	9	UI IN-8		IN8, ICOM8, 24V HOT, 24V COM			0		9-UI IN-8						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	AO OUT-1	Chillers-2A,2B	CHWBYPV-O	Chilled Water Bypass Valve O	IOM 2721	SA Bus	1	9	AO OUT-1					0		9-AO OUT-1						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-2	Chillers-2A,2B			IOM 2721	SA Bus	1	9	AO OUT-2					0		9-AO OUT-2											

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Drawing Title

CHILLER-2A,2B POINT SCHEDULE

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

Sales Engineer	Project Manager	Application Engineer	DRAWN	APPROVED
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS DATE 04/26/2018	BY DATE

Project Title

U of H Central Plant BAS Retrofit

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CONTRACT NUMBER
8N83-0217

DRAWING NUMBER
A01-06

CHILLER-5,6,7 POINT SCHEDULE

Electrician/Fitter		Point Information			Controller Information							Panel Information					Intermediate Device				Field Device					
Tag	Point Type	System Name	Object Name	Expanded ID	Controller Details	Trunk Type	Trunk Nbr	Trunk Addr.	Cable Destination Bay/Terminal	Module Type	Termination Out	Panel	Panel Location	Slot Number	Reference Drawing	Cable Number	Wiring /Tubing	Termination In	Device	Termination Out	Location	Wiring /Tubing	Termination In	Device	Location	Ref Detail Shape	Comment
		Chillers-5,6,7			IOM 4710																					Power to Controller
		Chillers-5,6,7			IOM 4710	SA Bus	1	10						0												BacNet SA Bus
	UI IN-1	Chillers-5,6,7	CH5CHW-F	Chiller 5 CHW Flow	IOM 4710	SA Bus	1	10	UI IN-1		IN1, ICOM1, 24V HOT, 24V COM			0		10-UI IN-1						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-2	Chillers-5,6,7	CH5CW-F	Chiller 5 CW Flow	IOM 4710	SA Bus	1	10	UI IN-2		IN2, ICOM2, 24V HOT, 24V COM			0		10-UI IN-2						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-3	Chillers-5,6,7	CH6CHW-F	Chiller 6 CHW Flow	IOM 4710	SA Bus	1	10	UI IN-3		IN3, ICOM3, 24V HOT, 24V COM			0		10-UI IN-3						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-4	Chillers-5,6,7	CH6CW-F	Chiller 6 CW Flow	IOM 4710	SA Bus	1	10	UI IN-4		IN4, ICOM4, 24V HOT, 24V COM			0		10-UI IN-4						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-5	Chillers-5,6,7	CH7CHW-F	Chiller 7 CHW Flow	IOM 4710	SA Bus	1	10	UI IN-5		IN5, ICOM5, 24V HOT, 24V COM			0		10-UI IN-5						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-6	Chillers-5,6,7	CH7CW-F	Chiller 7 CW Flow	IOM 4710	SA Bus	1	10	UI IN-6		IN6, ICOM6, 24V HOT, 24V COM			0		10-UI IN-6						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	BI IN-7	Chillers-5,6,7	PCHWP7-S	Primary CHW Pump 7 Status	IOM 4710	SA Bus	1	10	BI IN-7		IN7, ICOM7			0		10-BI IN-7	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-8	Chillers-5,6,7	PCHWP8-S	Primary CHW Pump 8 Status	IOM 4710	SA Bus	1	10	BI IN-8		IN8, ICOM8			0		10-BI IN-8	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BO OUT-1	Chillers-5,6,7	CH5-EN	Chiller 5 Enable	IOM 4710	SA Bus	1	10	BO OUT-1		OUT1, 24V COM			0		10-BO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-2	Chillers-5,6,7	CH6-EN	Chiller 6 Enable	IOM 4710	SA Bus	1	10	BO OUT-2		OUT2, 24V COM			0		10-BO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	BO OUT-3	Chillers-5,6,7	CH7-EN	Chiller 7 Enable	IOM 4710	SA Bus	1	10	BO OUT-3		OUT3, 24V COM			0		10-BO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Chiller Control Panel (Sw Hi, EXT Src)		F1002	
	CO OUT-4	Chillers-5,6,7	CH5CHWISOV	Chiller 5 CHW Isolation Valve	IOM 4710	SA Bus	1	10	CO OUT-4		OUT4, OCOM 4			0		10-CO OUT-4						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-5	Chillers-5,6,7	CH5CWISOV-(	Chiller 5 CW Isolation Valve C	IOM 4710	SA Bus	1	10	CO OUT-5		OUT5, OCOM 5			0		10-CO OUT-5						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-6	Chillers-5,6,7	CH6CHWISOV	Chiller 6 CHW Isolation Valve	IOM 4710	SA Bus	1	10	CO OUT-6		OUT6, OCOM 6			0		10-CO OUT-6						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	CO OUT-7	Chillers-5,6,7	CH6CWISOV-(	Chiller 6 CW Isolation Valve C	IOM 4710	SA Bus	1	10	CO OUT-7		OUT7, OCOM 7			0		10-CO OUT-7						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-8	Chillers-5,6,7	CH7CHWISOV	Chiller 7 CHW Isolation Valve	IOM 4710	SA Bus	1	10	AO OUT-8		OUT8, OCOM8			0		10-AO OUT-8						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-9	Chillers-5,6,7	CH7CWISOV-(	Chiller 7 CW Isolation Valve C	IOM 4710	SA Bus	1	10	AO OUT-9		OUT9, OCOM9			0		10-AO OUT-9						2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
		Chillers-5,6,7			IOM 4710																					Power to Controller
		Chillers-5,6,7			IOM 4710	SA Bus	1	11						0												BacNet SA Bus
	UI IN-1	Chillers-5,6,7	CH5CHWE-T	Chiller 5 CHW Entering Temp	IOM 4710	SA Bus	1	11	UI IN-1		IN1, ICOM1			0		11-UI IN-1						2/22	2-Wire	TE		F131	
	UI IN-2	Chillers-5,6,7	CH5CHWL-T	Chiller 5 CHW Leaving Tempe	IOM 4710	SA Bus	1	11	UI IN-2		IN2, ICOM2			0		11-UI IN-2						2/22	2-Wire	TE		F131	
	UI IN-3	Chillers-5,6,7	CH5CWE-T	Chiller 5 CW Entering Temper	IOM 4710	SA Bus	1	11	UI IN-3		IN3, ICOM3			0		11-UI IN-3						2/22	2-Wire	TE		F131	
	UI IN-4	Chillers-5,6,7	CH5CWL-T	Chiller 5 CW Leaving Tempera	IOM 4710	SA Bus	1	11	UI IN-4		IN4, ICOM4			0		11-UI IN-4						2/22	2-Wire	TE		F131	
	UI IN-5	Chillers-5,6,7	CH6CHWL-T	Chiller 6 CHW Leaving Tempe	IOM 4710	SA Bus	1	11	UI IN-5		IN5, ICOM5			0		11-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-5,6,7	CH6CHWL-T	Chiller 6 CHW Leaving Tempe	IOM 4710	SA Bus	1	11	UI IN-6		IN6, ICOM6			0		11-UI IN-6						2/22	2-Wire	TE		F131	
	BI IN-7	Chillers-5,6,7	PCHWP9-S	Primary CHW Pump 9 Status	IOM 4710	SA Bus	1	11	BI IN-7		IN7, ICOM7			0		11-BI IN-7	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-8	Chillers-5,6,7	PCHWP10-S	Primary CHW Pump 10 Status	IOM 4710	SA Bus	1	11	BI IN-8		IN8, ICOM8			0		11-BI IN-8	2/22	OUT, COM	Current Relay	Motor Lead		Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BO OUT-1	Chillers-5,6,7	PCHWP7-C	Primary CHW Pump 7 Comma	IOM 4710	SA Bus	1	11	BO OUT-1		OUT1, 24V COM			0		11-BO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	BO OUT-2	Chillers-5,6,7	PCHWP8-C	Primary CHW Pump 8 Comma	IOM 4710	SA Bus	1	11	BO OUT-2		OUT2, 24V COM			0		11-BO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	BO OUT-3	Chillers-5,6,7	PCHWP9-C	Primary CHW Pump 9 Comma	IOM 4710	SA Bus	1	11	BO OUT-3		OUT3, 24V COM			0		11-BO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	CO OUT-4	Chillers-5,6,7	PCHWP10-C	Primary CHW Pump 10 Comm	IOM 4710	SA Bus	1	11	CO OUT-4		OUT4, 24V COM			0		11-CO OUT-4	2/22	COIL-,COIL+	Relay	COM, NO		2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)		F1015	
	CO OUT-5	Chillers-5,6,7	PCHWP7-O	Primary CHW Pump 7 VFD C	IOM 4710	SA Bus	1	11	CO OUT-5		OUT5, OCOM 5			0		11-CO OUT-5						2/22	See VFD Detail	VFD Speed Control (Vdc)			
	CO OUT-6	Chillers-5,6,7	PCHWP8-O	Primary CHW Pump 8 VFD C	IOM 4710	SA Bus	1	11	CO OUT-6		OUT6, OCOM 6			0		11-CO OUT-6						2/22	See VFD Detail	VFD Speed Control (Vdc)			
	CO OUT-7	Chillers-5,6,7			IOM 4710	SA Bus	1	11	CO OUT-7					0		11-CO OUT-7											
	AO OUT-8	Chillers-5,6,7	PCHWP9-O	Primary CHW Pump 9 VFD C	IOM 4710	SA Bus	1	11	AO OUT-8		OUT8, OCOM8			0		11-AO OUT-8						2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-9	Chillers-5,6,7	PCHWP10-O	Primary CHW Pump 10 VFD	IOM 4710	SA Bus	1	11	AO OUT-9		OUT9, OCOM9			0		11-AO OUT-9						2/22	See VFD Detail	VFD Speed Control (Vdc)			
		Chillers-5,6,7			IOM 2721																					Power to Controller
		Chillers-5,6,7			IOM 2721	SA Bus	1	12						0												BacNet SA Bus
	UI IN-1	Chillers-5,6,7	CH6CWE-T	Chiller 6 CW Entering Temper	IOM 2721	SA Bus	1	12	UI IN-1		IN1, ICOM1			0		12-UI IN-1						2/22	2-Wire	TE		F131	
	UI IN-2	Chillers-5,6,7	CH6CWL-T	Chiller 6 CW Leaving Tempera	IOM 2721	SA Bus	1	12	UI IN-2		IN2, ICOM2			0		12-UI IN-2						2/22	2-Wire	TE		F131	
	UI IN-3	Chillers-5,6,7	CH7CHWE-T	Chiller 7 CHW Entering Temp	IOM 2721	SA Bus	1	12	UI IN-3		IN3, ICOM3			0		12-UI IN-3						2/22	2-Wire	TE		F131	
	UI IN-4	Chillers-5,6,7	CH7CHWL-T	Chiller 7 CHW Leaving Tempe	IOM 2721	SA Bus	1	12	UI IN-4		IN4, ICOM4			0		12-UI IN-4						2/22	2-Wire	TE		F131	
	UI IN-5	Chillers-5,6,7	CH7CWE-T	Chiller 7 CW Entering Temper	IOM 2721	SA Bus	1	12	UI IN-5		IN5, ICOM5			0		12-UI IN-5						2/22	2-Wire	TE		F131	
	UI IN-6	Chillers-5,6,7	CH7CWL-T	Chiller 7 CW Leaving Tempera	IOM 2721	SA Bus	1	12	UI IN-6		IN6, ICOM6			0		12-UI IN-6						2/22	2-Wire	TE		F131	
	UI IN-7	Chillers-5,6,7	CH5CHWE-P	Chiller 5 CHW Entering Press	IOM 2721	SA Bus	1	12	UI IN-7		IN7, +15V			0		12-UI IN-7						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-8	Chillers-5,6,7	CH5CHWL-P	Chiller 5 CHW Leaving Press	IOM 2721	SA Bus	1	12	UI IN-8		IN8, +15V			0		12-UI IN-8						2/22	-, +	DPT2xxx (mA)		F106	
	AO OUT-1	Chillers-5,6,7			IOM 2721	SA Bus	1	12	AO OUT-1					0		12-AO OUT-1											
	AO OUT-2	Chillers-5,6,7			IOM 2721	SA Bus	1	12	AO OUT-2					0		12-AO OUT-2											
		Chillers-5,6,7			IOM 2721																					Power to Controller
		Chillers-5,6,7			IOM 2721	SA Bus	1	13						0												BacNet SA Bus
	UI IN-1	Chillers-5,6,7	CH6CHWE-P	Chiller 6 CHW Entering Press	IOM 2721	SA Bus	1	13	UI IN-1		IN1, +15V			0		13-UI IN-1						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Chillers-5,6,7	CH6CHWL-P	Chiller 6 CHW Leaving Press	IOM 2721	SA Bus	1	13	UI IN-2		IN2 +15V			0		13-UI IN-2						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Chillers-5,6,7	CH7CHWE-P	Chiller 7 CHW Entering Press	IOM 2721	SA Bus	1	13	UI IN-3		IN3, +15V			0		13-UI IN-3						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-4	Chillers-5,6,7	CH7CHWL-P	Chiller 7 CHW Leaving Press	IOM 2721	SA Bus	1	13	UI IN-4		IN4, +15V			0		13-UI IN-4						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-5	Chillers-5,6,7	CHW-DP-Wes	CHW Diff Pressure West Tun	IOM 2721	SA Bus	1	13	UI IN-5		IN5, +15V			0		13-UI IN-5						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-6	Chillers-5,6,7	CHW-DP-Main	CHW Diff Pressure Main Can	IOM 2721	SA Bus	1	13	UI IN-6		IN6, +15V			0		13-UI IN-6						2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-7	Chillers-5,6,7	CHW-F-West	CHW Flow West Tunnel	IOM 2721	SA Bus	1	13	UI IN-7		IN7, ICOM7, 24V HOT, 24V COM			0		13-UI IN-7						4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	UI IN-8	Chillers-5,6,7			IOM 2721	SA Bus	1	13	UI IN-8					0		13-UI IN-8											
	AO OUT-1	Chillers-5,6,7			IOM 2721	SA Bus	1	13	AO OUT-1					0		13-AO OUT-1											
	AO OUT-2	Chillers-5,6,7			IOM 2721	SA Bus	1	13	AO OUT-2					0		13-AO OUT-2											

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Drawing Title

CHILLER-5,6,7 POINT SCHEDULE

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

Sales Engineer	Project Manager	Application Engineer	DRAWN	APPROVED
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS DATE 04/26/2018	BY DATE

Project Title

U of H Central Plant BAS Retrofit

Johnson Controls

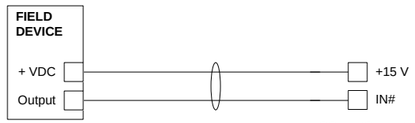
Branch Information
Johnson Conrols, Inc.
10644 West Little York, Suite 200
Houston, Texas 77041
Phone: 713-934-2400
Fax: 713-934-7865

CONTRACT NUMBER **8N83-0217**

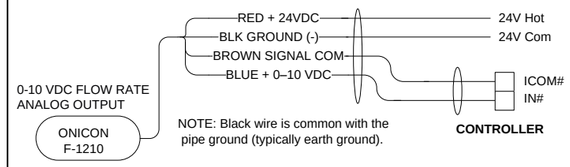
DRAWING NUMBER **A01-07**

CHILLER WIRING DETAILS

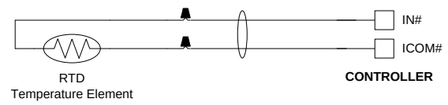
DETAIL F106 — CURRENT INPUT - INTERNAL SOURCE (2 Wire)



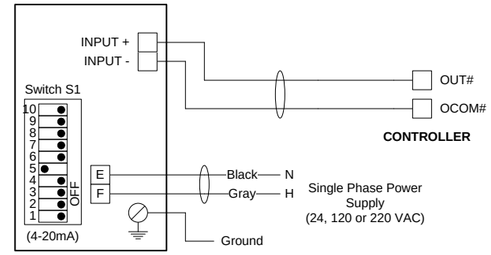
DETAIL F117 — ONICON Model F1x10 Flow Sensor With 0-10 VDC OUTPUT



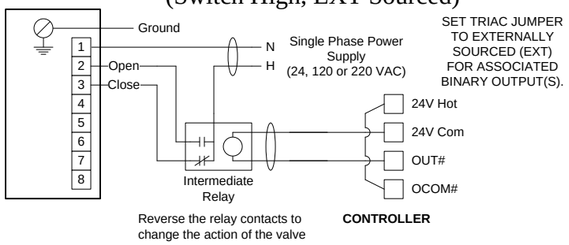
DETAIL F131 — TEMPERATURE SENSOR INPUT



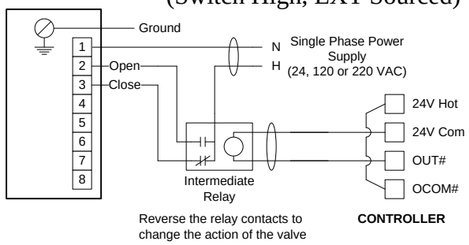
DETAIL F299 — 4-20 mA OUTPUT to VA-9070



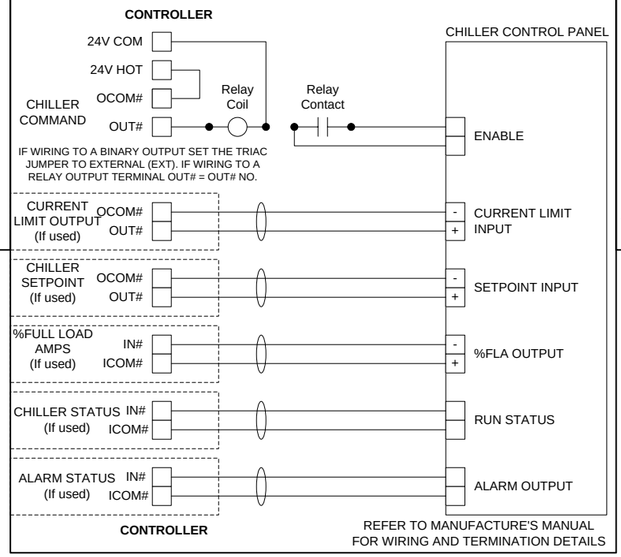
DETAIL F595 — ON-OFF CONTROL to VA-9070 (Switch High, EXT Sourced)



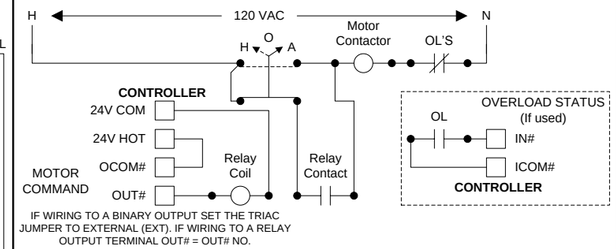
DETAIL F995 — ON-OFF CONTROL to VA-9070 (Switch High, EXT Sourced)



DETAIL F1002 — Chiller Control Wiring Detail



DETAIL F1015 — Starter without Safeties Wiring



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Drawing Title: **CHILLER WIRING DETAILS**

Project Title: **U of H Central Plant BAS Retrofit**

REFERENCE DRAWING	NO.	REVISION-LOCATION	ECN	DATE	BY

Sales Engineer	Project Manager	Application Engineer	DRAWN	APPROVED
R J Wagner Jr	Jacob Hall	Anitha Selvaganeshan	BY AS DATE 04/26/2018	BY DATE

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Fax: 713-934-7865

CONTRACT NUMBER: **8N83-0217**

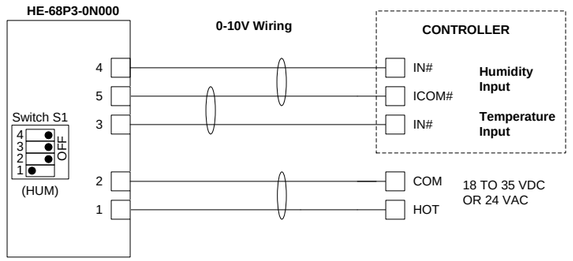
DRAWING NUMBER: **A01-08**

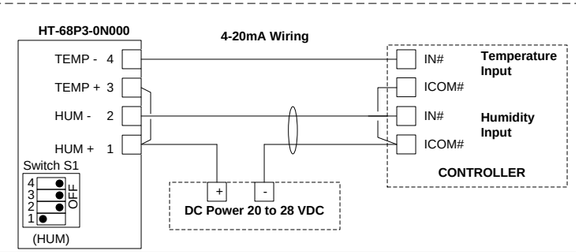
COOLING TOWER POINT SCHEDULE

Electrician/Fitter	Point Information			Controller Information						Panel Information					Intermediate Device				Field Device					
Tag	Point Type	System Name	Object Name	Expanded ID	Controller Details	Trunk Type	Trunk Ntwr	Trunk Addr.	Cable Destination Bay/Terminal	Module Type	Termination Out	Panel	Panel Location	Slot Number	Reference Drawing	Cable Number	Wiring /Tubing	Termination In	Device	Termination Out	Location	Wiring /Tubing	Termination In	Device	Location	Ref Detail Shape	Comment
		Towers			FAC 3611																						Power to Controller
		Towers			FAC 3611	MS/TP	1	4						0													BacNet FC Bus
	UI IN-1	Towers	CW-F	Condenser Water Flow	FAC 3611	MS/TP	1	4 UI IN-1			IN1, ICOM1, 24V HOT, 24V COM			0		4-UI IN-1											
	UI IN-2	Towers	CWS-T	Condenser Water Supply Tem	FAC 3611	MS/TP	1	4 UI IN-2			IN2, ICOM2			0		4-UI IN-2					2/22	2-Wire	TE		F131	
	UI IN-3	Towers	CWR-T	Condenser Water Return Tem	FAC 3611	MS/TP	1	4 UI IN-3			IN3, ICOM3			0		4-UI IN-3					2/22	2-Wire	TE		F131	
	UI IN-4	Towers	OA-T	Outside Air Temperature	FAC 3611	MS/TP	1	4 UI IN-4			IN4, ICOM4			0		4-UI IN-4					2/22	2-Wire	TE		F131	
	UI IN-5	Towers	OA-H	Outside Air Humidity	FAC 3611	MS/TP	1	4 UI IN-5			IN5, ICOM5,24V HOT,24V COM			0		4-UI IN-5					2/22 / 2/18	See wiring detail	HE-68P3-0N000 OA-H (mA)		F159	
	UI IN-6	Towers	CT3VIB-A	Tower 3 Vibration Alarm	FAC 3611	MS/TP	1	4 UI IN-6			IN6, ICOM6			0		4-UI IN-6					2/22	See wiring detail	Dry Contact		F301	
	UI IN-7	Towers			FAC 3611	MS/TP	1	4 UI IN-7			IN7, ICOM7			0		4-UI IN-7					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	UI IN-8	Towers	CT5VIB-A	Tower 5 Vibration Alarm	FAC 3611	MS/TP	1	4 UI IN-8			IN8, ICOM8			0		4-UI IN-8					2/22	See wiring detail	Dry Contact		F301	
	BI IN-9	Towers	CT1VIB-A	Tower 1 Vibration Alarm	FAC 3611	MS/TP	1	4 BI IN-9			IN9, ICOM9			0		4-BI IN-9					2/22	See wiring detail	Dry Contact		F301	
	BI IN-10	Towers	CT1-S	Tower 1 Status	FAC 3611	MS/TP	1	4 BI IN-10			IN10, ICOM10			0		4-BI IN-10	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-11	Towers	CT3-S	Tower 3 Status	FAC 3611	MS/TP	1	4 BI IN-11			IN11, ICOM11			0		4-BI IN-11	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-12	Towers	CT4-S	Tower 4 Status	FAC 3611	MS/TP	1	4 BI IN-12			IN12, ICOM12			0		4-BI IN-12	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-13	Towers	CT1ISOV-S	Tower 1 Isolation Valve Status	FAC 3611	MS/TP	1	4 BI IN-13			IN13, ICOM13			0		4-BI IN-13					2/22	See wiring detail	VA-9070 EndSwitch		F384	
	BI IN-14	Towers	CT2ISOV-S	Tower 2 Isolation Valve Status	FAC 3611	MS/TP	1	4 BI IN-14			IN14, ICOM14			0		4-BI IN-14					2/22	See wiring detail	VA-9070 EndSwitch		F384	
	AO OUT-1	Towers	CT2-O	Tower 2 Output	FAC 3611	MS/TP	1	4 AO OUT-1			OUT1, OCOM1			0		4-AO OUT-1					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-2	Towers	CT3-O	Tower 3 Output	FAC 3611	MS/TP	1	4 AO OUT-2			OUT2, OCOM2			0		4-AO OUT-2					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-3	Towers	CT1-O	Tower 1 Output	FAC 3611	MS/TP	1	4 AO OUT-3			OUT3, OCOM3			0		4-AO OUT-3					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-4	Towers	CT4-O	Tower 4 Output	FAC 3611	MS/TP	1	4 AO OUT-4			OUT4, OCOM4			0		4-AO OUT-4					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-5	Towers	CTBYV1-O	Tower Bypass Valve1 Output	FAC 3611	MS/TP	1	4 AO OUT-5			OUT5, OCOM5			0		4-AO OUT-5					2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
	AO OUT-6	Towers	CT5-O	Tower 5 Output	FAC 3611	MS/TP	1	4 AO OUT-6			OUT6, OCOM6			0		4-AO OUT-6					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	BO OUT-7	Towers			FAC 3611	MS/TP	1	4 BO OUT-7			OUT7, 24V COM			0		4-BO OUT-7										
	BO OUT-8	Towers	CWP1A-C	Condenser Water Pump 1A C	FAC 3611	MS/TP	1	4 BO OUT-8			OUT8, 24V COM			0		4-BO OUT-8	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	BO OUT-9	Towers	CWP1B-C	Condenser Water Pump 1B C	FAC 3611	MS/TP	1	4 BO OUT-9			OUT9, 24V COM			0		4-BO OUT-9	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	BO OUT-10	Towers	CT2ISOV-C	Tower 2 Isolation Valve Comm	FAC 3611	MS/TP	1	4 BO OUT-10			OUT10, 24V COM			0		4-BO OUT-10	2/22	COIL	Relay	COM, NO, NC	3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source	F695		
	BO OUT-11	Towers	CT3ISOV-C	Tower 3 Isolation Valve Comm	FAC 3611	MS/TP	1	4 BO OUT-11			OUT11, 24V COM			0		4-BO OUT-11	2/22	COIL	Relay	COM, NO, NC	3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source	F695		
	BO OUT-12	Towers	CWP2A-C	Condenser Water Pump 2A C	FAC 3611	MS/TP	1	4 BO OUT-12			OUT12, 24V COM			0		4-BO OUT-12	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
		Towers			IOM 3710	SA Bus	1	4						0													Power to Controller
		Towers			IOM 3710	SA Bus	1	4						0													BacNet SA Bus
	UI IN-1	Towers			IOM 3710	SA Bus	1	4 UI IN-1			IN1, ICOM1			0		4-UI IN-1					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	UI IN-2	Towers	CT2VIB-A	Tower 2 Vibration Alarm	IOM 3710	SA Bus	1	4 UI IN-2			IN2, ICOM2			0		4-UI IN-2					2/22	See wiring detail	Dry Contact		F301	
	UI IN-3	Towers	CT2-S	Tower 2 Status	IOM 3710	SA Bus	1	4 UI IN-3			IN3, ICOM3			0		4-UI IN-3	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-4	Towers	CT4VIB-A	Tower 4 Vibration Alarm	IOM 3710	SA Bus	1	4 UI IN-4			IN4, ICOM4			0		4-UI IN-4					2/22	See wiring detail	Dry Contact		F301	
	RO OUT-1	Towers	CT4-C	Tower 4 Command	IOM 3710	SA Bus	1	4 RO OUT-1			OUT1, 24V COM			0		4-RO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	VFD (Tower Vlb) (Sw Hi, EXT)	F1040		
	RO OUT-2	Towers	CWP3B-C	Condenser Water Pump 3B C	IOM 3710	SA Bus	1	4 RO OUT-2			OUT2, 24V COM			0		4-RO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	RO OUT-3	Towers	CT5ISOV-C	Tower 5 Isolation Valve Comm	IOM 3710	SA Bus	1	4 RO OUT-3			OCOM3, OUT3 NC			0		4-RO OUT-3					3/18	3, 2, 1	VA-9070 (On-Off)		F695	
	RO OUT-4	Towers	CWP3A-C	Condenser Water Pump 3A C	IOM 3710	SA Bus	1	4 RO OUT-4			OUT4, 24V COM			0		4-RO OUT-4	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	UO OUT-5	Towers	CT1ISOV-C	Tower 1 Isolation Valve Comm	IOM 3710	SA Bus	1	4 UO OUT-5			OUT5, 24V COM			0		4-UO OUT-5	2/22	COIL-,COIL+	Relay	COM, NO, NC	3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source	F995		
	UO OUT-6	Towers	CT3-C	Tower 3 Command	IOM 3710	SA Bus	1	4 UO OUT-6			OUT6, 24V COM			0		4-UO OUT-6	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	VFD (Tower Vlb) (Sw Hi, EXT)	F1040		
	UO OUT-7	Towers	CT4ISOV-C	Tower 4 Isolation Valve Comm	IOM 3710	SA Bus	1	4 UO OUT-7			OUT7, 24V COM			0		4-UO OUT-7	2/22	COIL	Relay	COM, NO, NC	3/18	3, 2, 1	VA-9070 (On-Off) (Sw Hi, EXT Source	F995		
	UO OUT-8	Towers	CT5-C	Tower 5 Command	IOM 3710	SA Bus	1	4 UO OUT-8			OUT8, 24V COM			0		4-UO OUT-8	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	VFD (Tower Vlb) (Sw Hi, EXT)	F1040		
		Towers			IOM 3710																						Power to Controller
		Towers			IOM 3710	SA Bus	1	5						0													BacNet SA Bus
	UI IN-1	Towers	CT5-S	Tower 5 Status	IOM 3710	SA Bus	1	5 UI IN-1			IN1, ICOM1			0		5-UI IN-1	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-2	Towers	CT4ISOV-S	Tower 4 Isolation Valve Status	IOM 3710	SA Bus	1	5 UI IN-2			IN2, ICOM2			0		5-UI IN-2					2/22	See wiring detail	VA-9070 EndSwitch		F384	
	UI IN-3	Towers	CT5ISOV-S	Tower 5 Isolation Valve Status	IOM 3710	SA Bus	1	5 UI IN-3			IN3, ICOM3			0		5-UI IN-3					2/22	See wiring detail	VA-9070 EndSwitch		F384	
	UI IN-4	Towers	CT3ISOV-S	Tower 3 Isolation Valve Status	IOM 3710	SA Bus	1	5 UI IN-4			IN4, ICOM4			0		5-UI IN-4					2/22	See wiring detail	VA-9070 EndSwitch		F384	
	RO OUT-1	Towers	CWP3B-C	Condenser Water Pump 3B C	IOM 3710	SA Bus	1	5 RO OUT-1			OUT1, 24V COM			0		5-RO OUT-1	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	RO OUT-2	Towers	CWP4A-C	Condenser Water Pump 4A C	IOM 3710	SA Bus	1	5 RO OUT-2			OUT2, 24V COM			0		5-RO OUT-2	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	RO OUT-3	Towers	CT2-C	Tower 2 Command	IOM 3710	SA Bus	1	5 RO OUT-3			OUT3, 24V COM			0		5-RO OUT-3	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	VFD (Tower Vlb) (Sw Hi, EXT)	F1040		
	RO OUT-4	Towers	CT1-C	Tower 1 Command	IOM 3710	SA Bus	1	5 RO OUT-4			OUT4, 24V COM			0		5-RO OUT-4	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	VFD (Tower Vlb) (Sw Hi, EXT)	F1040		
	UO OUT-5	Towers	CWP4B-C	Condenser Water Pump 4B C	IOM 3710	SA Bus	1	5 UO OUT-5			OUT5, 24V COM			0		5-UO OUT-5	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	UO OUT-6	Towers	CWP5A-C	Condenser Water Pump 5A C	IOM 3710	SA Bus	1	5 UO OUT-6			OUT6, 24V COM			0		5-UO OUT-6	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	UO OUT-7	Towers	CWP5B-C	Condenser Water Pump 5B C	IOM 3710	SA Bus	1	5 UO OUT-7			OUT7, 24V COM			0		5-UO OUT-7	2/22	COIL-,COIL+	Relay	COM, NO	2/14	See wiring detail	Starter (w/o Safeties) (Sw Hi, EXT)	F1015		
	UO OUT-8	Towers	CTBYV2-O	Tower Bypass Valve2 Output	IOM 3710	SA Bus	1	5 UO OUT-8			OUT8, OCOM8			0		5-UO OUT-8					2/22 / 2/18	1, 3, 10, 9	VA-9070 (mA)		F299	
		Towers			IOM 4710																						Power to Controller
		Towers			IOM 4710	SA Bus	1	6						0													BacNet SA Bus
	UI IN-1	Towers	CWP1-S	CW Pump 1 Status	IOM 4710	SA Bus	1	6 UI IN-1			IN1, ICOM1			0		6-UI IN-1	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-2	Towers	CWP2-S	CW Pump 2 Status	IOM 4710	SA Bus	1	6 UI IN-2			IN2, ICOM2			0		6-UI IN-2	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-3	Towers	CWP3-S	CW Pump 3 Status	IOM 4710	SA Bus	1	6 UI IN-3			IN3, ICOM3			0		6-UI IN-3	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-4	Towers	CWP4-S	CW Pump 4 Status	IOM 4710	SA Bus	1	6 UI IN-4			IN4, ICOM4			0		6-UI IN-4	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-5	Towers	CWP5-S	CW Pump 5 Status	IOM 4710	SA Bus	1	6 UI IN-5			IN5, ICOM5			0		6-UI IN-5	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	UI IN-6	Towers	CWP6-S	CW Pump 6 Status	IOM 4710	SA Bus	1	6 UI IN-6			IN6, ICOM6			0		6-UI IN-6	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-7	Towers	CWP7-S	CW Pump 7 Status	IOM 4710	SA Bus	1	6 BI IN-7			IN7, ICOM7			0		6-BI IN-7	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-8	Towers	CWP8-S	CW Pump 8 Status	IOM 4710	SA Bus	1	6 BI IN-8			IN8, ICOM8			0		6-BI IN-8	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BO OUT-1	Towers			IOM 4710	SA Bus	1	6 BO OUT-1			OUT1, 24V COM			0		6-BO OUT-1										
	BO OUT-2	Towers			IOM 4710	SA Bus	1	6 BO OUT-2			OUT2, 24V COM			0		6-BO OUT-2										
	BO OUT-3	Towers			IOM 4710	SA Bus	1	6 BO OUT-3			OUT3, 24V COM			0		6-BO OUT-3										
	CO OUT-4	Towers			IOM 4710	SA Bus	1	6 CO OUT-4			OUT4, 24V COM			0		6-CO OUT-4										
	CO OUT-5	Towers	CT1MUV-O	Tower1 Make Up Valve Output	IOM 4710	SA Bus	1	6 CO OUT-5			OUT5, OCOM 5			0		6-CO OUT-5					2/22 / 2/18	1, 3, 10, 9	Tower Basin Panel VA-9070 (mA)		F299	
	CO OUT-6	Towers	CT2MUV-O	Tower2 Make Up Valve Output	IOM 4710	SA Bus	1	6 CO OUT-6			OUT6, OCOM 6			0		6-CO OUT-6					2/22 / 2/18	1, 3, 10, 9	Tower Basin Panel VA-9070 (mA)		F299	
	CO OUT-7	Towers	CT3MUV-O	Tower3 Make Up Valve Output	IOM 4710	SA Bus	1	6 CO OUT-7			OUT7, OCOM 7			0		6-CO OUT-7					2/22 / 2/18	1, 3, 10, 9	Tower Basin Panel VA-9070 (mA)		F299	
	AO OUT-8	Towers	CT4MUV-O	Tower4 Make Up Valve Output	IOM 4710	SA Bus	1	6 AO OUT-8			OUT8, OCOM8			0		6-AO OUT-8					2/22 / 2/18	1, 3, 10, 9	Tower Basin Panel VA-9070 (mA)		F299	
	AO OUT-9	Towers	CT5MUV-O	Tower5 Make Up Valve Output	IOM 4710	SA Bus	1	6 AO OUT-9			OUT9, OCOM9			0		6-AO OUT-9					2/22 / 2/18	1, 3, 10, 9	Tower Basin Panel VA-9070 (mA)		F299	
		Towers			IOM 4710																						Power to Controller
		Towers			IOM 4710	SA Bus	1	7						0													BacNet SA Bus
	UI IN-1	Towers	CH1CWE-P	Chiller 1 CW Entering Pressu	IOM 4710	SA Bus	1	7 UI IN-1			IN1, +15V			0		7-UI IN-1					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Towers	CH1CWL-P	Chiller 1 CW Leaving Pressu	IOM 4710	SA Bus	1	7 UI IN-2			IN2 +15V			0		7-UI IN-2					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Towers	CH2CWE-P	Chiller 2 CW Entering Pressu	IOM 4710	SA Bus	1	7 UI IN-3			IN3, +15V			0		7-UI IN-3					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-4	Towers	CH2CWL-P	Chiller 2 CW Leaving Pressu	IOM 4710	SA Bus	1	7 UI IN-4			IN4, +15V			0		7-UI IN-4					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-5	Towers	CH3CWE-P	Chiller 3 CW Entering Pressu	IOM 4710	SA Bus	1	7 UI IN-5			IN5, +15V			0		7-UI IN-5					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-6	Towers	CH3CWL-P	Chiller 3 CW Leaving Pressu	IOM 4710	SA Bus	1	7 UI IN-6			IN6, +15V			0		7-UI IN-6					2/22	-, +	DPT2xxx (mA)		F106	
	BI IN-7	Towers			IOM 4710	SA Bus	1	7 BI IN-7			IN7, ICOM7			0		7-BI IN-7	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BI IN-8	Towers			IOM 4710	SA Bus	1	7 BI IN-8			IN8, ICOM8			0		7-BI IN-8	2/22	OUT, COM	Current Relay	Motor Lead	Motor Lead	See wiring detail	Motor Status (Contact)		F301	
	BO OUT-1	Towers			IOM 4710	SA Bus	1	7 BO OUT-1			OUT1, 24V COM			0		7-BO OUT-1										
	BO OUT-2	Towers			IOM 4710	SA Bus	1	7 BO OUT-2			OUT2, 24V COM			0		7-BO OUT-2										
	BO OUT-3	Towers			IOM 4710	SA Bus	1	7 BO OUT-3			OUT3, 24V COM			0		7-BO OUT-3										
	CO OUT-4	Towers			IOM 4710	SA Bus	1	7 CO OUT-4			OUT4, 24V COM			0		7-CO OUT-4										
	CO OUT-5	Towers	CWP1A-O	Condenser water Pump 1A VF	IOM 4710	SA Bus	1	7 CO OUT-5			OUT5, OCOM 5			0		7-CO OUT-5					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	CO OUT-6	Towers	CWP2A-O	Condenser water Pump 2A VF	IOM 4710	SA Bus	1	7 CO OUT-6			OUT6, OCOM 6			0		7-CO OUT-6					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	CO OUT-7	Towers	CWP3A-O	Condenser water Pump 3A VF	IOM 4710	SA Bus	1	7 CO OUT-7			OUT7, OCOM 7			0		7-CO OUT-7					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-8	Towers	CWP4A-O	Condenser water Pump 4A VF	IOM 4710	SA Bus	1	7 AO OUT-8			OUT8, OCOM8			0		7-AO OUT-8					2/22	See VFD Detail	VFD Speed Control (Vdc)			
	AO OUT-9	Towers	CWP5A-O	Condenser water Pump 5A VF	IOM 4710	SA Bus	1	7 AO OUT-9			OUT9, OCOM9			0		7-AO OUT-9					2/22	See VFD Detail	VFD Speed Control (Vdc)			
		Towers			IOM 2721																						Power to Controller
		Towers			IOM 2721	SA Bus	1	8						0													BacNet SA Bus
	UI IN-1	Towers	CH4CWE-P	Chiller 4 CW Entering Pressu	IOM 2721	SA Bus	1	8 UI IN-1			IN1, +15V			0		8-UI IN-1					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Towers	CH4CWL-P	Chiller 4 CW Leaving Pressu	IOM 2721	SA Bus	1	8 UI IN-2			IN2 +15V			0		8-UI IN-2					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Towers	CH5CWE-P	Chiller 5 CW Entering Pressu	IOM 2721	SA Bus	1	8 UI IN-3			IN3, +15V			0		8-UI IN-3					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-4	Towers	CH5CWL-P	Chiller 5 CW Leaving Pressu	IOM 2721	SA Bus	1	8 UI IN-4			IN4, +15V			0		8-UI IN-4					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-5	Towers	CH6CWE-P	Chiller 6 CW Entering Pressu	IOM 2721	SA Bus	1	8 UI IN-5			IN5, +15V			0		8-UI IN-5					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-6	Towers	CH6CWL-P	Chiller 6 CW Leaving Pressu	IOM 2721	SA Bus	1	8 UI IN-6			IN6, +15V			0		8-UI IN-6					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-7	Towers	CH7CWE-P	Chiller 7 CW Entering Pressu	IOM 2721	SA Bus	1	8 UI IN-7			IN7, +15V			0		8-UI IN-7					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-8	Towers	CH7CWL-P	Chiller 7 CW Leaving Pressu	IOM 2721	SA Bus	1	8 UI IN-8			IN8, +15V			0		8-UI IN-8					2/22	-, +	DPT2xxx (mA)		F106	
	AO OUT-1	Towers			IOM 2721	SA Bus	1	8 AO OUT-1						0		8-AO OUT-1										
	AO OUT-2	Towers			IOM 2721	SA Bus	1	8 AO OUT-2						0		8-AO OUT-2										
		Towers			IOM 2721																						Power to Controller
		Towers			IOM 2721	SA Bus	1	9						0													BacNet SA Bus
	UI IN-1	Towers	CH8CWE-P	Chiller 8 CW Entering Pressu	IOM 2721	SA Bus	1	9 UI IN-1			IN1, +15V			0		9-UI IN-1					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-2	Towers	CH8CWL-P	Chiller 8 CW Leaving Pressu	IOM 2721	SA Bus	1	9 UI IN-2			IN2, +15V			0		9-UI IN-2					2/22	-, +	DPT2xxx (mA)		F106	
	UI IN-3	Towers	BASIN 1-L	Basin 1 Level	IOM 2721	SA Bus	1	9 UI IN-3			IN3, ICOM3,24V HOT, 24V COM			0		9-UI IN-3										
	UI IN-4	Towers	BASIN 2-L	Basin 2 Level	IOM 2721	SA Bus	1	9 UI IN-4			IN4, ICOM4,24V HOT, 24V COM			0		9-UI IN-4										
	UI IN-5	Towers	BASIN 3-L	Basin 3 Level	IOM 2721	SA Bus	1	9 UI IN-5			IN5, ICOM5,24V HOT, 24V COM			0		9-UI IN-5										
	UI IN-6	Towers	BASIN 4-L	Basin 4 Level	IOM 2721	SA Bus	1	9 UI IN-6			IN6, ICOM6,24V HOT, 24V COM			0		9-UI IN-6										
	UI IN-7	Towers	BASIN 5-L	Basin 5 Level	IOM 2721	SA Bus	1	9 UI IN-7			IN7, ICOM7,24V HOT, 24V COM			0		9-UI IN-7										
	UI IN-8	Towers	MUW-F	Makeup Water Flow	IOM 2721	SA Bus	1	9 UI IN-8			IN8, ICOM8, 24V HOT, 24V COM			0		9-UI IN-8					4/22	BLU, BRN, RED, BLK	Flow Meter F-1x10 (mA)		F117	
	AO OUT-1	Towers			IOM 2721	SA Bus	1	9 AO OUT-1						0		9-AO OUT-1										
	AO OUT-2	Towers			IOM 2721	SA Bus	1	9 AO OUT-2						0		9-AO OUT-2										
		Towers			IOM 2721																						Power to Controller
		Towers			IOM 2721	SA Bus	1	10						0													BacNet SA Bus
	BI IN-1	Towers	SUMP1 LVL-A	Sump1 Level Alarm	IOM 3721	SA Bus	1	10 BI IN-1			IN1, ICOM1			0		10-BI IN-1					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	BI IN-2	Towers	SUMP1 HI/LO-	Sump1 High/Low level Alarm	IOM 3721	SA Bus	1	10 BI IN-2			IN2, ICOM2			0		10-BI IN-2					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	BI IN-3	Towers	SUMP2 LVL-A	Sump2 Level Alarm	IOM 3721	SA Bus	1	10 BI IN-3			IN3, ICOM3			0		10-BI IN-3					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	BI IN-4	Towers	SUMP2 HI/LO-	Sump2 High/Low level Alarm	IOM 3721	SA Bus	1	10 BI IN-4			IN4, ICOM4			0		10-BI IN-4					2/22	See Basin Panel Detail	Tower Basin Panel (NO or NC)		F1003	
	BI IN-5	Towers	SUMP3 LVL-A	Sump3 Level Alarm	IOM 3721	SA Bus	1

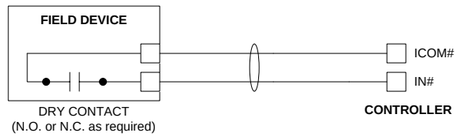
COOLING TOWER WIRING DETAILS

DETAIL F159 — HE-68P3-0N000/HT-68P3-0N000 Outdoor Humidity Sensor

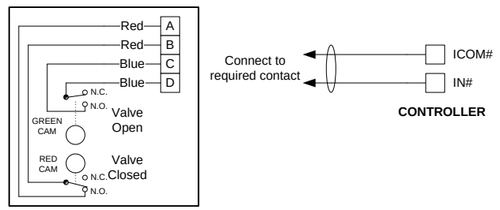




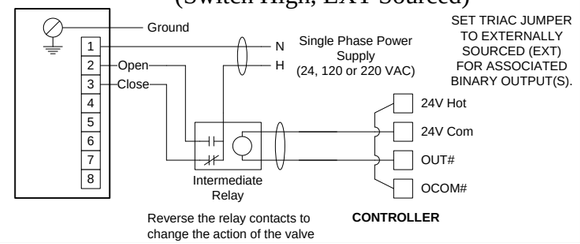
DETAIL F301 — BINARY INPUT (DRY CONTACT)



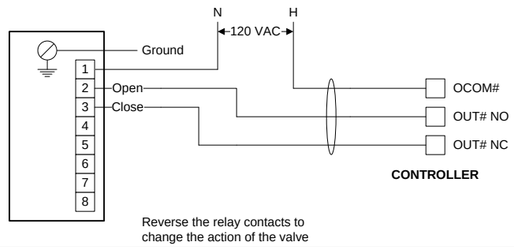
DETAIL F384 — BINARY INPUT from VA-9070



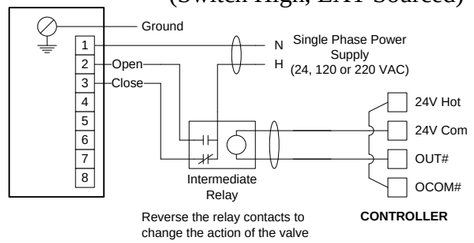
DETAIL F595 — ON-OFF CONTROL to VA-9070 (Switch High, EXT Sourced)



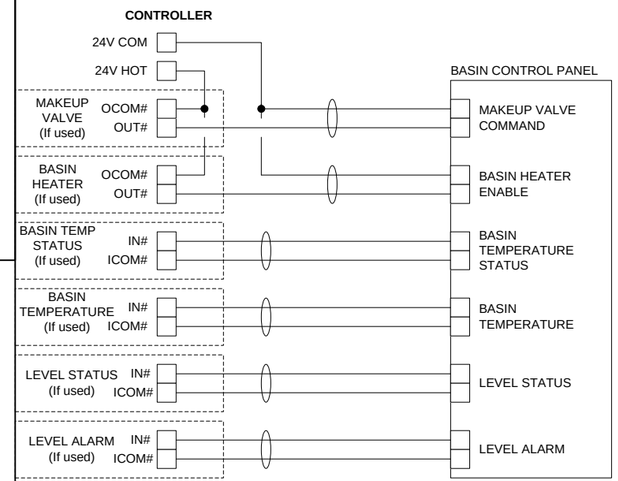
DETAIL F695 — ON-OFF CONTROL to VA-9070



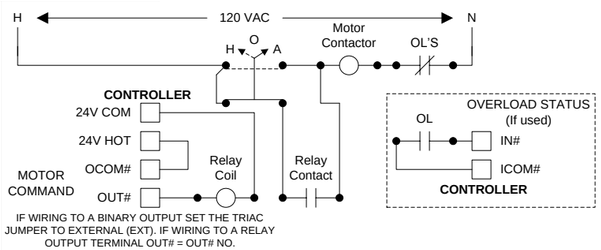
DETAIL F995 — ON-OFF CONTROL to VA-9070 (Switch High, EXT Sourced)



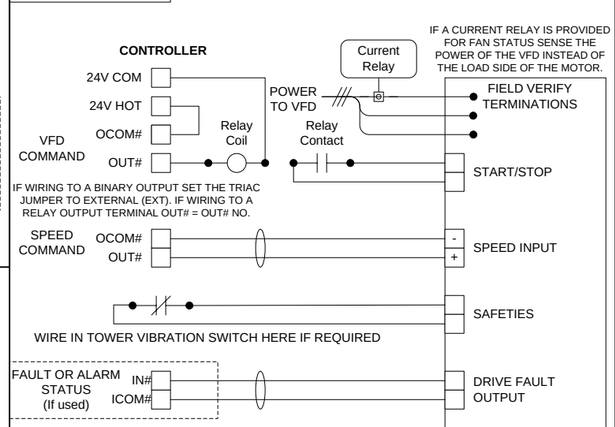
DETAIL F1003 — Tower Basin Wiring Detail



DETAIL F1015 — Starter without Safeties Wiring



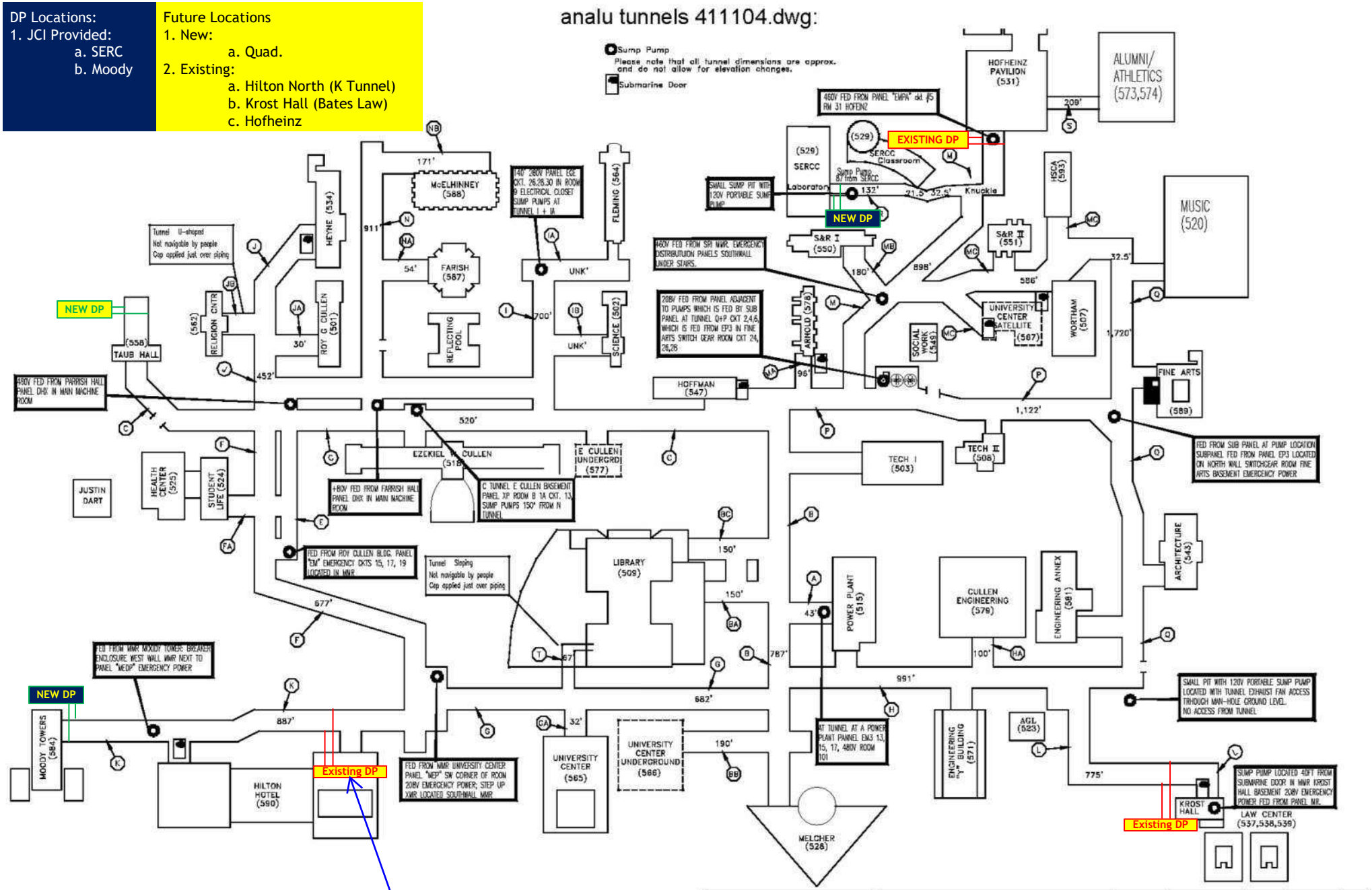
DETAIL F1040 — VFD with Tower Vibration



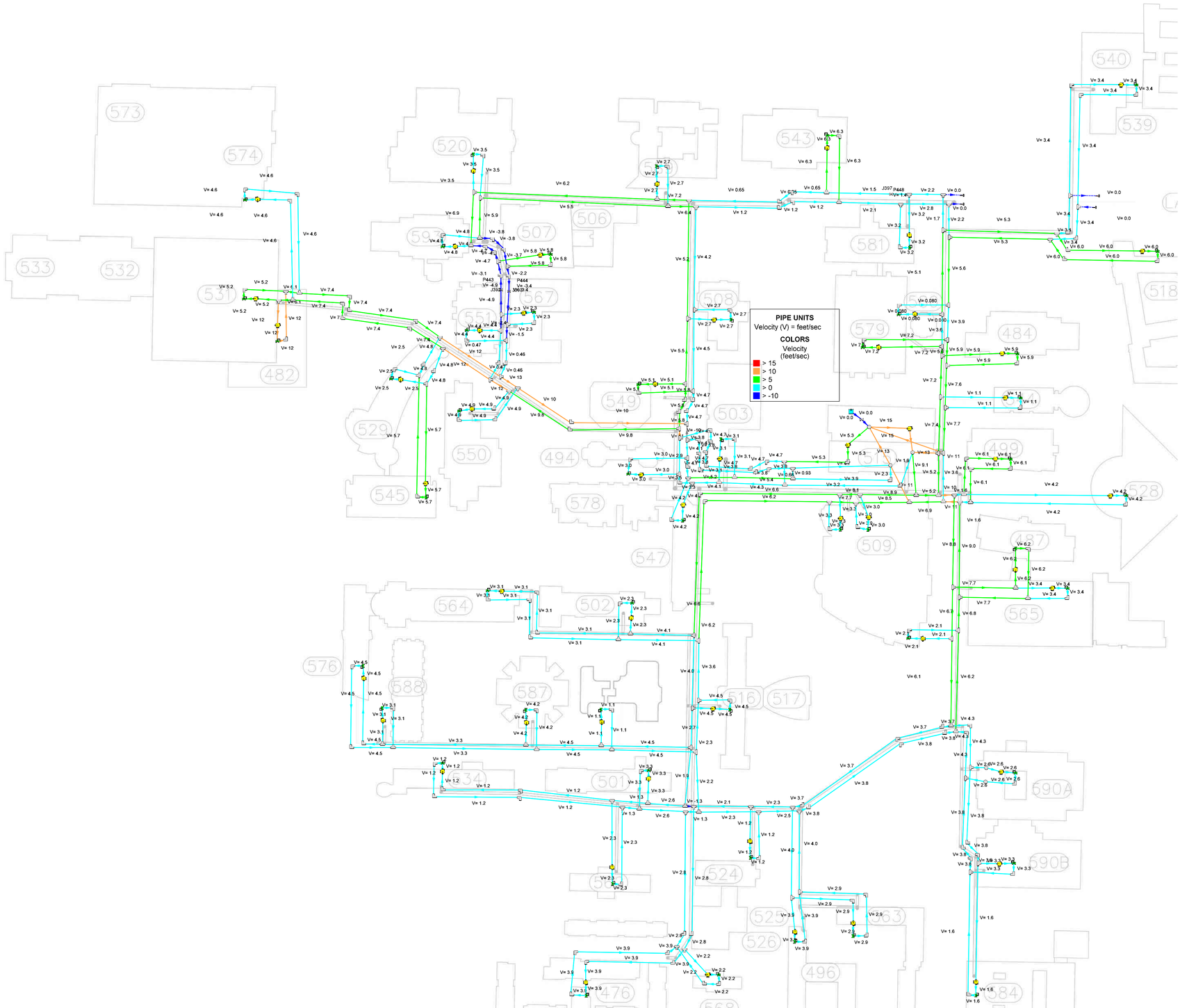
Drawing Title: COOLING TOWER WIRING DETAILS						
REFERENCE DRAWING	NO.	REVISION-LOCATION		ECN	DATE	BY
Sales Engineer: R J Wagner Jr	Project Manager: Jacob Hall	Application Engineer: Anitha Selvaganeshan	DRAWN: BY AS DATE 04/26/2018		APPROVED: BY	DATE
Project Title: U of H Central Plant BAS Retrofit	Johnson Controls	Branch Information: Johnson Conrols, Inc. 10644 West Little York, Suite 200 Houston, Texas 77041 Phone: 713-934-2400 Fax: 713-934-7865		CONTRACT NUMBER: 8N83-0217		
				DRAWING NUMBER: A01-10		

DP Locations:
1. JCI Provided:
   a. SERC
   b. Moody

Future Locations
1. New:
   a. Quad.
2. Existing:
   a. Hilton North (K Tunnel)
   b. Krost Hall (Bates Law)
   c. Hofheinz



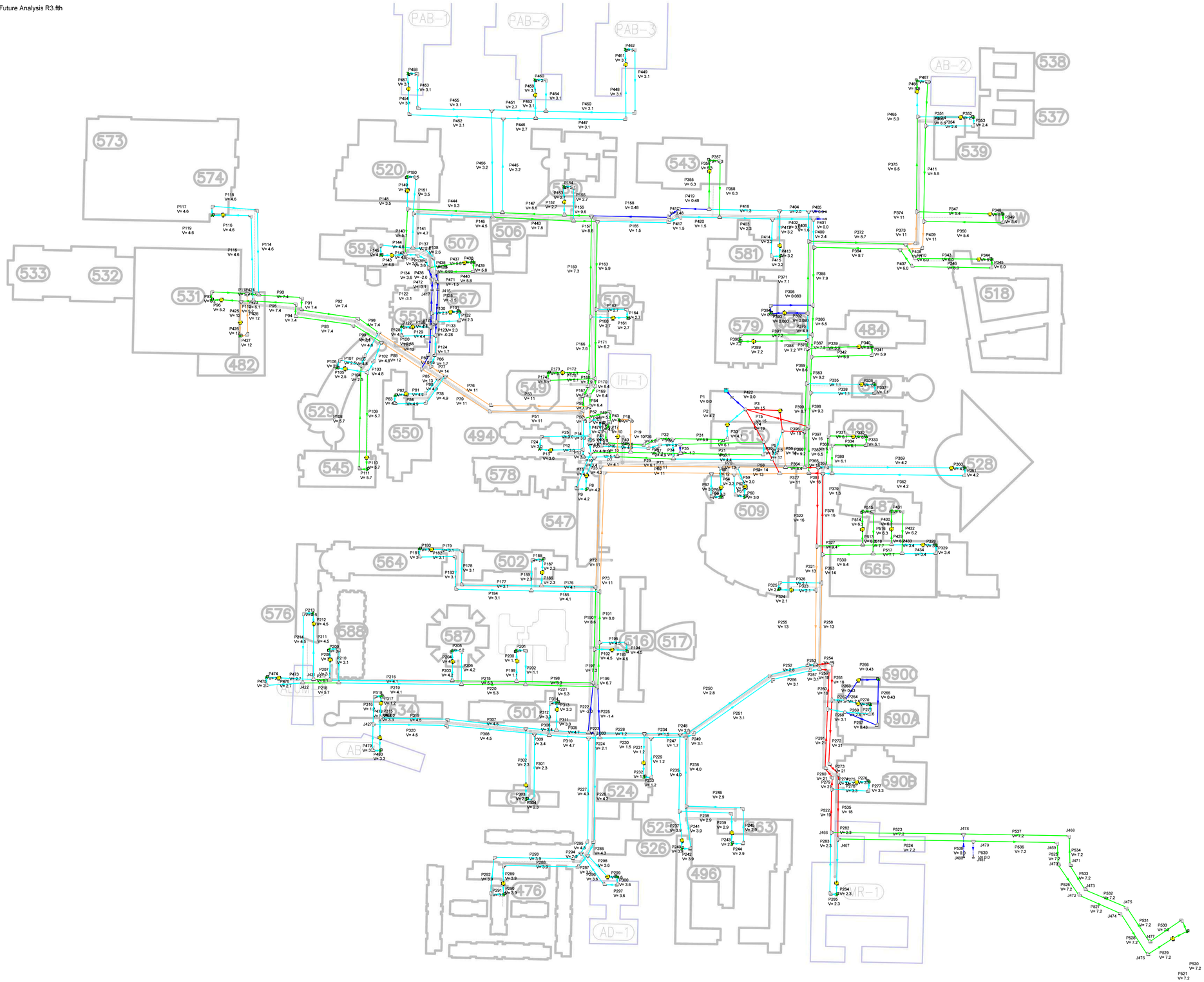
Appendix F
Piping Model Outputs



AFT Fathom Model

Baseline 2022 - Existing Campus Loads

PIPE UNITS
COLORS
Velocity (feet/sec)
> 15
> 10
> 5
> 1
> -15



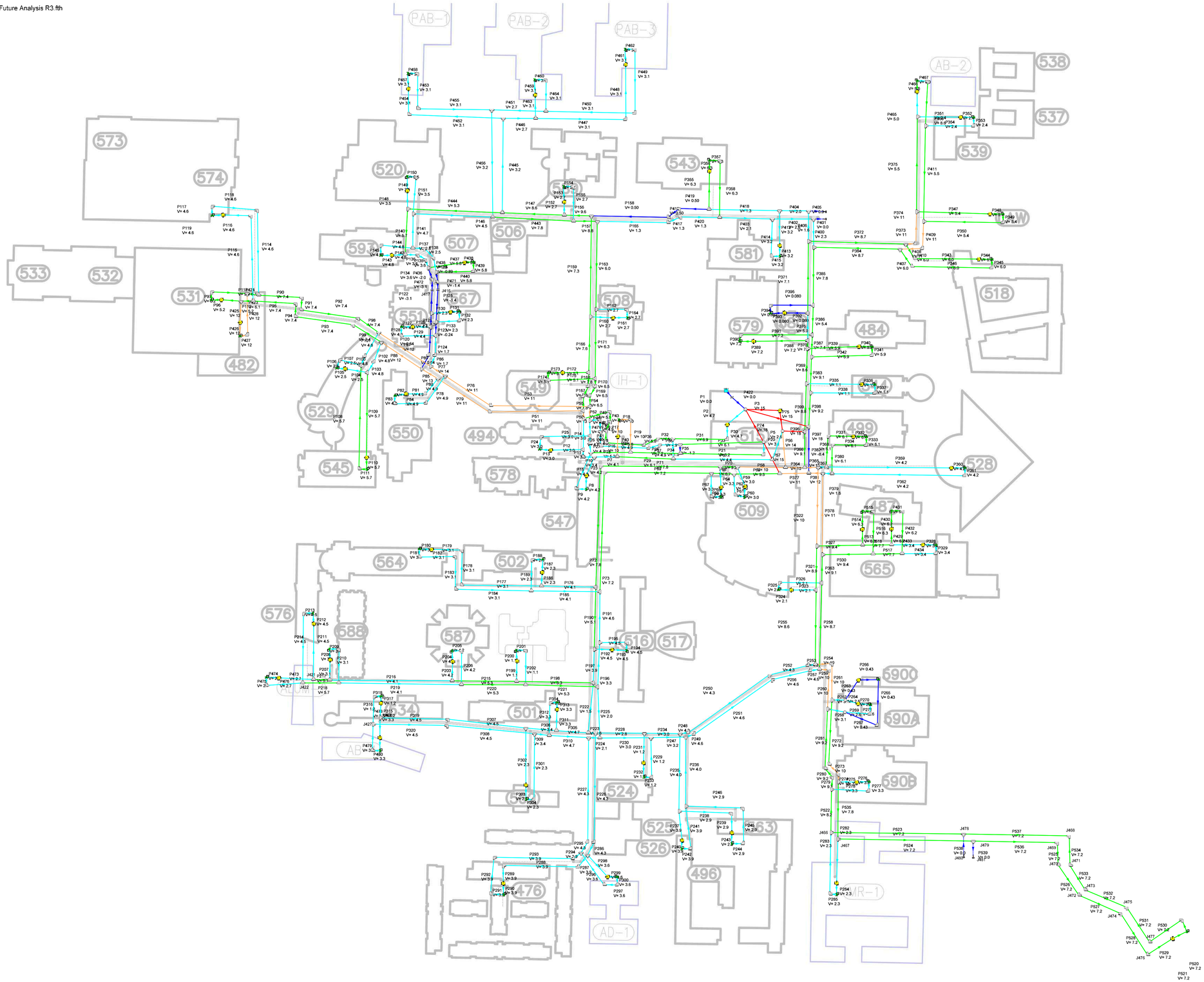
AFT Fathom Model

2040 Campus Option 0 - No Piping Upgrades

AFT Fathom Model
C:\local projects\Univ of Houston\piping models\Chilled Water Piping - Future Analysis R3.fth
Base Scenario/2040 base analysis/Option 0 - Expand CUP

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
- > 15
- > 10
- > 5
- > 1
- > -15



AFT Fathom Model
C:\local projects\Univ of Houston\piping models\Chilled Water Piping - Future Analysis R3.fth
Base Scenario/2040 base analysis/Option 0 - Expand CUP/Athletic Branch Pipe Change

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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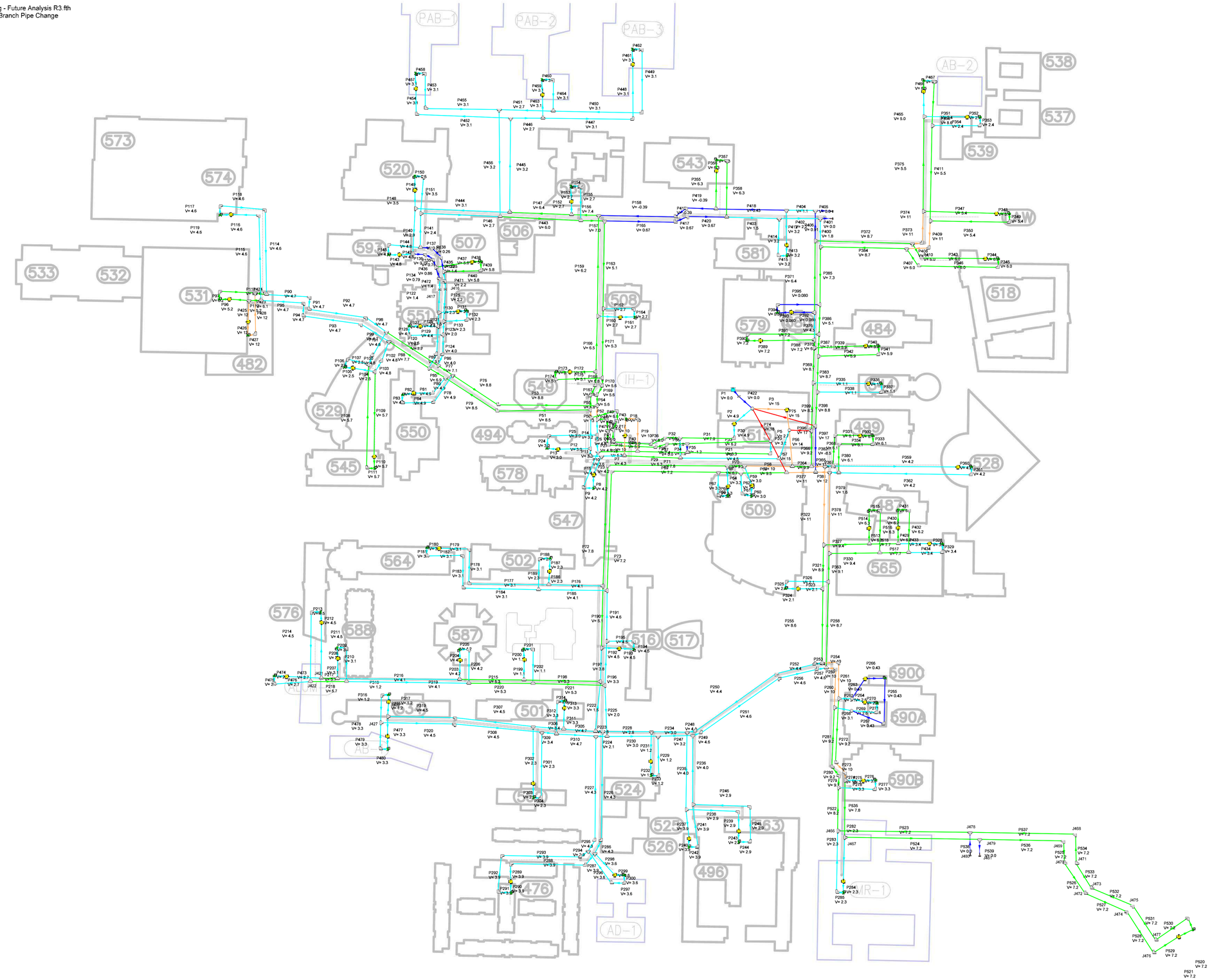
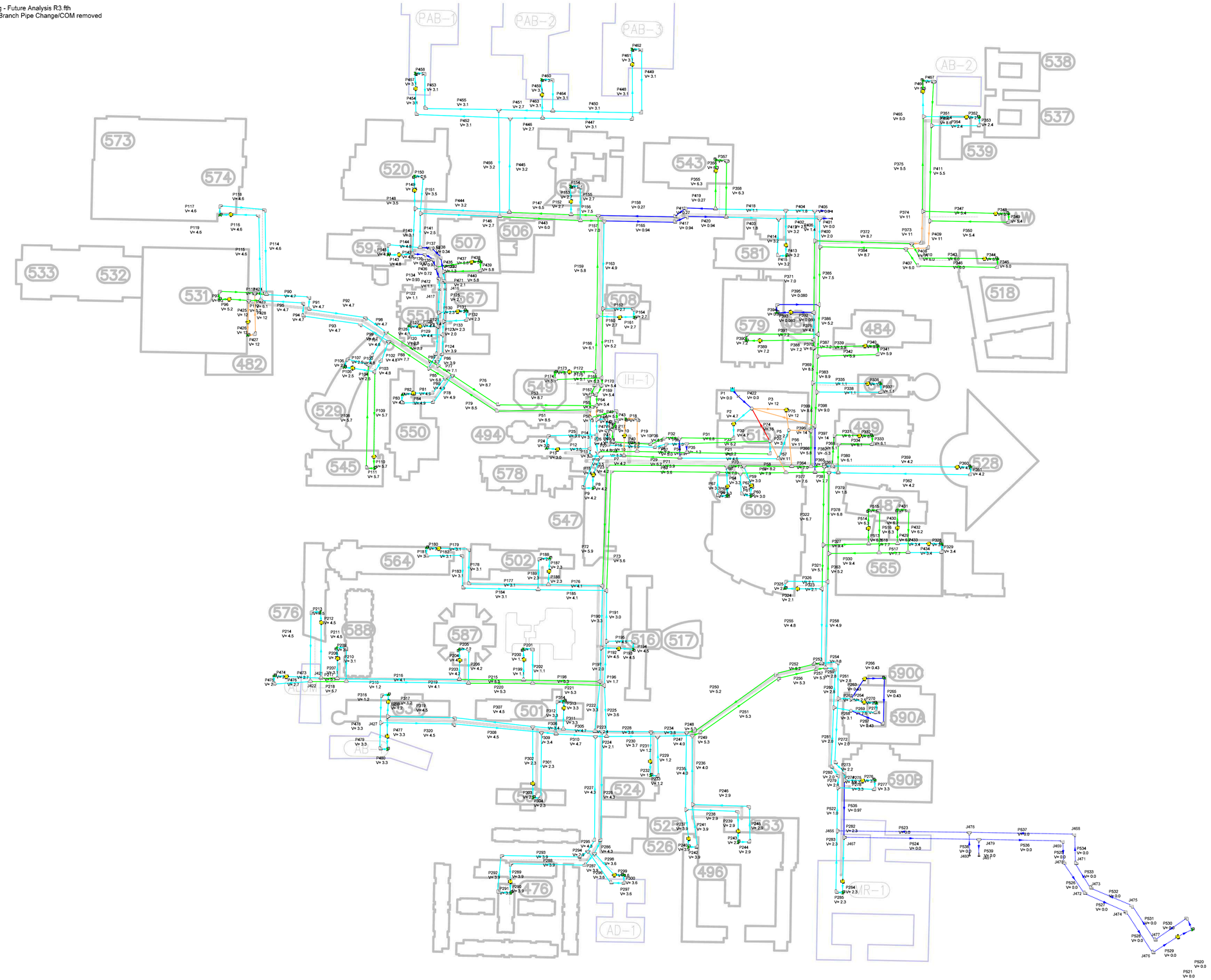
- > 10
- > 5
- > 1
- > -15



AFT Fathom Model
C:\local projects\Univ of Houston\piping models\Chilled Water Piping - Future Analysis R3.fth
Base Scenario/2040 base analysis/Option 0 - Expand CUP/Athletic Branch Pipe Change/COM removed

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
- > 15
- > 10
- > 5
- > 1
- > -15



PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)

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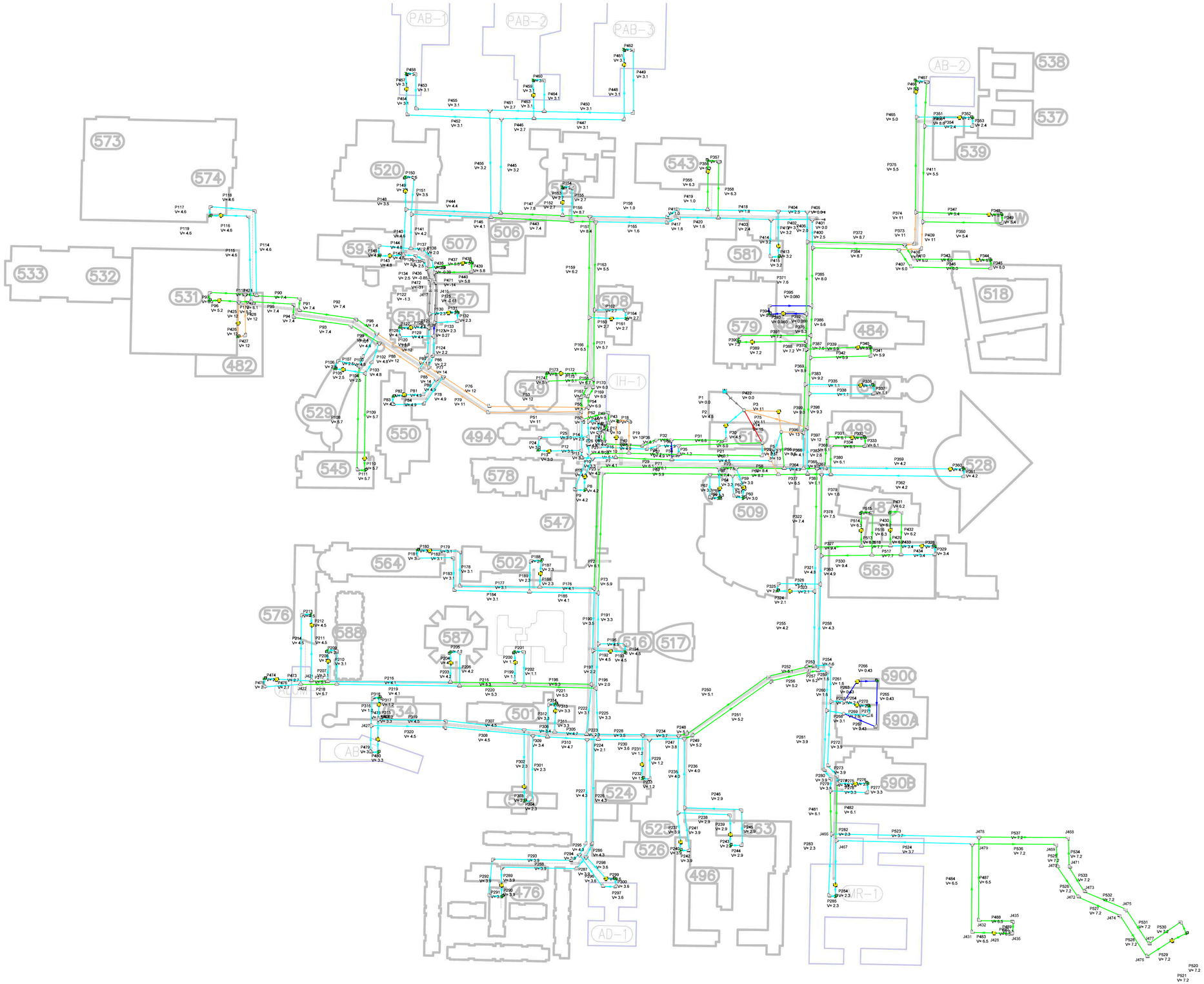
- > 10
- > 5
- > 1
- > 0



PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)

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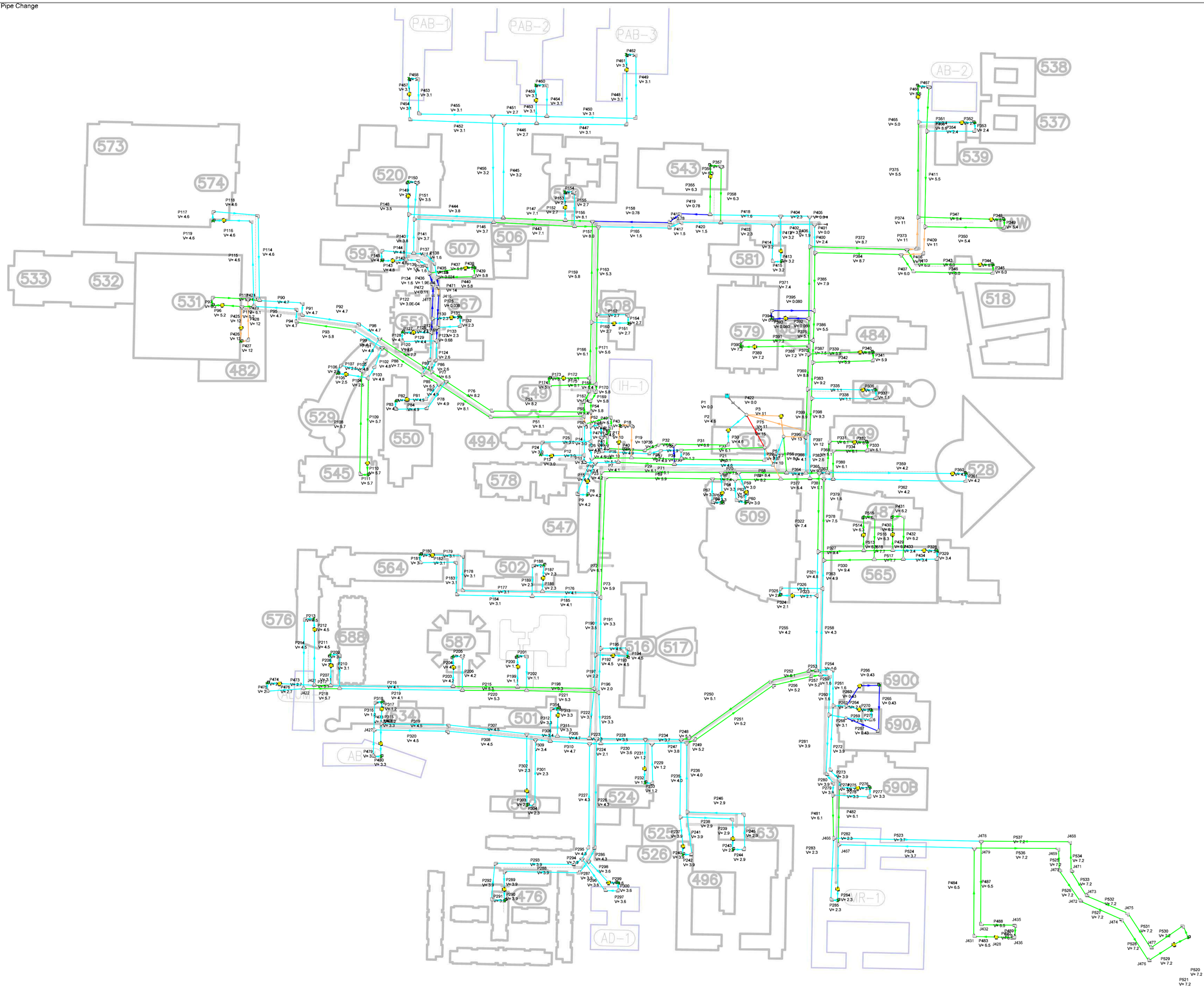
- > 10
- > 5
- > 1
- > 0



Base Scenario/2040 base analysis/Option 1 - SE Plant/Athletic Branch Pipe Change/COM removed

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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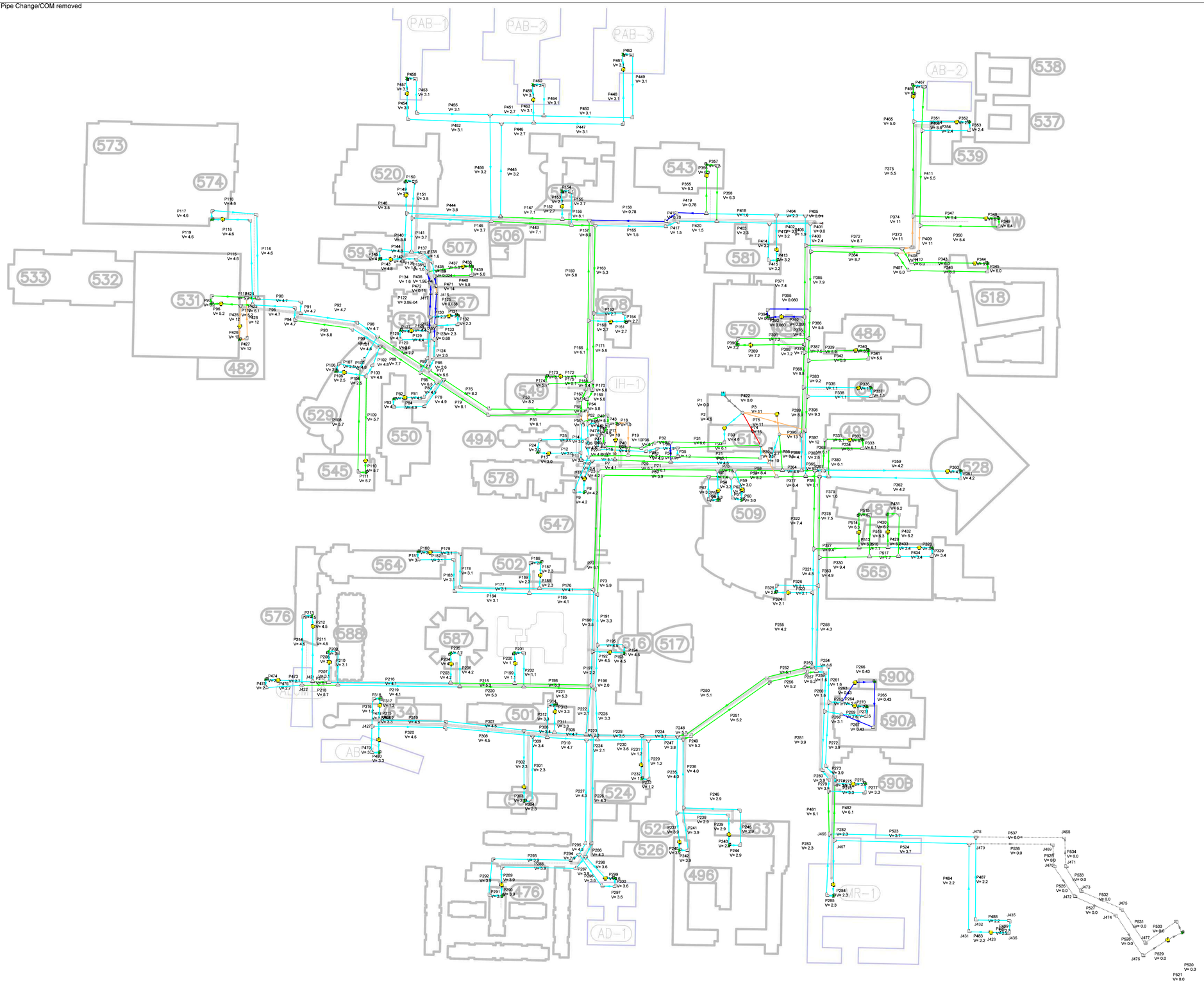
- > 10
- > 5
- > 1
- > 0



AFT Fathom 11 (Visual Report) 8/2/2022 Page 1 of 1	AFT Fathom Model 2040 Campus Option 1 - Athletics Piping Upgrade no COM	

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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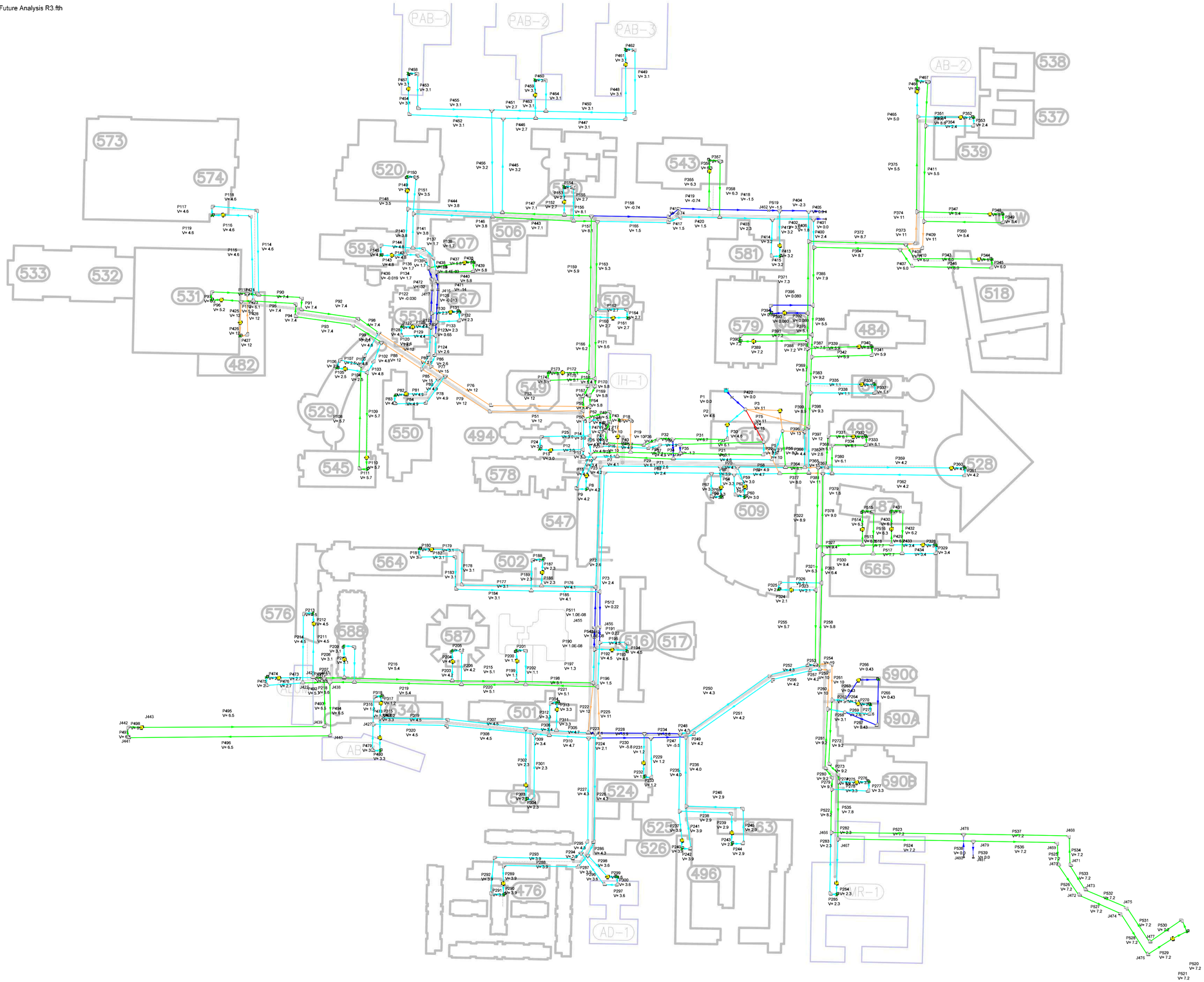
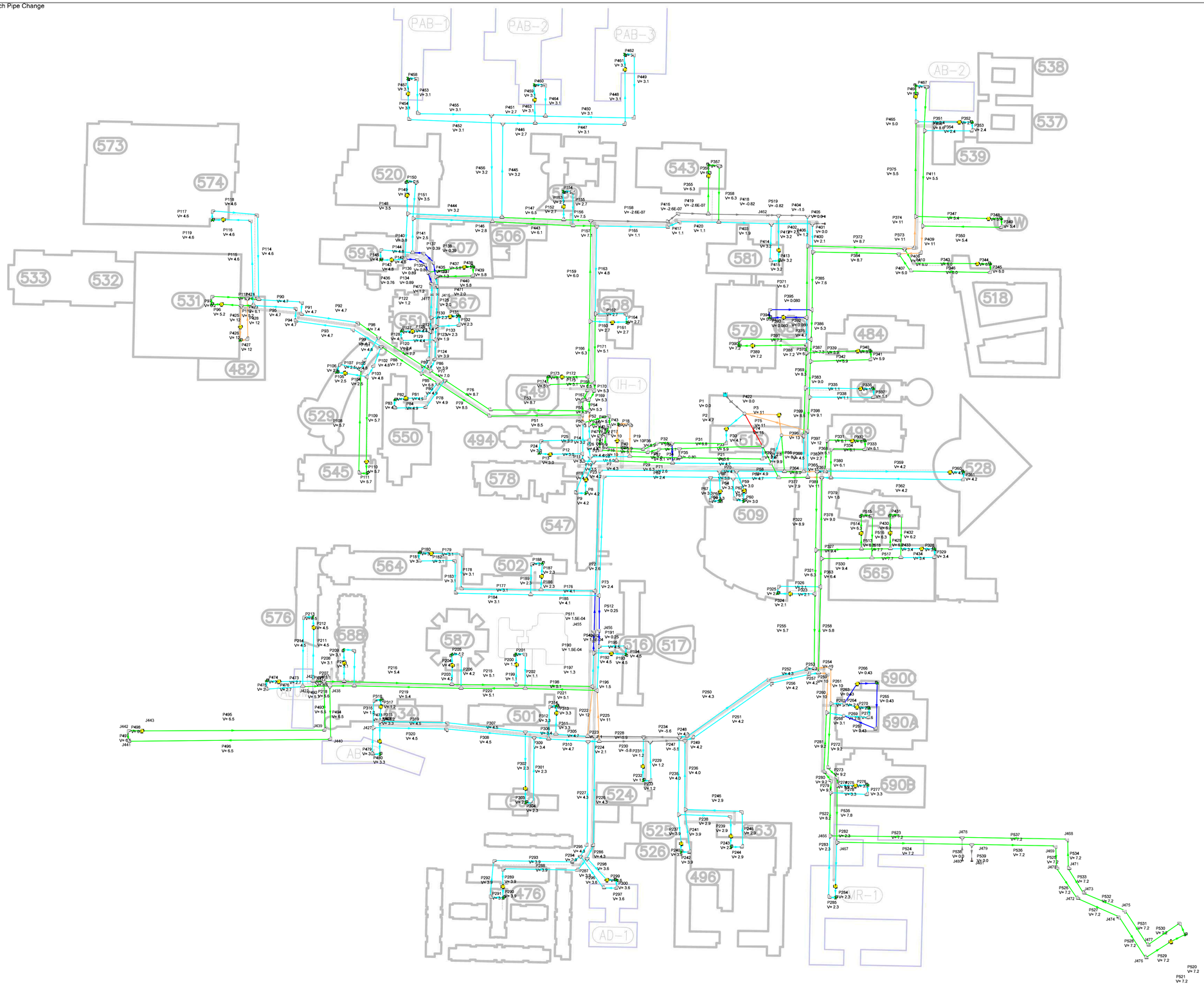
- > 10
- > 5
- > 1
- > -15



PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)

- > 15
- > 10
- > 5
- > 1
- > 0



AFT Fathom Model

2040 Campus Option 2 - Piping Upgrades with COM

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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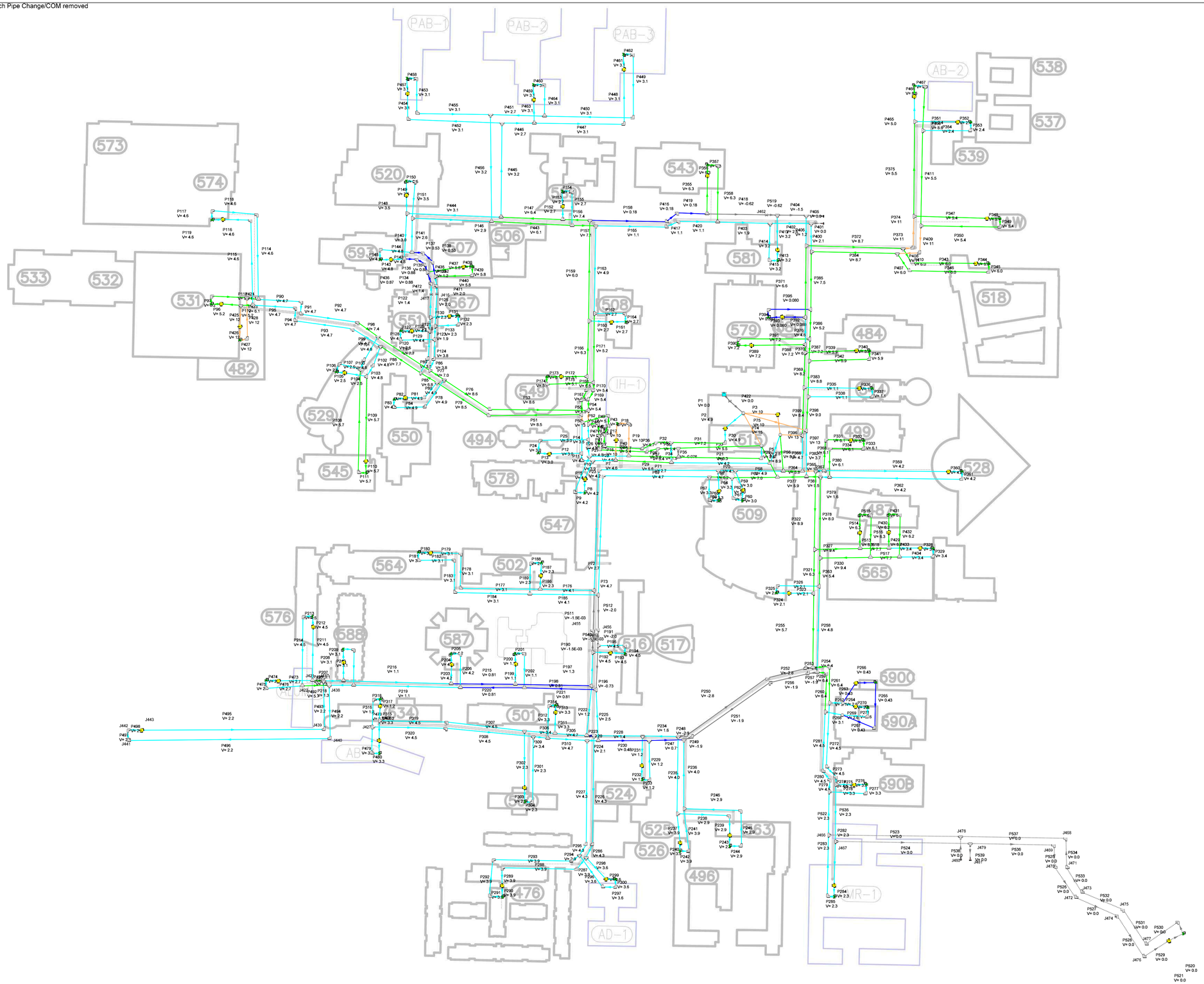
- > 10
- > 5
- > 1
- > 0



Base Scenario/2040 base analysis/Option 3 - North Plant

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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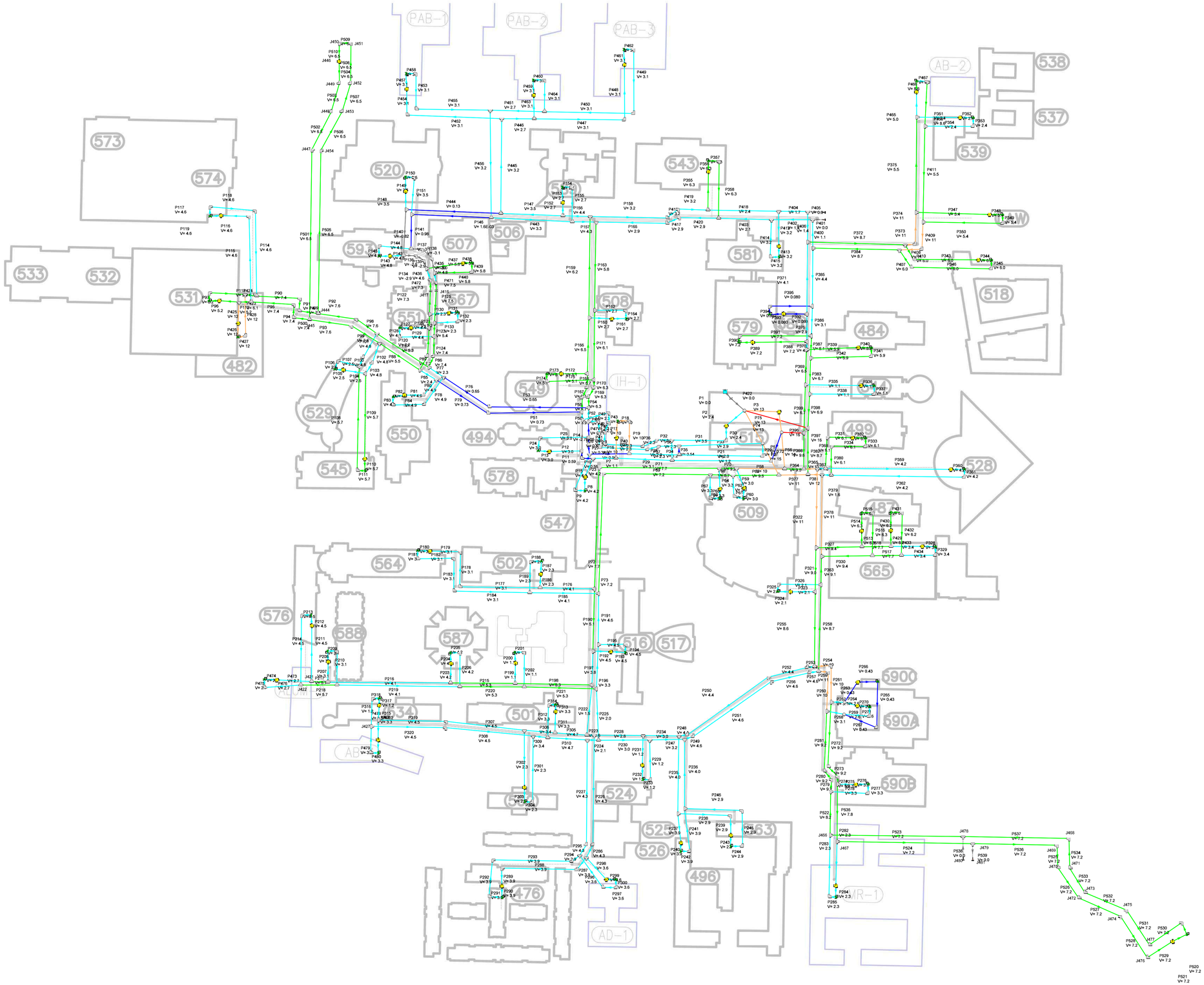
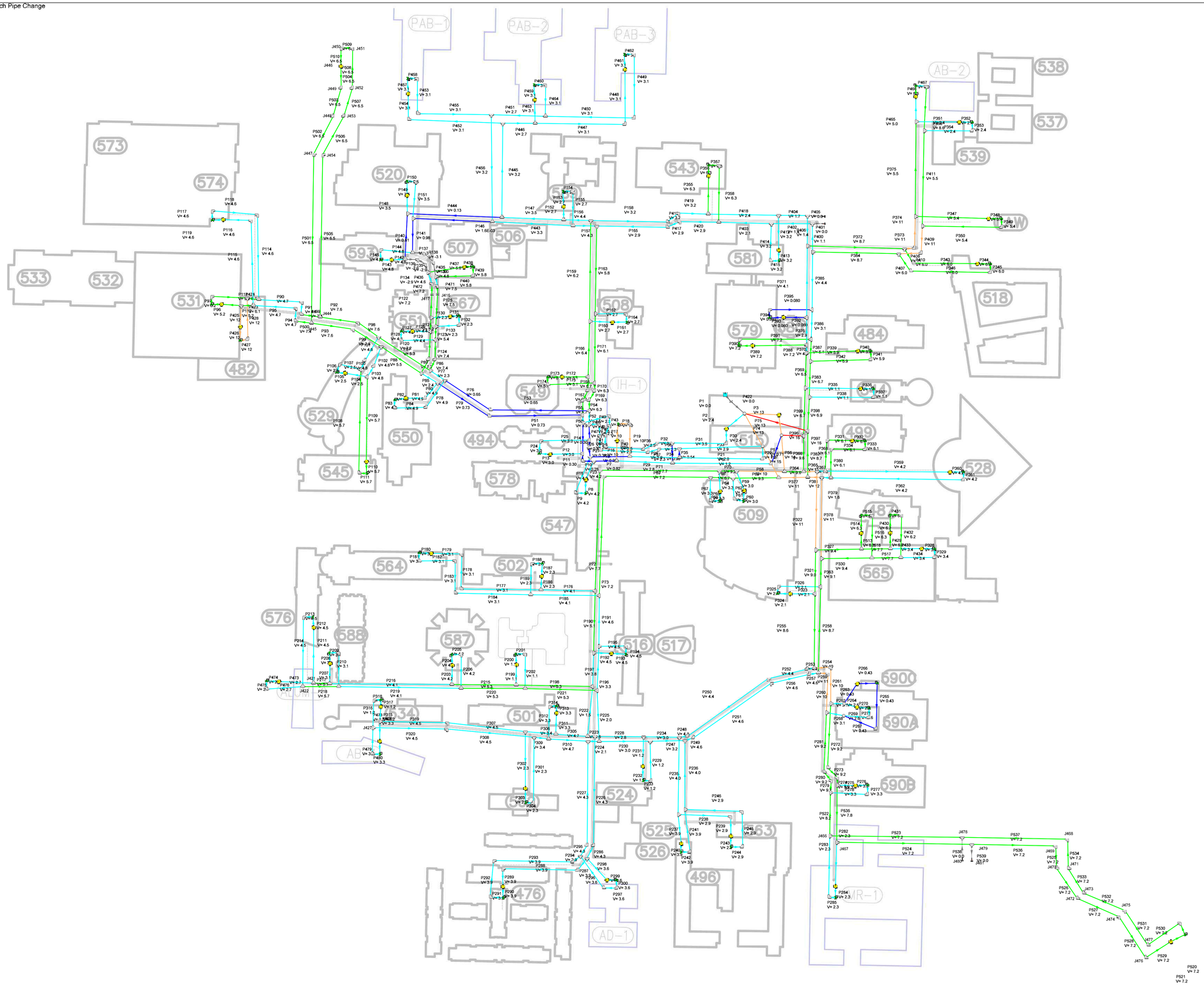
- > 10
- > 5
- > 1
- > 0



PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)

- > 15
- > 10
- > 5
- > 1
- > 0



Base Scenario/2040 base analysis/Option 3 - North Plant/Athletic Branch Pipe Change/COM removed

PIPE UNITS
Velocity (V) = feet/sec

COLORS
Velocity (feet/sec)
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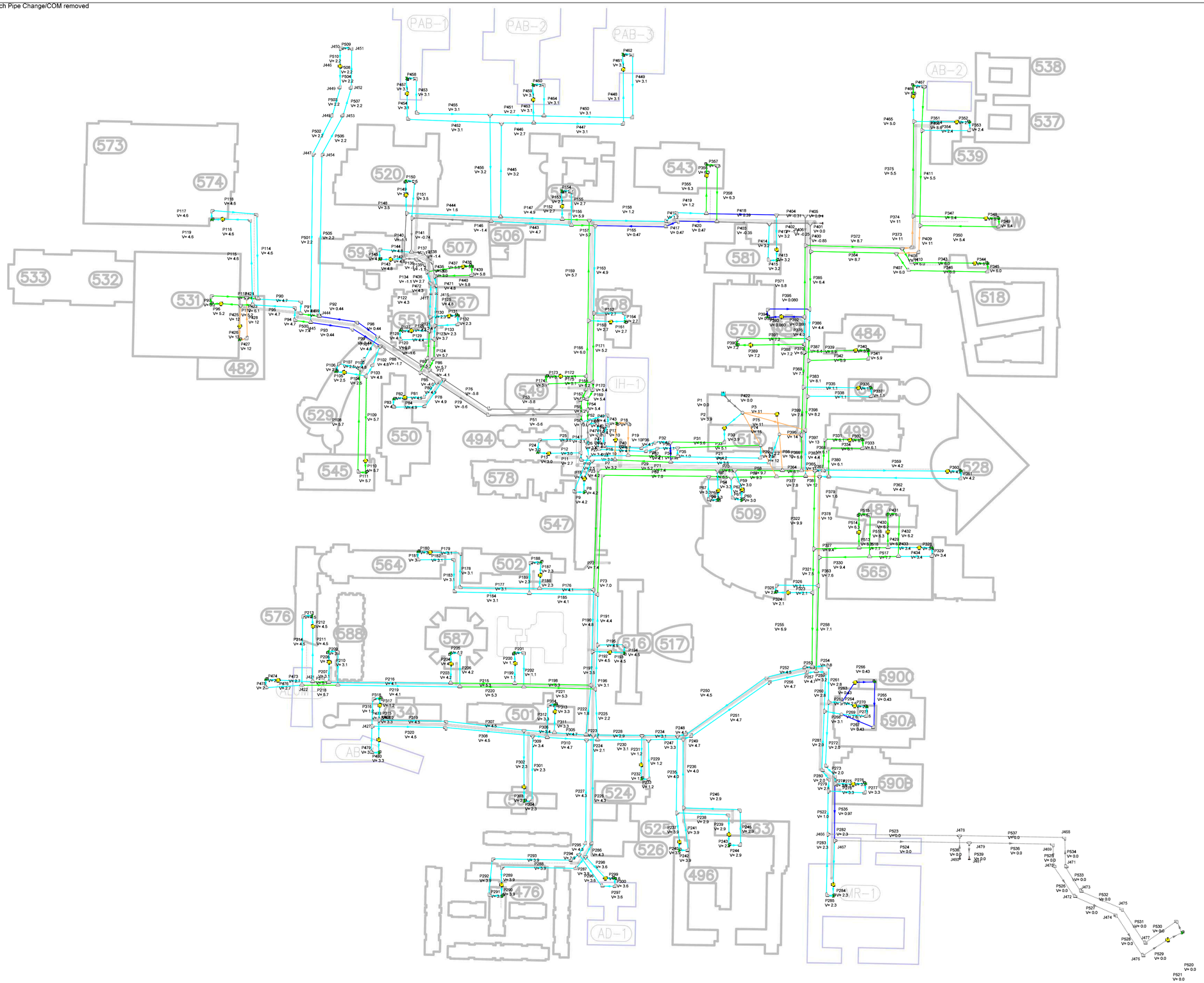
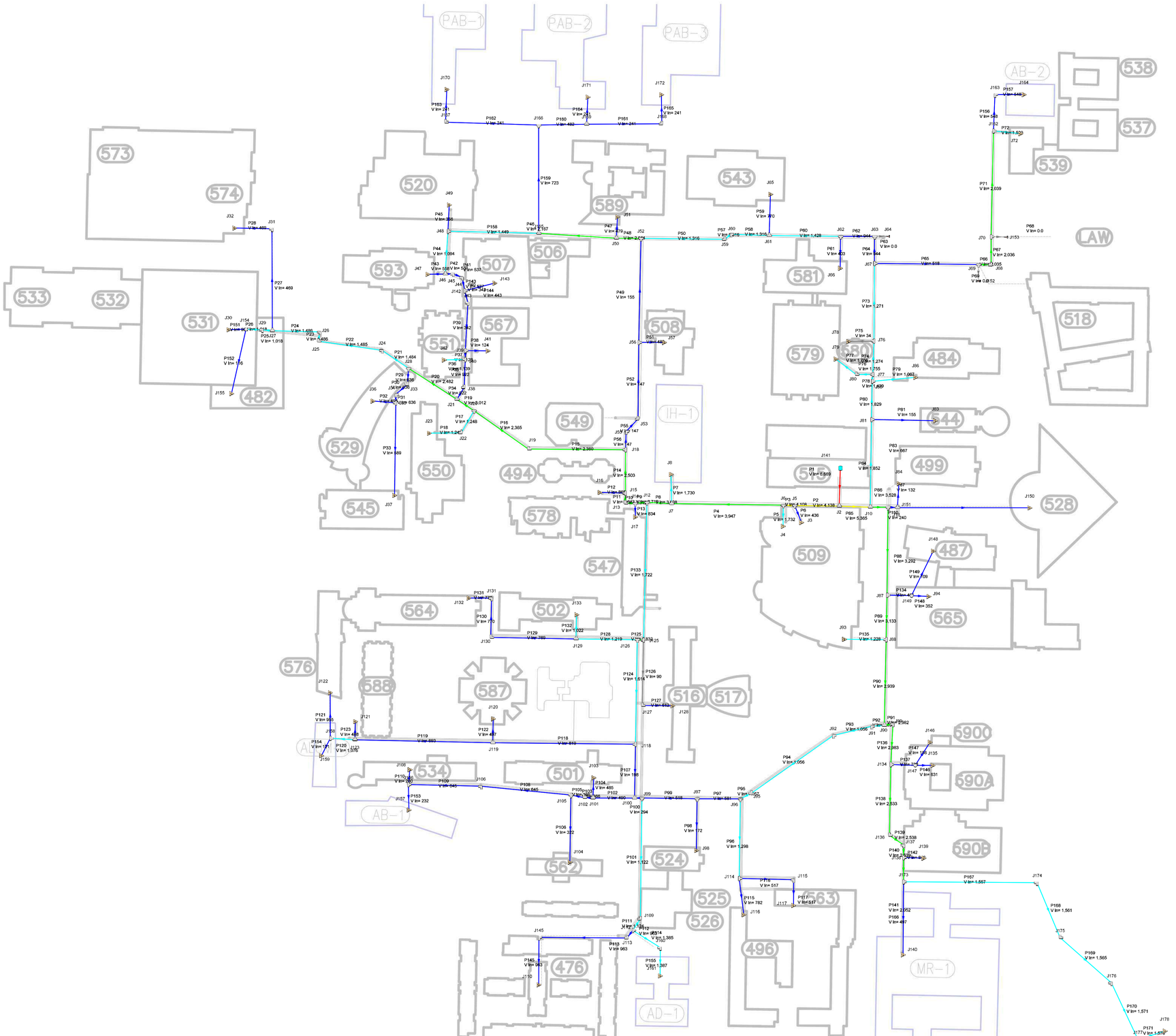
- > 10
- > 5
- > 1
- > 0



AFT Fathom 11 (Visual Report) 8/2/2022 Page 1 of 1	AFT Fathom Model 2040 Campus Option 3 - Athletics Piping Upgrade no COM	

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
- > 6000
- > 4000
- > 2000
- > 1000
- > 100

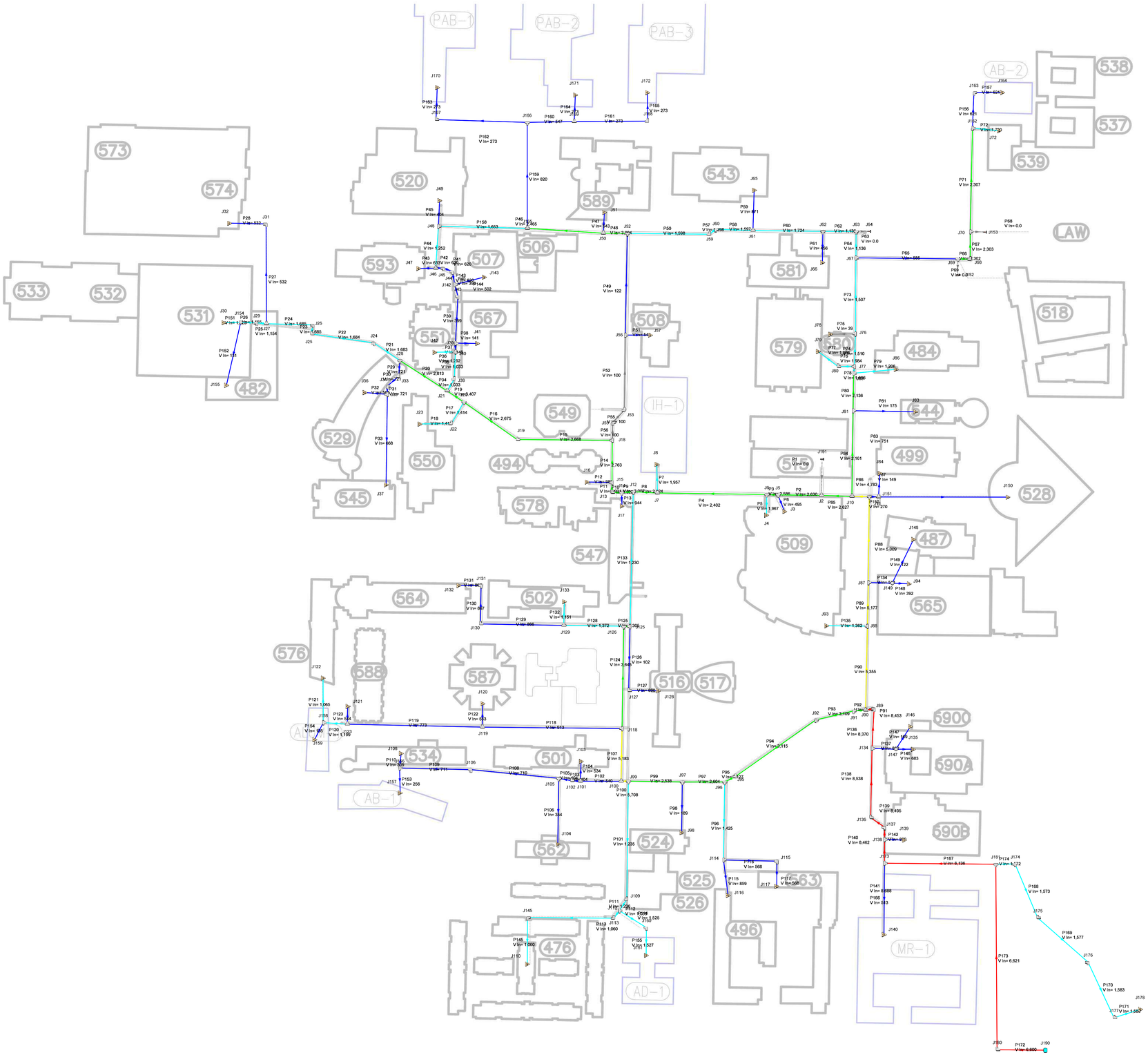


AFT Arrow Model

Baseline 2022 - Existing Campus Loads

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
- > 6000
- > 4000
- > 2000
- > 1000
- > 100



AFT Arrow Model

2040 Campus Option 1 - Baseline

Base Scenario/2022 base analysis/Option 1/Option 1A

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
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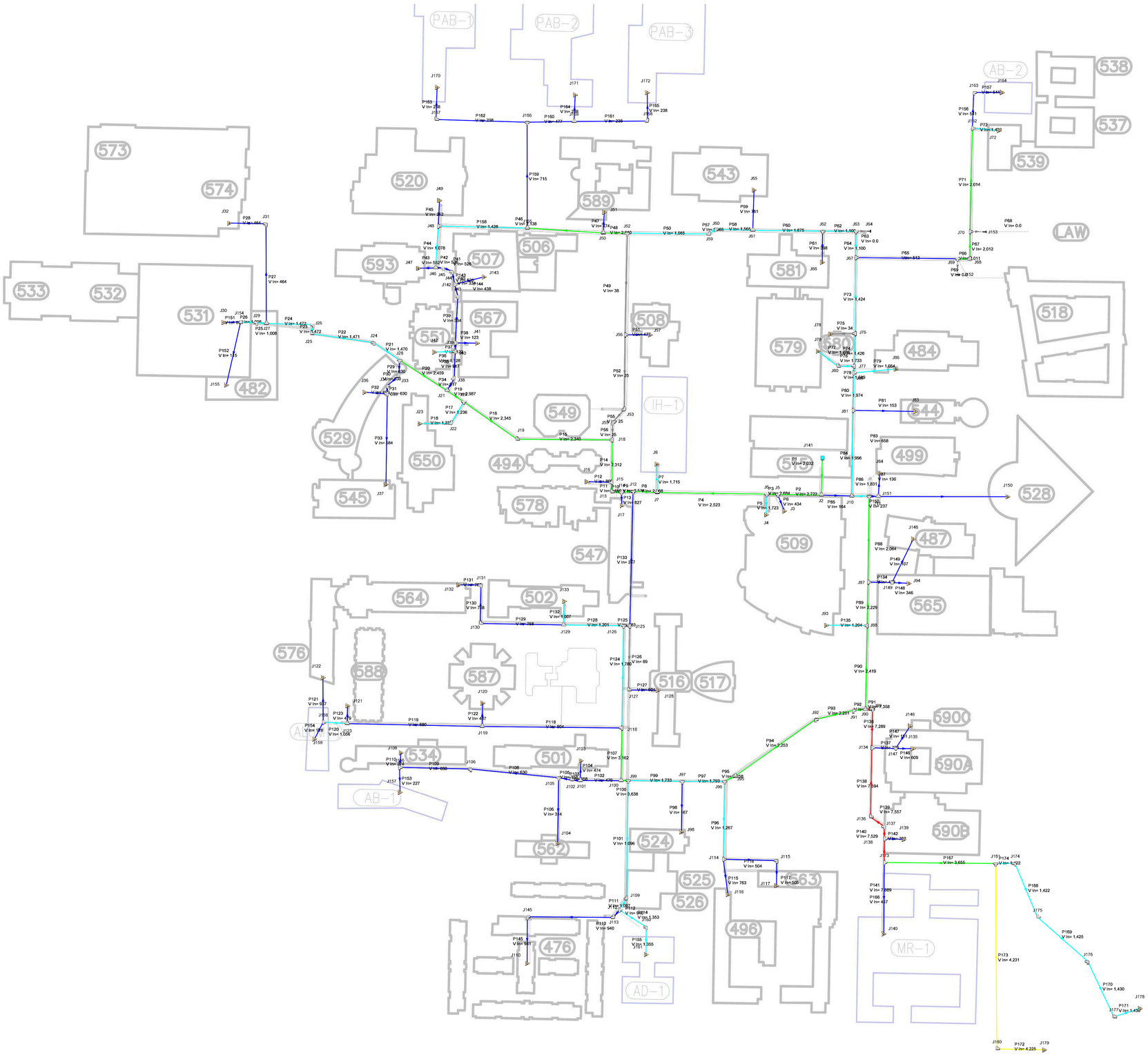
- > 4000
- > 2000
- > 1000
- > 100



PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
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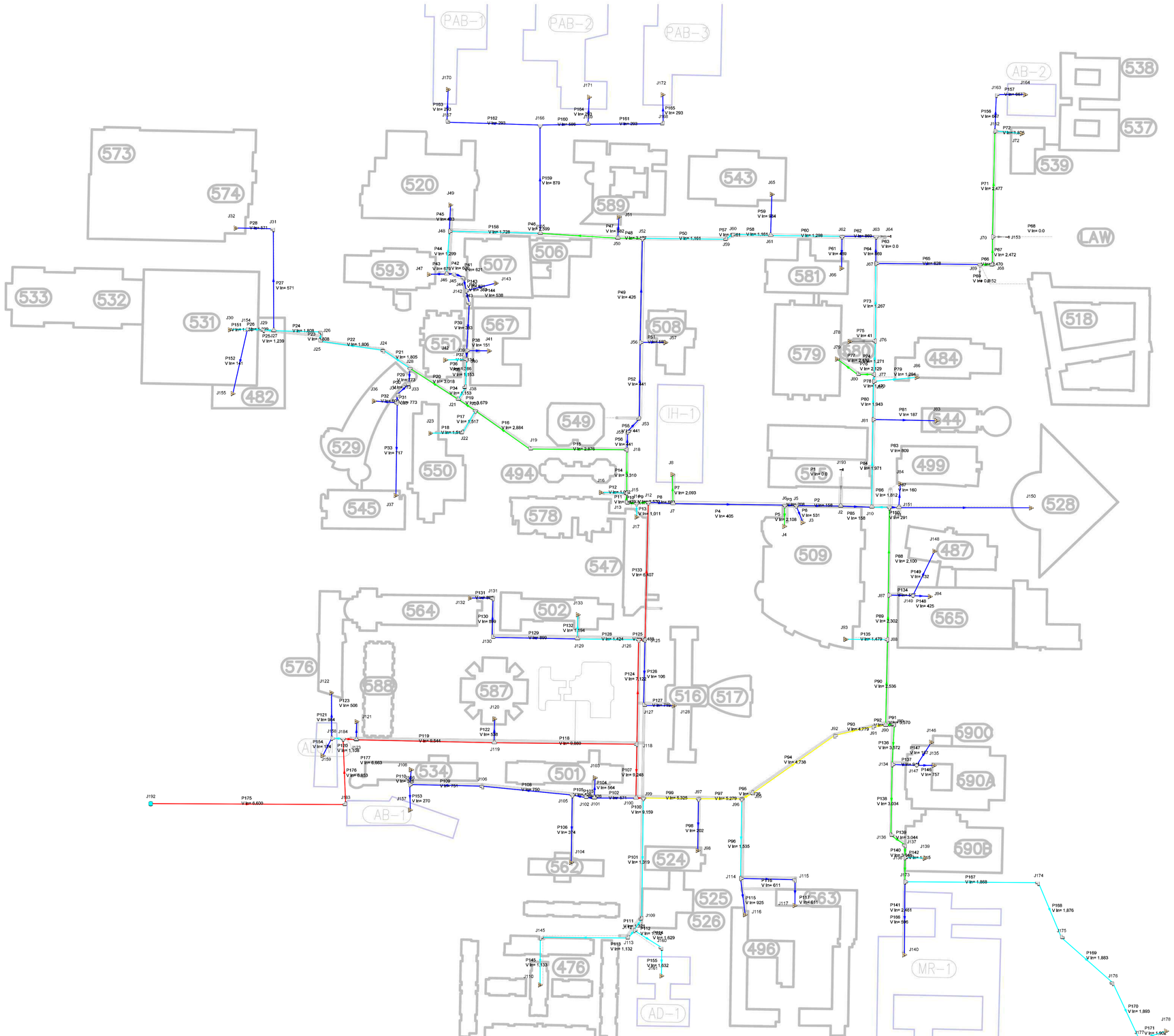
- > 4000
- > 2000
- > 1000
- > 100



AFT Arrow 8 (Visual Report) 6/7/2022 Page 1 of 1	AFT Arrow Model 2040 Campus Option 1 - Baseline	

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
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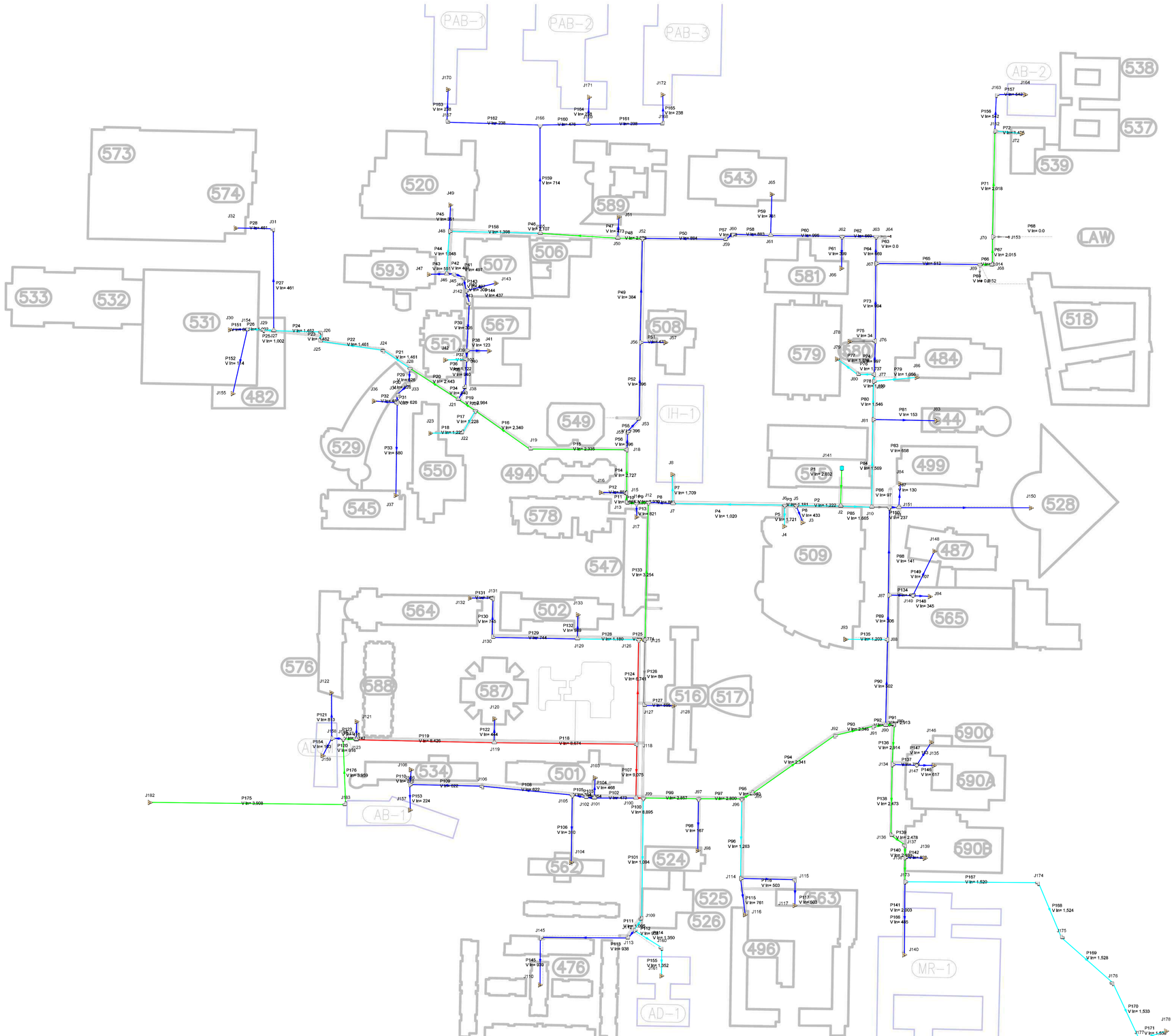
- > 4000
- > 2000
- > 1000
- > 100



AFT Arrow Model

2040 Campus Option 2 - Piping Upgrades

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
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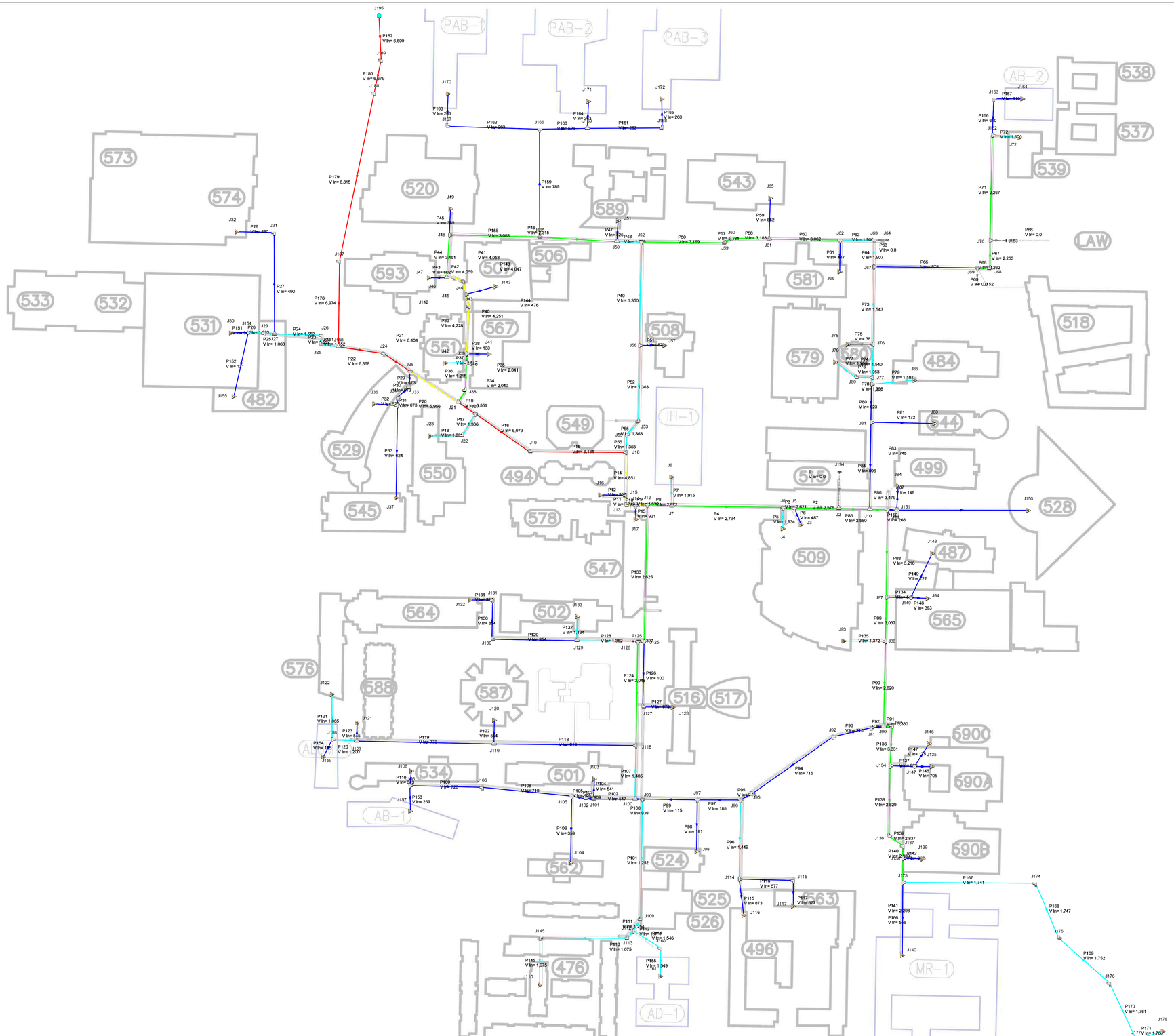
- > 4000
- > 2000
- > 1000
- > 100

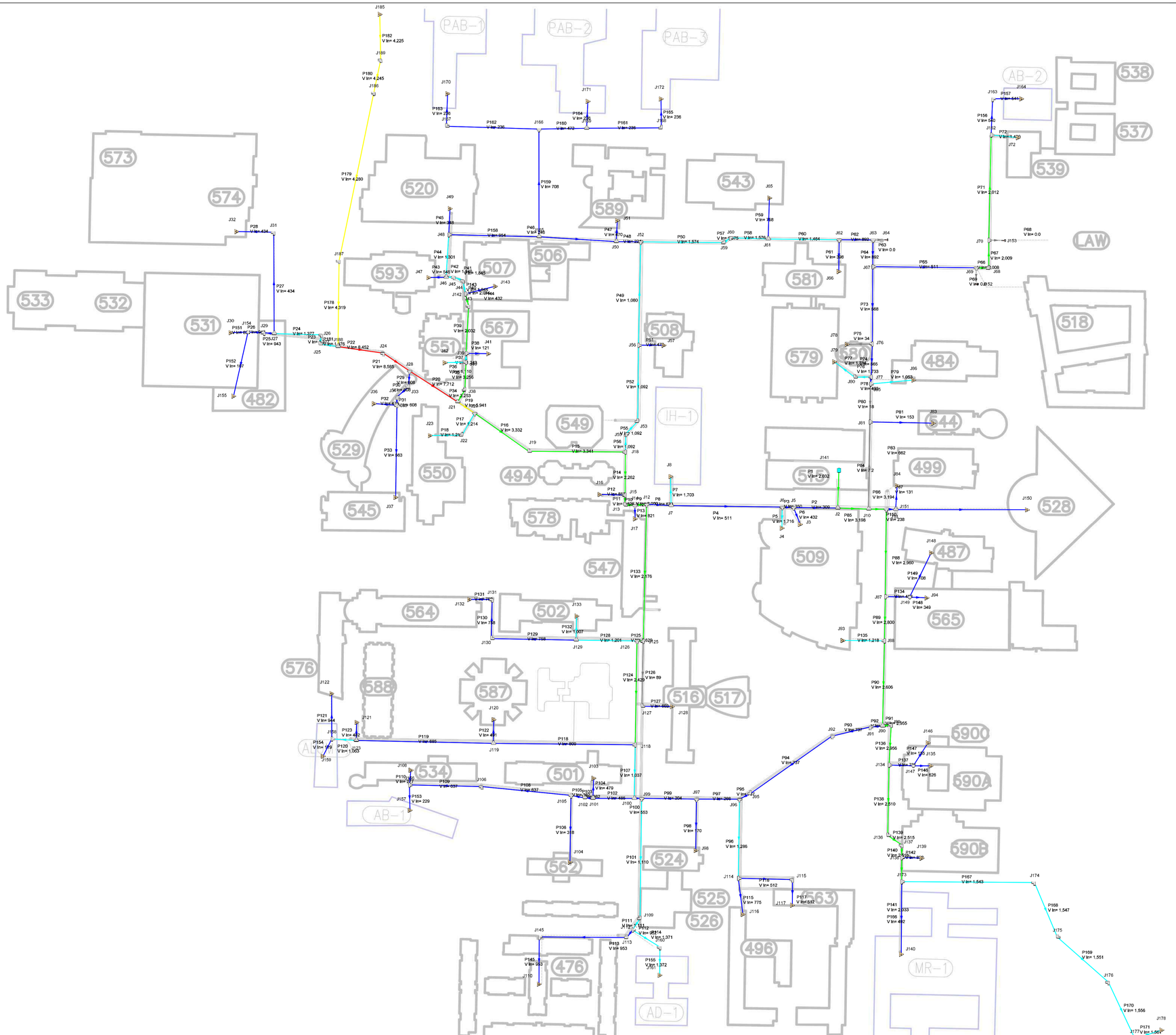


AFT Arrow Model

2040 Campus Option 1 - Baseline

PIPE UNITS
Velocity Inlet (V In) = feet/mi

COLORS
Velocity Inlet (feet/min)
- > 6000
- > 4000
- > 2000
- > 1000
- > 100



AFT Arrow Model

2040 Campus Option 3 - Piping Upgrades

Appendix G
Equipment Selection Considerations

1. Equipment Selection Considerations

All equipment that is added to the campus infrastructure should be reviewed not only for the first installed cost, but for reliability and maintainability as well. If equipment is difficult to maintain, then it will likely not be maintained and become a reliability issue in the future. This appendix briefly describes some considerations for new equipment that is associated with the campus Energy Master Plan.

1.1 Cooling Towers

Heat rejection from future chillers will be accomplished using cooling towers because of their efficiency, maintainability, and relatively low cost. At this juncture in the design process, the main decision related to cooling towers is the construction process, either factory-assembled or field-erected. Determining the construction type will determine cooling tower cell sizing and physical arrangement which will in turn influence the layout of the plant and site. Table shows a summary review of the different construction methodologies followed by a recommendation.

Table G-1. Cooling Tower Construction Summary

Item	Factory-manufactured	Field-erected
Energy Efficiency	Can be energy efficient but a higher cell count is required	Larger cell size increases energy efficiency
Design Flexibility	Limited customization of tower size and geometry	Towers can be customized to fit site constraints
Capital Cost	Minimal cost difference	
O&M	Increased O&M due to the increased number of cells and components	Fewer cells require less overall maintenance, access is easier due to size and custom access points and platforms
Construction Schedule	Towers are delivered, set, and connected; initial tower installation can be completed in 2 to 4 weeks	Components are assembled onsite; installation time of 8-12 weeks plus additional time for the basin
OEM Parts and Service	Parts are readily available	Most parts are readily available, but some components will have longer lead time
Maximum Flow Rate per Cell (typical)	6,000 gpm	15,000 gpm
Appearance	Metal finish, screen wall is required to alter appearance	Appearance can be customized to fit location and can be integrated into a building structure
Projected Service Life	20 to 25 years	25 to 30+ years

Based on the information in Table G-1 and the projected system flow rates, field-erected cooling towers are recommended for the new plant. The field-erected towers will provide the university with design flexibility, equipment longevity, and improved maintenance. During detailed design, parameters such as efficiency, material, size, basin arrangement, pumping, sound attenuation, and other elements will need to be selected.

1.2 Pumps

1.2.1 Chilled Water Pumps

Any new chilled water pumps installed into the existing Central Utilities Plant (CUP) will need to be reviewed both in terms of operational characteristics (such as flow versus head) and where in the system they are connected. There are three different piping connections that connect the CUP into the chilled water distribution system. The addition of any new flows has the potential to cause systemwide problems such as excessive velocities and pressure imbalances in locations not readily apparent such as at buildings at the end of the distribution system.

1.2.2 Condenser Water Pumps

The addition of any new condenser water pump will only occur should a new cooling tower be installed. The existing pumping arrangement for the existing cooling towers is N+1 per tower. Should a new cooling tower be installed, either at the CUP or a remote satellite facility, this practice is recommended to remain as it provides significant redundancy and resiliency to the system.

Integration of a new condenser water pump at the existing CUP will likely prove difficult due to the dense piping already inside the CUP. An analysis of the condenser water system under various flow configurations should be modeled before any expansion of the condenser water system is considered.

1.3 Combined Heat and Power Equipment Selections

1.3.1 Reciprocating Engine Generators

The reciprocating engine generators selected were Caterpillar CG260-16 that can each produce 4 megawatts of electricity. The fuel was pipeline-quality natural gas with properties matching that of typical natural gas in the Houston area. The generators were selected at 12.4 kilovolts to allow integration into the campus medium voltage electrical system.

1.3.2 Combustion Turbine Generators

The combustion turbine generators (CTGs) selected were Solar Mercury 50 recuperated gas turbines. This turbine is a high-efficiency ultra-low emission CTG with a nominal power output of 4.6 megawatts. To increase the efficiency of this turbine, air inlet cooling was modeled. The cooling source was chilled water that was either produced by absorption chillers or by using the campus chilled water system.

A CTG typically requires pressures above what is provided by the local utility companies. The local gas pressure for the University of Houston (UH) is 35 to 55 pounds per square inch gauge; thus, a gas compressor will be required. A gas compressor utilizing an electric motor was modeled as a parasitic load in the Thermoflex model.

1.3.3 Chillers

The sizing of the new chillers was determined in correspondence with vendors regarding a reasonable cost per ton and maximizing operational efficiency based on the historical cooling load profiles provided to Jacobs. Various chiller types were reviewed to optimize efficiencies as part of the combined heat and power (CHP) analysis. Based on the operating conditions of the new chillers and the requirements of the campus, two types of chillers were used as the basis for the CHP analysis.

The first type of chiller is a high-efficiency magnetic bearing chiller. This type of chiller has several benefits, including (1) the ability to work with condenser water temperatures that are below what most standard centrifugal chillers can accept and (2) reduced maintenance. For the magnetic bearing chillers, there is a price premium for chillers that are larger than 1,000 tons; thus, the magnetic bearing chillers were selected at 1,000 tons.

The second type of chiller is a lithium bromide (LiBr) absorption chiller. This technology has the benefit of being able to directly use waste heat to generate chilled water with minimal electricity consumption. The type selected for this application was a single stage machine using either hot water or steam as the heat source. A single-stage LiBr chiller was selected due to overall system efficiencies—while a two-stage chiller could be used, it would likely require steam at a pressure slightly higher than what the campus distribution system requires, which would decrease the efficiency of the heat recovery equipment.

Table G- lists the chillers that were used as the basis of design for the analysis. The selections assumed a 10°F temperature differential across the chilled water side.

Table G-2. New Chillers

Chiller Manufacturer	Model	Capacity (tons)	Flow (gpm)	Type	Refrigerant
York	YMC2	1,000	2,400	Centrifugal	HCFC-134a[a]
York	YHAU[b]	1,000	2,400	Absorption	LiBr

[a] HCFC-134a was used instead of a refrigerant with low global warming potential as there is an efficiency de-rate on existing chillers. This is likely to change as new low global warming potential chillers are developed in the near future.

[b] Chiller can operate on either hot water or steam.

2. Fuel Selection

As part of the equipment selection process, different fuel types were reviewed at a cursory level. This was done to ensure completeness of the equipment selection. **Error! Reference source not found.** provides a summary of the different fuels reviewed and the advantages and disadvantages associated with each fuel type.

Table G-3. Fuel Selection Review

Fuel Type	Advantage	Disadvantage
Natural Gas	Existing pipelines in area	Could require a compressor to increase pressure depending on technology selected for CHP
	Relatively reliable infrastructure	Dependent on existing pipelines
Liquid Fuel (diesel or similar)	Can store additional fuel onsite	Fuel is flammable and has hazards associated with it
	--	Creates additional CO_2 and emissions compared to other fuels
	--	Expensive compared to natural gas
Hydrogen	Clean-burning fuel, does not create CO_2	Expensive to store due to low density and volumes required
	--	Emerging technology not yet fully developed for utility applications
	--	Possibly the most expensive fuel
Propane or LNG	Can be sourced from local suppliers	Depending on storage requirements there could be significant amount of storage required
	Can store additional fuel onsite	Fuel is flammable and has hazards associated with it; large storage systems have stringent requirements and safety clearances
Solid Fuel	Typically biowaste (woodchips, for example)	Can be a low-energy density fuel
	Can be low-cost if local sources are available	Large storage system required
	--	Extensive material handling equipment required

Based on the fuel sources reviewed, it was determined that natural gas was to be used as the fuel for the CHP analysis. This decision was primarily based on two factors:

- Availability and ease of use: natural gas is already used on campus and is a common fuel.
- Storage: liquid and solid fuels would require a significant storage facility on campus. As UH is surrounded by the City of Houston, space is at a premium.

The only downside to using natural gas as a fuel is that, depending on the CHP technology pursued, a gas compressor would likely be required. This is due to CenterPoint Energy only being able to supply gas pressure to UH between 35 and 55 pounds per square inch gauge.

Appendix H
Conceptual Drawings

GENERAL NOTES

A. DEMOLISHED BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. COUGAR SUBSTATION
2. HEALTH BUILDING SWITCHGEAR
3. CENTRAL UTILITY PLANT SWITCHGEAR
4. BUILDING TO BE DEMOLISHED AS PART OF MASTER PLAN

FEEDER LEGEND

- COUGAR FEEDER 1, 2, & 3 UG
- COUGAR FEEDER 1, 2, & 3 OH
- COUGAR FEEDER 1 UG
- COUGAR FEEDER 1 OH
- COUGAR FEEDER 2 & 3 UG
- COUGAR FEEDER 2 & 3 OH
- COUGAR FEEDER 4 & 5 UG

1 **OVERALL ELECTRICAL PLAN - EXISTING**
NTS

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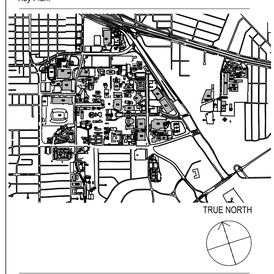
REV	DESCRIPTION	DATE

UNIVERSITY of HOUSTON

UNIVERSITY OF HOUSTON
THERMAL UTILITY SITE PLAN
HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:

OVERALL ELECTRICAL PLAN - EXISTING

Date: 09/09/2022

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Drawing No.: ES100

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GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. COUGAR SUBSTATION
2. HEALTH BUILDING SWITCHGEAR
3. CENTRAL UTILITY PLANT SWITCHGEAR
4. NEW BUILDING PER MASTER PLAN
5. NEW COLLEGE OF MEDICINE BUILDING
6. FEEDER FROM HEALTH SWITCHGEAR TO COLLEGE OF MEDICINE

FEEDER LEGEND

- COUGAR FEEDER 1, 2, & 3 UG
- COUGAR FEEDER 1, 2, & 3 OH
- COUGAR FEEDER 1 UG
- COUGAR FEEDER 1 OH
- COUGAR FEEDER 2 & 3 UG
- COUGAR FEEDER 2 & 3 OH
- COUGAR FEEDER 4 & 5 UG
- COM FEEDER UG

1 **OVERALL ELECTRICAL PLAN - NEW COM FEEDERS**
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REV	DESCRIPTION	DATE

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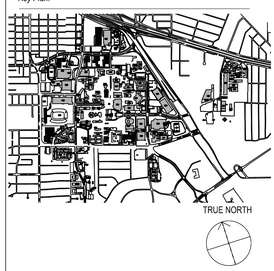
HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:
OVERALL ELECTRICAL PLAN - NEW COM FEEDERS

Date: 09/09/2022

Designed:
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Drawing No.:
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GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. COUGAR SUBSTATION TO BE DECOMMISSIONED
2. HEALTH BUILDING SWITCHGEAR (CAMPUS SWITCHGEAR B)
3. CENTRAL UTILITY PLANT SWITCHGEAR
4. NEW SUBSTATION
5. TO TECHNOLOGY BRIDGE MVATS
6. COUGAR FEEDERS 4 & 5 RE-USED TO SERVE TECHNOLOGY BRIDGE
7. NEW CABLE SPLICES TO EXISTING COUGAR FEEDERS 4 & 5. DISCONNECT FROM CAMPUS SUBSTATION SWITCHGEAR TO SERVE THE TECHNOLOGY BRIDGE.
8. NEW COLLEGE OF MEDICINE BUILDING
9. FEEDER FROM NEW SUBSTATION TO COLLEGE OF MEDICINE

FEEDER LEGEND

- NEW CAMPUS UG FEEDER 1 & 2
- NEW CAMPUS UG FEEDER 3
- NEW CAMPUS UG FEEDER 4 & 5
- NEW UG FEEDERS TO CONNECT WITH EXISTING COUGAR 4 & 5 FEEDERS
- EXISTING COUGAR FEEDER 4 & 5
- EXISTING FEEDERS TO TECHNOLOGY BRIDGE
- COM FEEDER UG

1 **OVERALL ELECTRICAL PLAN - NEW SUBSTATION FEEDERS**
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REV	DESCRIPTION	DATE

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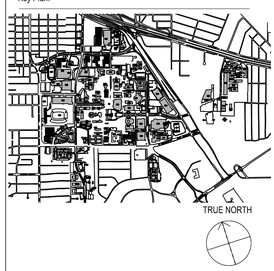
THERMAL UTILITY SITE PLAN
HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:
OVERALL ELECTRICAL PLAN - NEW SUBSTATION FEEDERS

Date: 09/09/2022

Designed:
Drawn :
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Drawing No.: ES102

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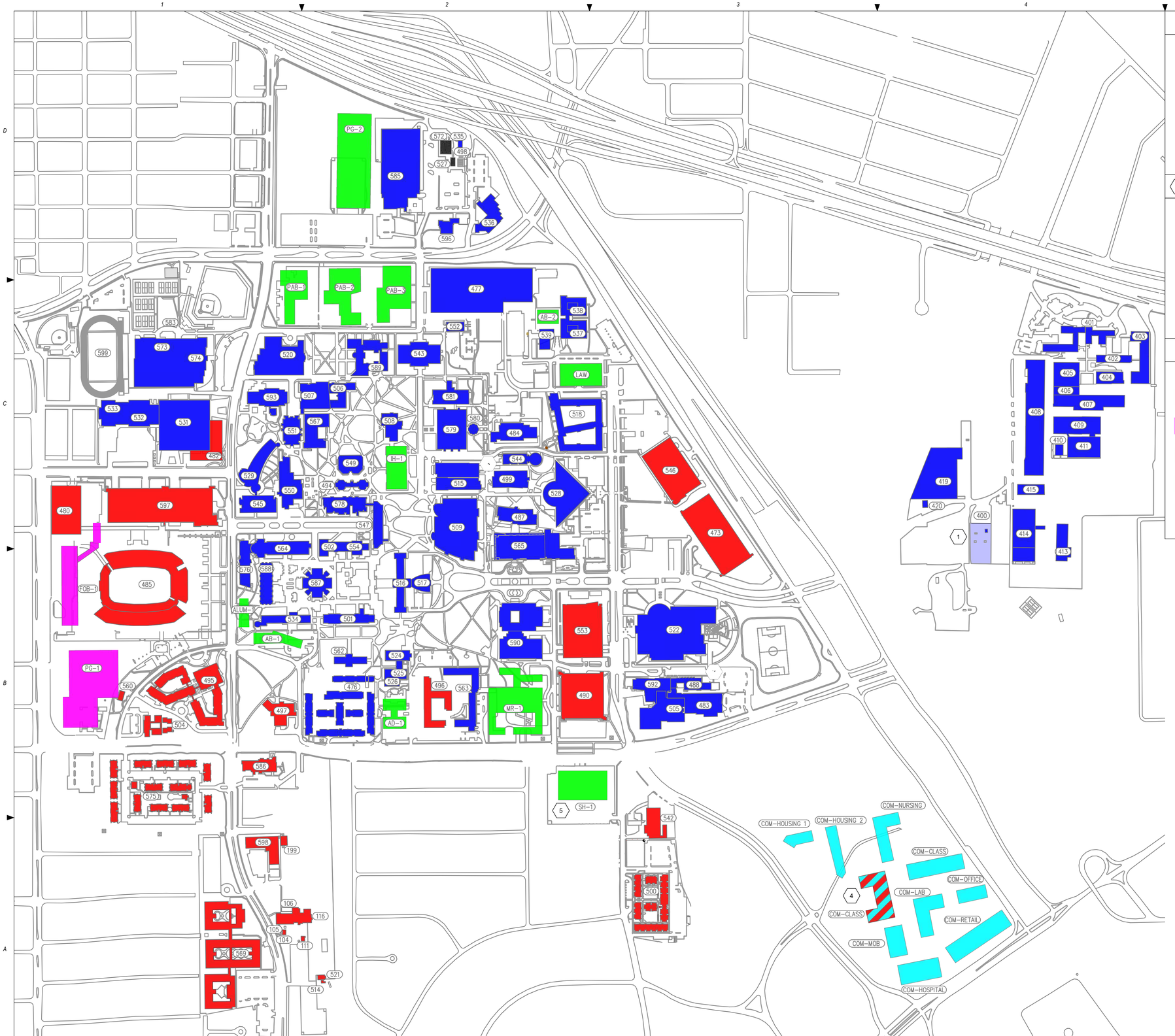

1 **CAMPUS ELECTRICAL DESTRIBUTION**
NTS

GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. COUGAR SUBSTATION
2. HEALTH BUILDING SWITCHGEAR
3. CENTRAL UTILITY PLANT SWITCHGEAR
4. BUILDING CURRENTLY ON CPE SERVICE BUT WOULD BE SWITCHED TO THE CAMPUS ELECTRICAL SYSTEM SHOULD THE COM BE PLACED ON THE CAMPUS GRID.
5. STUDENT HOUSING AT SAME LOCATION AS OPTION 1 FOR A NEW UTILITY PLANT AND/OR SUBSTATION.

SHADING LEGEND

- EXISTING BUILDING ON CPE SERVICE
- FUTURE BUILDING ASSUMED TO BE ON CPE SERVICE
- EXISTING BUILDING ON CAMPUS SERVICE
- FUTURE BUILDING ON CAMPUS SERVICE
- FUTURE COM BUILDING THAT COULD BE PLACED ON CAMPUS SERVICE

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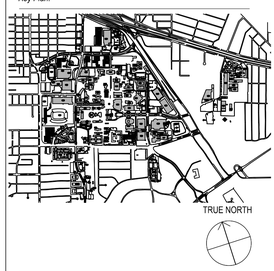
THERMAL UTILITY SITE PLAN
HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:
GENERAL
OVERALL SITE
ELECTRICAL SERVICE
PLAN - NEW

Date: 09/09/2022

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Drawing No.:
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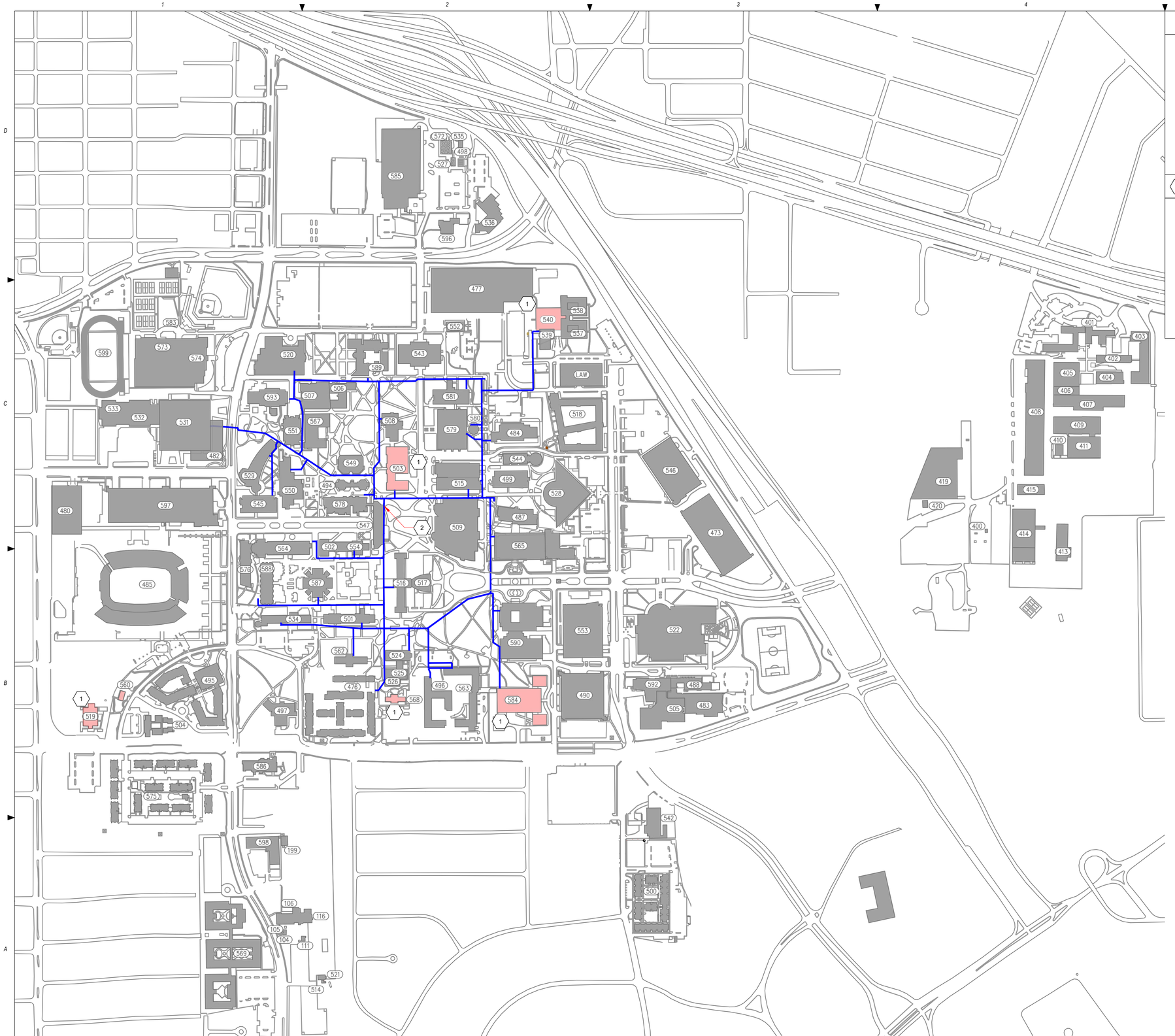

1 **OVERALL SITE PLAN - EXISTING**
NTS

GENERAL NOTES

A. DEMOLISHED BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

X

1. BUILDING TO BE DEMOLISHED AS PART OF MASTER PLAN
2. EXISTING UTILITY TUNNELS

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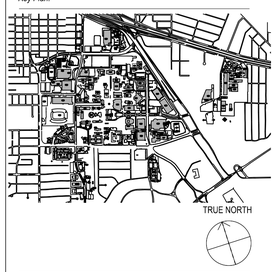
THERMAL UTILITY SITE PLAN

HOUSTON, TEXAS

Key Plan:



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Jacobs Project No.: WFXR3000

Drawing Title:

OVERALL SITE PLAN - EXISTING

Date: 09/09/2022

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Drawing No.: MS100

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GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. NEW BUILDING PER MASTER PLAN
2. NEW COLLEGE OF MEDICINE BUILDING
3. EXISTING COLLEGE OF MEDICINE BUILDING
4. COLLEGE OF MEDICINE UTILITY PATH FOR CAMPUS SYSTEMS
5. EXISTING UTILITY TUNNELS

1 **OVERALL SITE PLAN - NEW**
NTS

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HOUSTON, TEXAS

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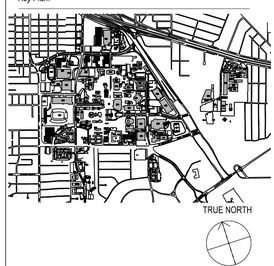

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Jacobs Project No.: WFXR3000

Drawing Title:

OVERALL SITE PLAN - NEW

Date: 09/09/2022

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Drawing No.: MS101

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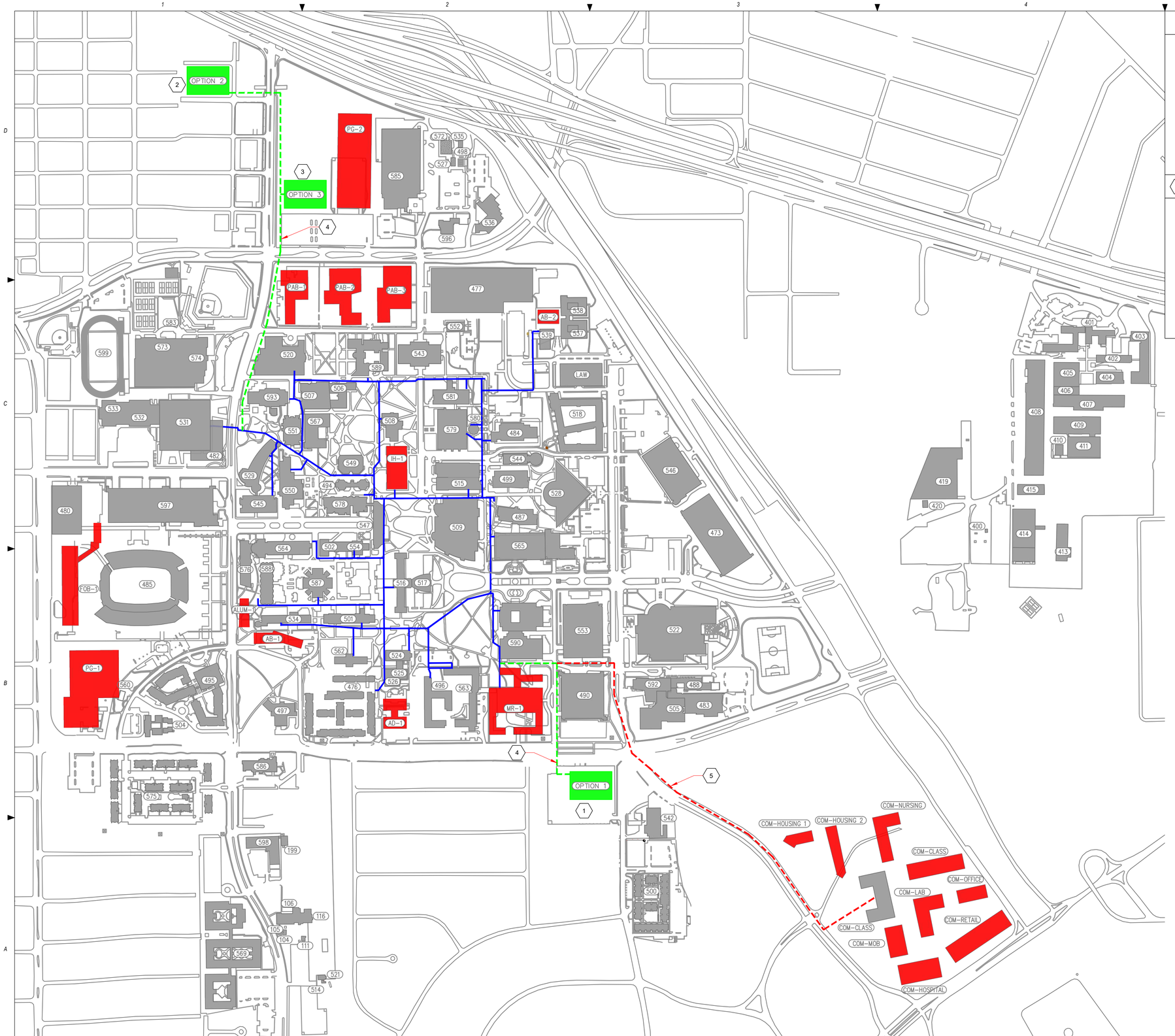

1 **NEW UTILITY PLANT SITE OPTIONS**
NTS

GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

X

1. UTILITY PLANT SITE OPTION 1
2. UTILITY PLANT SITE OPTION 2
3. UTILITY PLANT SITE OPTION 3
4. PROPOSED UTILITY PATH FOR INTEGRATION OF PLANT AND CAMPUS SYSTEMS
5. COLLEGE OF MEDICINE UTILITY PATH FOR CAMPUS SYSTEMS

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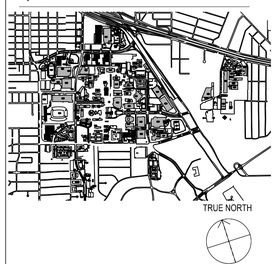
HOUSTON, TEXAS

Key Plan:



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Jacobs Project No.: WFXR3000

Drawing Title:

NEW UTILITY PLANT SITE OPTIONS

Date: 09/09/2022

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Drawing No.: MS102

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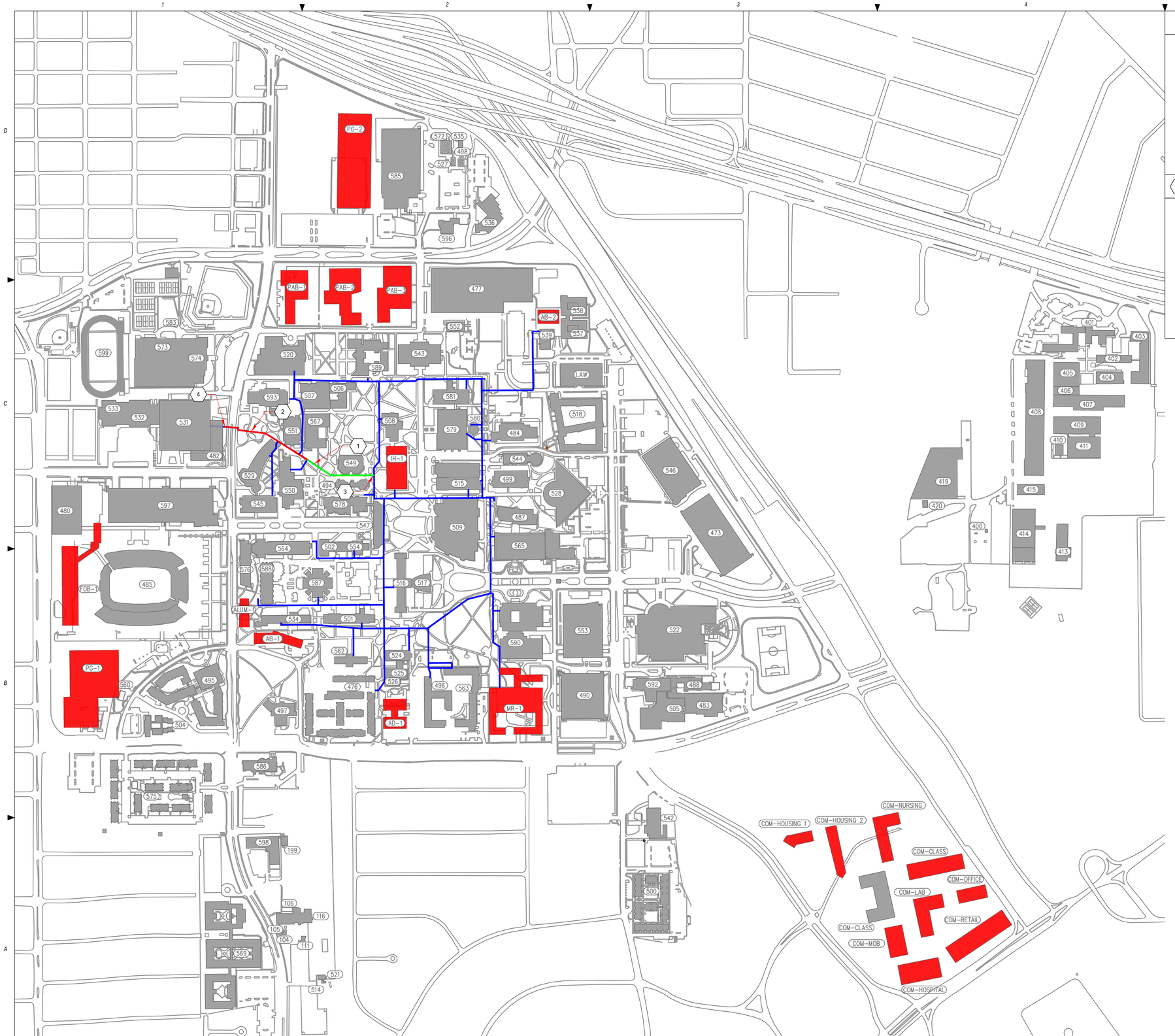

1 **ATHLETICS CHILLED WATER PIPING REPLACEMENT**
NTS

GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

X

1. UPGRADE PIPE SIZE FROM 20 INCH TO 24 INCH
2. UPGRADE PIPE SIZE FROM 16 INCH TO 20 INCH
3. START UPGRADE AT TEE INTERSECTION IN TUNNEL
4. STOP UPGRADE AFTER TEE INTERSECTION SERVING BUILDING 574

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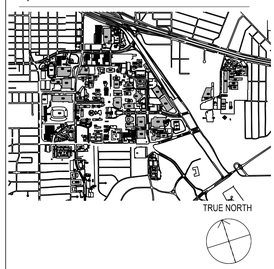
THERMAL UTILITY SITE PLAN

HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:

ATHLETICS CHILLED WATER PIPING REPLACEMENT

Date: 09/09/2022

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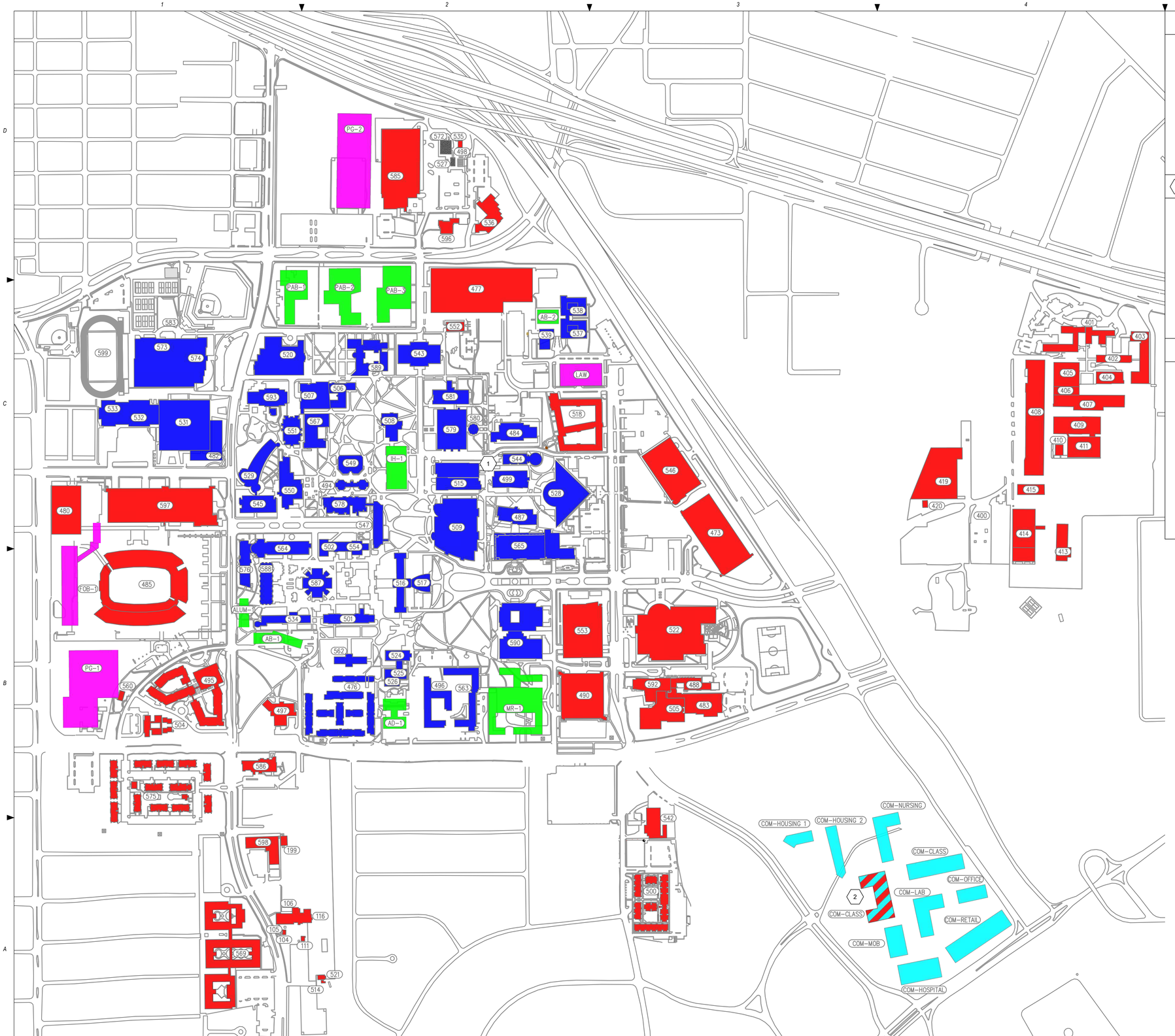

1 **CAMPUS STEAM DISTRIBUTION**
NTS

GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. EXISTING CUP
2. EXISTING BUILDING SERVED BY COM CUP. BUILDING COULD BE PLACED ONTO CAMPUS SYSTEM IF COM INTEGRATED INTO CAMPUS STEAM SYSTEM.

SHADING LEGEND

- EXISTING BUILDING NOT ON CAMPUS STEAM
- FUTURE BUILDING NOT ON CAMPUS STEAM
- EXISTING BUILDING ON CAMPUS STEAM
- FUTURE BUILDING ON CAMPUS STEAM
- FUTURE COM BUILDING THAT COULD BE ON CAMPUS STEAM

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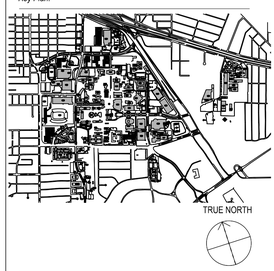
HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:

CAMPUS STEAM DISTRIBUTION

Date: 09/09/2022

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Drawing No.: MS104

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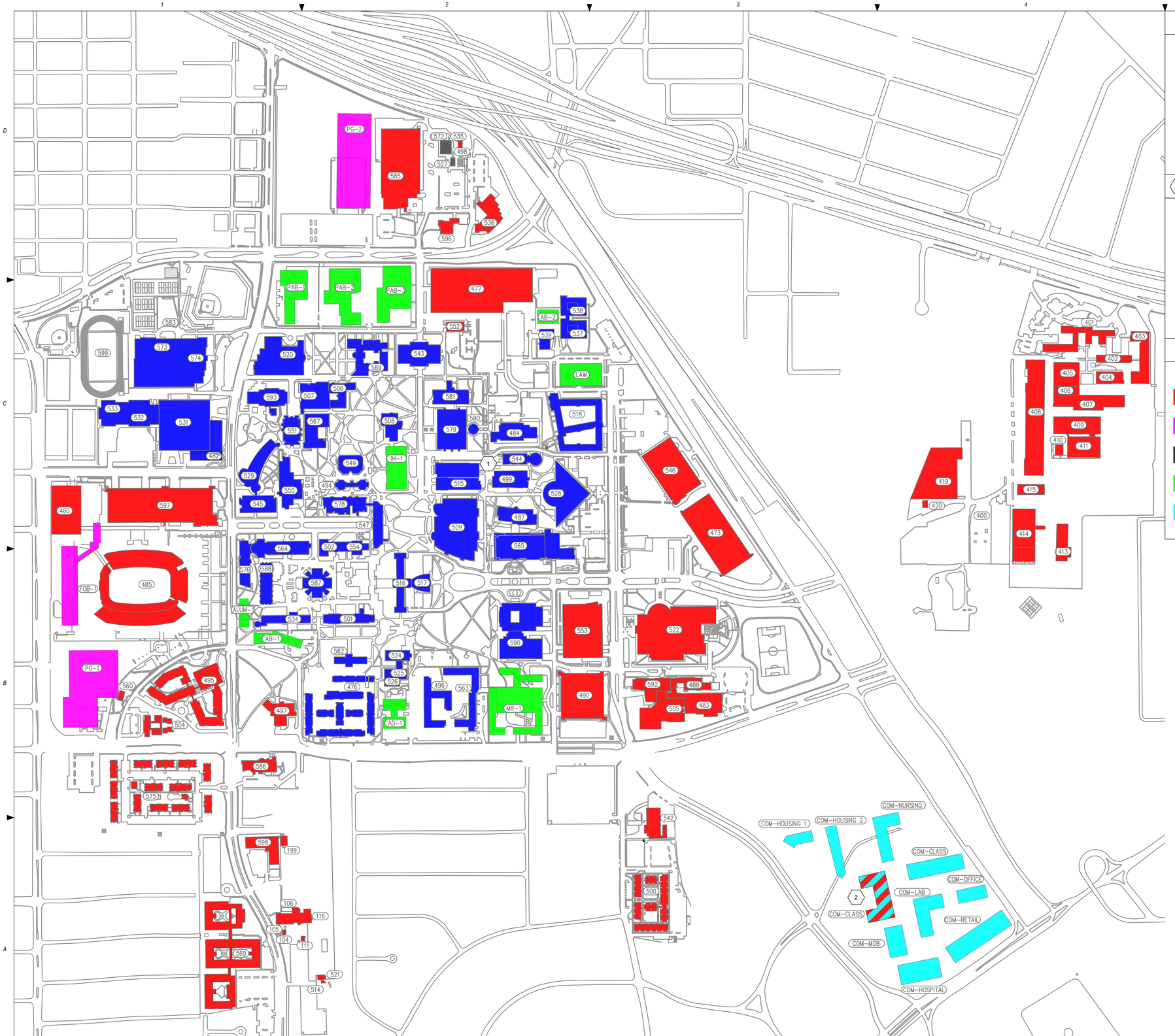

1 **CAMPUS CHILLED WATER DISTRIBUTION**
NTS

GENERAL NOTES

A. NEW BUILDINGS SHOWN ALIGN WITH THE CURRENT CAMPUS MASTER PLAN AS COORDINATED BETWEEN UH AND JACOBS.

KEYNOTES

1. EXISTING CUP
2. EXISTING BUILDING SERVED BY COM CUP. BUILDING COULD BE PLACED ONTO CAMPUS SYSTEM IF COM INTEGRATED INTO CAMPUS CHILLED WATER SYSTEM.

SHADING LEGEND

- EXISTING BUILDING NOT ON CAMPUS CHILLED WATER
- FUTURE BUILDING NOT ON CAMPUS CHILLED WATER
- EXISTING BUILDING ON CAMPUS CHILLED WATER
- FUTURE BUILDING ON CAMPUS CHILLED WATER
- FUTURE COM BUILDING THAT COULD BE ON CAMPUS CHILLED WATER

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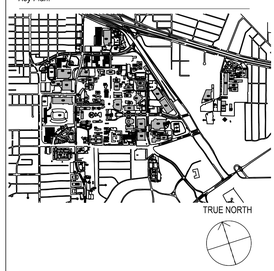
THERMAL UTILITY SITE PLAN

HOUSTON, TEXAS

Key Plan:



Scales:

Jacobs Project No.: WFXR3000

Drawing Title:

CAMPUS CHILLED WATER DISTRIBUTION

Date: 09/09/2022

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Drawing No.: MS104

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Appendix I
Cost Estimates

University of Houston
UH Executive Summary Table 1-1
Cost Breakdown
Conceptual Design Estimate Summary
9/21/2022

Executive Summary Table

Item	Description	Cost
1	New satellite utility plant Alternative 0C. Includes both the cost of the plant and integration of the plant at site Option 3.	102,781,000
2	New electrical Substation	40,707,000
3	SCADA system with new electric, chilled water, steam, and condensate meters	2,904,000
4	HVAC Control Upgrades	51,684,000
5	Lighting Upgrades	7,552,000
6	Recommissioning/retrocommissioning buildings	21,524,000
7	Photovoltaic panels on building roofs	85,379,000
8	Replacement of infrastructure at end of life	26,983,000
9	Upgrading existing utility systems to enhance performance	5,767,000

		Values From Report		Executive Summary Table Item Number									
Identifier	Description	deficiency	upgrade	1	2	3	4	5	6	7	8	9	Remarks
PLANT-01	Alternative 0C Plant Cost		$ 81,543,000	$ 81,543,000									
PLANT-02	Utility plant integration costs for site option 3		$ 21,238,000	$ 21,238,000									
CHW-01	Survey of chilled water system with non-destructive testing	$ 107,000	$ -								$ 107,000		
CHW-02	Replace Chilled Water Pump 1 with a new 4,500-gpm vertical turbine pump on variable speed drive	$ 247,000	$ -								$ 247,000		
CHW-03	Replace Chilled Water Pump 2 with new 4,500-gpm vertical turbine pump on variable speed drive	$ 247,000	$ -								$ 247,000		
CHW-04	Replace Chilled Water Pump 3 with new 6,000-gpm vertical turbine pump on variable speed drive	$ 304,000	$ -								$ 304,000		
CHW-05	Replace Chilled Water Pump 4 with new 9,000-gpm vertical turbine pump on variable speed drive	$ 428,000	$ -								$ 428,000		
CHW-06	Optimize chilled water control system after equipment in CUP has been upgraded	$ -	$ 76,000									$ 76,000	
CHW-07	Replace 500 feet of 20-inch chilled water supply and return piping per year in the distribution system in the tunnels; does not include pipe supports	$ 10,880,000	$ -								$ 10,880,000		
CHW-08	Replace chilled water piping serving Athletics Area of campus	$ 3,225,000	$ -								$ 3,225,000		
CHW-09	Replace chilled water valves in distribution system	$ 1,336,000	$ -								$ 1,336,000		
CHW-10	Install condenser water filtration system	$ -	$ 138,000									$ 138,000	
CHW-11	Chilled water meters for all buildings on campus	$ -	$ 679,000			$ 679,000							
STM-01	DA tank inspections	$ 27,000	$ -								$ 27,000		
STM-02	Replace of 500 feet of 6-inch condensate pipe per year; does not include pipe supports	$ 3,904,000	$ -								$ 3,904,000		
STM-03	Steam trap maintenance program allowance	$ 214,000	$ -								$ 214,000		
STM-04	Steam meters for all buildings on campus	$ -	$ 652,000			$ 652,000							
STM-05	Condensate meters for all buildings on campus	$ -	$ 595,000			$ 595,000							Condensate meters used instead of electric meters as condensate meters may not be required. Refer to report section for details
ELEC-01	New feeders from new substation to CUP and Health building switchgear		$ 14,993,000		$ 14,993,000								
ELEC-02	New 138kV substation, 6 position ring busbar configuration		$ 25,714,000		$ 25,714,000								
ELEC-03	Microgrid study.	$ -	$ 896,000									$ 896,000	
ELEC-04	Electric meters.	$ -	$ 527,000			--							Condensate meter value used instead. This is conservative
ELEC-05	PV System	$ -	$ 85,379,000							$ 85,379,000			
ELEC-06	Lighting Upgrade	$ -	$ 7,552,000					$ 7,552,000					
UT-01	Utility tunnel inspection report.	$ 84,000	$ -								$ 84,000		
UT-02	Utility tunnel structure repair.	$ 800,000	$ -								$ 800,000		
UT-03	Sump pump replacement and maintenance program.	$ 60,000	$ -								$ 60,000		
UT-04	Replace 500 feet of pipe supports per year. Does not include piping.	$ 5,120,000	$ -								$ 5,120,000		
MISC-01	Emergency water storage tank of 1,600,000 gallons	$ -	$ 4,568,000									$ 4,568,000	
MISC-02	HVAC building controls study	$ 1,229,000	$ -				$ 1,229,000						
MISC-03	Existing building HVAC control upgrades	$ 50,455,000	$ -				$ 50,455,000						
MISC-04	Commissioning of existing buildings	$ -	$ 21,524,000						$ 21,524,000				
MISC-05	SCADA system	$ -	$ 978,000			$ 978,000							
MISC-06	CUP booster pump	$ -	$ 89,000									$ 89,000	
				$ 102,781,000	$ 40,707,000	$ 2,904,000	$ 51,684,000	$ 7,552,000	$ 21,524,000	$ 85,379,000	$ 26,983,000	$ 5,767,000	

University of Houston
UH Alternate 0B
Alternative 0B—Non-CHP: Satellite Chilled Water Plant
Conceptual Design Estimates
8/5/2022

Alternate 0B	18,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement										
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	18,750	sf		$0		$0	$ 1.00	$18,750	$1.00	$18,750
Dump fee	174	cy		$0		$0	$ 25.00	$4,340	$25.00	$4,340
Haul off 12 cy/ld x 2 hr rt	43	hr		$0		$0	$ 68.00	$2,951	$68.00	$2,951
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	2,083	cy		$0		$0	$ 18.00	$37,500	$18.00	$37,500
Import fill	2,083	cy	$ 6.00	$12,500	$ 9.00	$18,750	$ 10.00	$20,833	$25.00	$52,083
Fdn Struct exc	1,650	cy		$0		$0	$ 25.00	$41,250	$25.00	$41,250
Dump fee	3,733	cy		$0		$0	$ 25.00	$93,333	$25.00	$93,333
Hal off 12 cy/ld x 3 hr rt	933	hr		$0		$0	$ 68.00	$63,467	$68.00	$63,467
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	1,389	cy		$0		$0	650.00	$902,778	$650.00	$902,778
Misc concrete	200	cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	61	cy		$0		$0	1000.00	$61,111	$1,000.00	$61,111
Slab on grade 12in	18,750	sf		$0		$0	14.00	$262,500	$14.00	$262,500
Tilt skin 30 hi	16,500	sf		$0		$0	55.00	$907,500	$55.00	$907,500
Mechanical pads	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
				$0		$0		$0	$0.00	$0
Div 34										
CMU misc	3,420	sf		$0		$0	28.00	$95,760	$28.00	$95,760
									$0.00	
Metals										
Steel framing #15lb/sf	141	tn		$0		$0	$ 8,000.00	$1,125,000	$8,000.00	$1,125,000
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	18,750	sf		$0		$0	$ 5.00	$93,750	$5.00	$93,750
skin back u framing 4#/sf	33	tn		$0		$0	$ 8,000.00	$264,000	$8,000.00	$264,000
Misc metals	18,750	sf		$0		$0	$ 1.00	$18,750	$1.00	$18,750
Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	18,750	sf	$ 1.00	$18,750	$ 1.00	$18,750		$0	$2.00	$37,500
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	16	lf		$0		$0	$ 350.00	$5,600	$350.00	$5,600
Counter top	40	sf		$0		$0	$ 58.00	$2,320	$58.00	$2,320
Wall cabinets	16	lf		$0		$0	$ 375.00	$6,000	$375.00	$6,000
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	18,750	sf		$0		$0	$ 0.40	$7,500	$0.40	$7,500
Fire stopping	18,750	sf		$0		$0	$ 0.50	$9,375	$0.50	$9,375
Waterproofing slab	18,750	sf		$0		$0	$ 8.00	$150,000	$8.00	$150,000
Waterproofing walls	1,650	sf		$0		$0	$ 9.00	$14,850	$9.00	$14,850
Roofing	18,750	sf		$0		$0	$ 18.00	$337,500	$18.00	$337,500
Sheet metal	18,750	sf		$0		$0	$ 4.75	$89,063	$4.75	$89,063
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	18,750	sf		$0		$0	$ 4.50	$84,375	$4.50	$84,375
				$0		$0		$0	$0.00	$0
Div 8										
HM Frame	11	ea	$150	$1,650	650	$7,150		$0	$800.00	$8,800
Hm Door	11	ea	$150	$1,650	700	$7,700		$0	$850.00	$9,350
Hardware	11	ea	$150	$1,650	1,000	$11,000		$0	$1,150.00	$12,650
Glass dr	1	ea		$0		$0	$3,800	$3,800	$3,800.00	$3,800
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	1,650	sf		$0		$0	$125	$206,250	$125.00	$206,250
Int glazing	800	sf		$0		$0	$125	$100,000	$125.00	$100,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	1	ea		$0		$0	$20,000	$20,000	$20,000.00	$20,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall (interor of exteror wall) x 30-0		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,900	sf		$0		$0	18.00	$34,200	$18.00	$34,200
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	80	hr		$0		$0	125.00	$10,000	$125.00	$10,000
Firestopping at top of wall	190	lf		$0		$0	6.00	$1,140	$6.00	$1,140
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	1,750	sf		$0		$0	$ 10.00	$17,500	$10.00	$17,500
Open ceiling painted	17,000	sf		$0		$0	$ 1.50	$25,500	$1.50	$25,500
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	18,750	sf		$0		$0	$ 2.00	$37,500	$2.00	$37,500
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	18,750	sf		$0		$0	$ 1.50	$28,125	$1.50	$28,125
Carpet,		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	1,750	sf		$0		$0	$ 8.00	$14,000	$8.00	$14,000
Epoxy sealer	17,000	sf		$0		$0	15.00	$255,000	$15.00	$255,000
Epoxy sealer mezzanine	-	sf		$0		$0	15.00	$0	$15.00	$0
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	3,800	sf		$0		$0	1.00	$3,800	$1.00	$3,800
Paint drs	11	ea		$0		$0	150.00	$1,650	$150.00	$1,650
Paint steel	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Hoisting	24	hr		$0		$0	125.00	$3,000	$125.00	$3,000
Paint mezzanine	-	sf		$0		$0	1.00	$0	$1.00	$0
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	18,750	sf		$0		$0	2.00	$37,500	$2.00	$37,500
Signage	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1	ls		$0		$0	60,000	$60,000	$60,000.00	$60,000
				$0		$0		$0	$0.00	$0
Option-7 Satellite Major Equipment 18,750 GSF										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
1000 Ton Magnetic Bearing Chiller	2	EA	$ 75,000	$150,000	$448,000	$896,000		$0	$523,000	$1,046,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250

Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	2	EA	$ 100,000	$200,000	$196,000	$392,000		$0	$296,000	$592,000
Primary CHW Pumps	3	EA	$ 15,000	$45,000	$60,000	$180,000		$0	$75,000	$225,000
Secondary CHW Pumps	3	EA	$ 25,000	$75,000	$150,000	$450,000		$0	$175,000	$525,000
Chilled Water Expansion Tank	1	EA	$ 5,000	$5,000	$40,000	$40,000		$0	$45,000	$45,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	2	EA	$ 25,000	$50,000	$150,000	$300,000		$0	$175,000	$350,000
MEP General Conditions - 18,750 GSF										
Temp Power & Lighting - mods area	18,750	sf		$0		$0	$1.00	$18,750	$1.00	$18,750
MEP Hoisting - Crane Rental, HVAC Equipment	26	day		$0		$0	$ 1,800.00	$46,800	$1,800.00	$46,800
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	18,750	sf		$0		$0	5.10	$95,625	$5.10	$95,625
Fire Protection Pipe Sleeves & Fire Seal Penetrations	18,750	sf		$0		$0	0.10	$1,875	$0.10	$1,875
Fire Protection Seismic Restraints per NFPA 13	18,750	sf		$0		$0	0.15	$2,813	$0.15	$2,813
8" Entry Assy w valves & meters -	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	20	lf		$0		$0	145.00	$2,900	$145.00	$2,900
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	32	mh		$0		$0	115.00	$3,680	$115.00	$3,680
Fire Pump 100 HP, 1500 gpm - allw - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	6,283.63	$6,284	$6,283.63	$6,284
Plumbing - 18,750 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	7	fix		$0		$0	137.00	$959	$137.00	$959
Sterilization, Chlorination, Domestic Water System	7	fix		$0		$0	45.00	$315	$45.00	$315
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,000.00	$2,000	$2,000.00	$2,000
22-05-29.10 Hangers And Supports For Plumbing/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (8 ea x 4)	32	ea		$0		$0	100.00	$3,200	$100.00	$3,200
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	18,750	sf		$0		$0	0.80	$15,000	$0.80	$15,000
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	18,750	sf		$0		$0	0.10	$1,875	$0.10	$1,875
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	7	ea		$0		$0	2,950.00	$20,650	$2,950.00	$20,650
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	5,625	sf		$0		$0	3.70	$20,813	$3.70	$20,813
Building Nat Gas Pipe Distribution - none required	-	sf		$0		$0	0.70	$0	$0.70	$0
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	1	ea		$0		$0	9,900.00	$9,900	$9,900.00	$9,900
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	18,750	sf		$0		$0	0.30	$5,625	$0.30	$5,625
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters (2 ea)	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	7	ea		$0		$0	3,200.00	$22,400	$3,200.00	$22,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	6	ea		$0		$0	450.00	$2,700	$450.00	$2,700
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	18,750	sf		$0		$0	0.30	$5,625	$0.30	$5,625
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	4	ea		$0		$0	575.00	$2,300	$575.00	$2,300
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	140	lf		$0		$0	210.00	$29,400	$210.00	$29,400
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	18,750	sf		$0		$0	2.20	$41,250	$2.20	$41,250
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	14,529.63	$14,530	$14,529.63	$14,530
				$0		$0		$0	$0.00	$0
HVAC - 18,750 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	18,750	sf		$0		$0	0.75	$14,063	$0.75	$14,063
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	4,000	ton		$0		$0	38.00	$152,000	$38.00	$152,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	18,750	sf		$0		$0	0.33	$6,188	$0.33	$6,188
Mech Contractor Assist 3rd Party - Cx Commissioning Support (4 men 1 week)	160	mh		$0		$0	130.00	$20,800	$130.00	$20,800
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	18,750	sf		$0		$0	3.00	$56,250	$3.00	$56,250
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	12,188	lb		$0		$0	0.15	$1,828	$0.15	$1,828
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	4,000	ton		$0		$0	88.00	$352,000	$88.00	$352,000
Plant HVAC Chilled Water Pipe Insulation	4,000	ton		$0		$0	110.00	$440,000	$110.00	$440,000
Cooling Tower Cell Overflow Drain Piping	5	ea		$0		$0	3,000.00	$15,000	$3,000.00	$15,000
Cooling Tower Equalizer & By-pass piping	4,000	ton		$0		$0	162.00	$648,000	$162.00	$648,000
Cooling Tower Chill & Condenser Water Plant Piping	4,000	ton		$0		$0	294.00	$1,176,000	$294.00	$1,176,000
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	-	lsum		$0		$0	500,000.00	$0	$500,000.00	$0
Boiler Install - Loose Piping from Vendor	-	ea		$0		$0	7,000.00	$0	$7,000.00	$0
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	-	sf		$0		$0	11.00	$0	$11.00	$0
Boiler Feedwater Piping & Insulation	-	sf		$0		$0	14.00	$0	$14.00	$0

23-07-13.10 Duct Thermal Insulation								
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	7,313	sf	$0	$0	5.40	$39,490	$5.40	$39,490
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	4,000	ton	$0	$0	10.00	$40,000	$10.00	$40,000
23-09-23.10 Control Components/DDC Systems								
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (8 ea) allw	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt	$0	$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	2	pt	$0	$0	2,000.00	$4,000	$2,000.00	$4,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt	$0	$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea	$0	$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	18,750	sf	$0	$0	2.00	$37,500	$2.00	$37,500
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
23-09-53.10 Control Components								
Control Components, Chill & Condsr Control Valves & Specialties	4,000	ton	$0	$0	60.00	$240,000	$60.00	$240,000
Control Components, Steam & Stm Condensate Control Valves & Specialties	-	ls	$0	$0	200,000.00	$0	$200,000.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	8	ea	$0	$0	170.00	$1,360	$170.00	$1,360
23-23-16.10 Refrigerant Piping Component Specialties								
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 4,000 Ton)	10,000	lb	$0	$0	14.00	$140,000	$14.00	$140,000
23-31-13.13 Rectangular Metal Ducts								
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (18,750 sf)	12,188	lb	$0	$0	14.40	$175,507	$14.40	$175,507
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 4 ea	-	lf	$0	$0	280.00	$0	$280.00	$0
23-31-13.19 Duct Accessories								
Balance Dampers & Turning Vanes (SF Basis) at 50%	18,750	sf	$0	$0	0.25	$4,688	$0.25	$4,688
Flex Duct (SF Basis) at 50% - SA Only	18,750	sf	$0	$0	0.14	$2,625	$0.14	$2,625
Fire/ Smoke Dampers (SF Basis)	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
Duct Access Door, insulated, (SF Basis)	18,750	sf	$0	$0	0.13	$2,438	$0.13	$2,438
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea	$0	$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans								
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	18,750	sf	$0	$0	2.00	$37,500	$2.00	$37,500
23-36-13.10 Constant Volume Mixing Boxes								
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	8	ea		$0	1480	$11,840	$1,480.00	$11,840
23-37-13.10 Diffusers								
Grilles, Registers & Diffusers (SF Basis)	18,750	sf	$0	$0	0.70	$13,125	$0.70	$13,125
25-10-10.10 Integrated Automation - Instrumentation & Controls								
Controllers (Redundant PLC, Panel & Remote I/O Panels) (0.25)	1	ls	$0	$0	126,480	$126,480	$126,480	$126,480
Control System Hardware (2 Work Sta, 2 Server, Server Racks Redundant Switches Firewall (0.50)	1	ls	$0	$0	60,000	$60,000	$60,000	$60,000
Control Room Furniture (Console, 4 dual screen monitors) (0.50)	1	ls	$0	$0	100,000	$100,000	$100,000	$100,000
Control System Software (License)	1	ls	$0	$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning) (0.25)	1	ls	$0	$0	510,000	$510,000	$510,000	$510,000
Balance of Plant Instrumentation (0.25)	1	ls	$0	$0	127,000	$127,000	$127,000	$127,000
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	143,147.09	$143,147	$143,147.09	$143,147
Electrical - 18,750 GSF								
26-05-13.10 Cable Terminations,								
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	18,750	sf	$0	$0	0.65	$12,188	$0.65	$12,188
26-05-19.35 Cable Terminations								
Termination 2-way connectors, copper or alum, 600 volt, #600 - (800A) 4 ckt x 2 set x 3w x 2 plcs, 970 T Chiller Ckt	48	ea	$0	$0	225.00	$10,800	$225.00	$10,800
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	24	ea	$0	$0	245.00	$5,880	$245.00	$5,880
26-05-19.90 Wire								
Wire, copper, for Light Fixtures (Sqft Basis)	18,750	sf	$0	$0	1.60	$30,000	$1.60	$30,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	18,750	sf	$0	$0	1.05	$19,688	$1.05	$19,688
26-05-26.80 Grounding								
Building Ground Ring	550	lf	$0	$0	26.00	$14,300	$26.00	$14,300
Grounding New Panels & Switchboards	12	ea	$0	$0	300.00	$3,600	$300.00	$3,600
Ground New Substation (Dbl Ended)	2	ea	$0	$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea	$0	$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea	$0	$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea	$0	$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
26-05-29.20 Hangers								
Seismic or Special Bracing of Conduit & equipment	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	14	ea	$0	$0	475.00	$6,650	$475.00	$6,650
26-05-33.05 Conduit								
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	18,750	sf	$0	$0	3	$56,250	$3.00	$56,250
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	18,750	sf	$0	$0	2.25	$42,188	$2.25	$42,188
Conduit for Light Fixtures (Sqft Basis) -	18,750	sf	$0	$0	3.80	$71,250	$3.80	$71,250
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	18,750	sf	$0	$0	1.10	$20,625	$1.10	$20,625
20A Feeder Ckt. - FCU Term Unit x 80' ave (8 allw)	640	lf	$0	$0	13.30	$8,512	$13.30	$8,512
100A Feeder Ckt - Cool Tower Fans., 5 each x 220' each ave	1,100	lf	$0	$0	33.00	$36,300	$33.00	$36,300
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf	$0	$0	33.00	$5,280	$33.00	$5,280
100A Feeder Ckt - Boiler FD Fans, 4 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
150A Elect Ckt - CHW Primary Pumps, 5 each x 100' ave allw	500	lf	$0	$0	37.00	$18,500	$37.00	$18,500
225A Elect Ckt - Boiler Feedwater Pumps, 4 each x 120' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
225A Elect Ckt - Btm Discharge FD Boiler Fan, 4 each x 100' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
650A Elect Ckt - CHW Secondary Pumps - 5 each x 70' ea ave	350	lf	$0	$0	205.00	$71,750	$205.00	$71,750
600A Elect Ckt - Cool Tower Pumps, 4 ea x 120' each ave	480	lf	$0	$0	183.00	$87,840	$183.00	$87,840
1000A Elect Ckt - 1000 Ton Chillers, 4 each x 140' each ave	560	lf	$0	$0	344.00	$192,640	$344.00	$192,640
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel								
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea	$0	$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes								
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	223	ea	$0	$0	57.00	$12,711	$57.00	$12,711
Outlet boxes, pressed steel, 4" square - Card Readers - CR	4	ea	$0	$0	57.00	$228	$57.00	$228
Outlet boxes, pressed steel, 4" square - CCTV locations	6	ea	$0	$0	57.00	$342	$57.00	$342
26-05-33.65 Pull Boxes								
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	4	ea	$0	$0	350.00	$1,400	$350.00	$1,400
26-05-33.95 Cutting And Drilling								
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea	$0	$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type								
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	18,750	sf	$0	$0	0.95	$17,813	$0.95	$17,813
26-05-80.10 Motor Connections								
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	18,750	sf	$0	$0	0.95	$17,813	$0.95	$17,813
26-13-00.00 Medium Voltage Switchgear/ Substations								
7000A Double Ended Substation #1, CUP size allw	1	ea	$0	$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2	-	ea	$0	$0	1,380,000.00	$0	$1,380,000.00	$0
1200A Switchgear, 15 KV - CUP size allw	1	ea	$0	$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP allw	2	ea	$0	$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls	$0	$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type								
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	5	ea	$0	$0	9,500.00	$47,500	$9,500.00	$47,500
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	-	ea	$0	$0	35,000.00	$0	$35,000.00	$0
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, CUP Utility allw	2	ea	$0	$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	5	ea	$0	$0	725.00	$3,625	$725.00	$3,625
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	-	ea	$0	$0	1,170.00	$0	$1,170.00	$0
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA CUP Utility allw	2	ea	$0	$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls	$0	$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards								
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 970 ton Chillers (1 per)	4	ea	$0	$0	22,700.00	$90,800	$22,700.00	$90,800
26-24-16.30 Panelboards Commercial Applications								
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	18,750	sf	$0	$0	3.01	$56,438	$3.01	$56,438
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	18,750	sf	$0	$0	1.05	$19,688	$1.05	$19,688
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	18,750	sf	$0	$0	0.75	$14,063	$0.75	$14,063
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	18,750	sf	$0	$0	0.26	$4,875	$0.26	$4,875
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea	$0	$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea	$0	$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12	ea	$0	$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center								
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea	$0	$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements								
Duplex & Special Receptacle Devices CUP (SF Basis)	18,750	sf	$0	$0	0.85	$15,938	$0.85	$15,938
26-28-16.10 Circuit Breakers								
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	18,750	sf	$0	$0	1.12	$21,000	$1.12	$21,000
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	4	ea	$0	$0	8,500.00	$34,000	$8,500.00	$34,000
26-28-16.20 Safety Switches								
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives								
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	4	ea	$0	$0	5,900.00	$23,600	$5,900.00	$23,600
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0

Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	4	ea	$0	$0	7,300.00	$29,200	$7,300.00	$29,200
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	-	ea	$0	$0	8,100.00	$0	$8,100.00	$0
Variable frequency drives, custom-engineered, 460 volt, 450 HP - labor only, CHW Sec Pumps	4	ea	$0	$0	12,200.00	$48,800	$12,200.00	$48,800
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4	ea	$0	$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators								
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly Tank was 1 ea	-	ea	$0	$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2) was 2 ea	-	ea	$0	$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel was 750 gal	-	gal	$0	$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection								
Building Lightning Protection CUP (SF Basis)	18,750	sf	$0	$0	0.70	$13,125	$0.70	$13,125
26-51-13.50 Interior Lighting Fixtures								
Interior Networked EMCS Light Control Points, Conduit & wire	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	18,750	sf	$0	$0	11.00	$206,250	$11.00	$206,250
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	33	ea	$0	$0	170.00	$5,610	$170.00	$5,610
26-52-13.10 Emergency Lighting And Battery Units								
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8	ea	$0	$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures								
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	3	ea	$0	$0	435.00	$1,305	$435.00	$1,305
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea	$0	$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices								
Lighting Controls, Conduit and wire - Office area - 30% of Plant	5,625	sf	$0	$0	2.00	$11,250	$2.00	$11,250
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8	ea	$0	$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips								
Fixture Whips (SF Basis) -	18,750	sf	$0	$0	0.45	$8,438	$0.45	$8,438
					$0			
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	108,656.04	$108,656	$108,656.04	$108,656
27-00-00.00 COMMUNICATIONS								
27-11-19.10 Termination Blocks And Patch Panels								
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea	$0	$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber								
Tel/ Data System CUP Conduit & Cable (SF Basis)	18,750	sf	$0	$0	3.00	$56,250	$3.00	$56,250
Tel/ Data System, Engineer & Program (SF Basis)	18,750	sf	$0	$0	0.21	$3,938	$0.21	$3,938
Tel/ Data System, Backbone allw (SF Basis)	18,750	sf	$0	$0	0.30	$5,625	$0.30	$5,625
Tel/ Data Devices CUP (SF Basis)	18,750	sf	$0	$0	0.65	$12,188	$0.65	$12,188
Tel./ Data Equipment Rack complete allw	2	ea	$0	$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	10	ea	$0	$0	280.00	$2,800	$280.00	$2,800
Wire Management, Vertical & Horiz per Rack	2	ea	$0	$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	22	lf	$0	$0	78.00	$1,716	$78.00	$1,716
			$0	$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System								
Sound & Public Address System Conduit & cable - CUP (SF Basis)	18,750	sf	$0	$0	1.00	$18,750	$1.00	$18,750
Sound & PA Speaker 1 per 800 sf, qty allw	23	ea	$0	$0	250.00	$5,750	$250.00	$5,750
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
WAP - Wireless Access Paging Device - 1 per 2400 sf	8	ea	$0	$0	270.00	$2,160	$270.00	$2,160
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	18,750	sf	$0	$0	0.40	$7,500	$0.40	$7,500
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls	$0	$0	7,170.30	$7,170	$7,170.30	$7,170
28-05-00.00 ELECTRONIC SAFETY & SECURITY								
28-23-13.10 CCTV Security & Door Egress System								
CCTV Security Monitoring System Conduit & Cable (SF Basis)	18,750	sf	$0	$0	0.80	$15,000	$0.80	$15,000
CCTV Camera Dome Fixed (7 ea) - interior qty allw	4	ea	$0	$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	2	ea	$0	$0	2,570.00	$5,140	$2,570.00	$5,140
Security Door Egress System Conduit and Cable (SF Basis)	18,750	sf	$0	$0	0.75	$14,063	$0.75	$14,063
Door Card Reader Control/ Alarm Panel	1	ea	$0	$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - qty allw	4	ea	$0	$0	1,150.00	$4,600	$1,150.00	$4,600
Door Duress Pushbutton - PB , qty allw	4	ea	$0	$0	145.00	$580	$145.00	$580
Door Strike/ Contact	4	ea	$0	$0	220.00	$880	$220.00	$880
Door Position Switch	4	ea	$0	$0	200.00	$800	$200.00	$800
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	4	ea	$0	$0	680.00	$2,720	$680.00	$2,720
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea	$0	$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea	$0	$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	4	ea	$0	$0	55.00	$220	$55.00	$220
Door Large Pull Box/ J- Box 12"x12" x 4"	4	ea	$0	$0	190.00	$760	$190.00	$760
28-31-23.50 Alarm Panels And Devices								
Fire Alarm System Core & Shell (SF Basis)	18,750	sf	$0	$0	3.52	$66,000	$3.52	$66,000
Fire Alarm System Programming (SF Basis)	18,750	sf	$0	$0	0.32	$6,000	$0.32	$6,000
Fire Alarm System Test & Check Out	18,750	sf	$0	$0	0.15	$2,813	$0.15	$2,813
Fire Alarm Master Control Panel, Office > 28,000 SF	1	ea	$0	$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	23	ea	$0	$0	340.00	$7,820	$340.00	$7,820
Fire Alarm Pull Station (addressable), qty allw	2	ea	$0	$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls	$0	$0	8,306.75	$8,307	$8,306.75	$8,307
			$0	$0		$0		$0
Cost of Work Subtotal			$732,250	$3,349,940		$15,663,158		$19,745,348

	Premium Time		
	Direct Construction Costs		$19,745,348
	General Conditions	10.00%	$1,974,535
	Sub-Total Construction Costs		$21,719,883
	P&P bonds	2.5%	$542,997
	Building Permit	0.45%	$97,739
	Sub-Total Construction Costs		$22,360,620
	GL & Umbrella	1.50%	$335,409
	Professional liability	1.00%	$223,606
	Builder Risk	0.10%	$22,361
	Design Completion Uncertainty Factor	25.00%	$5,735,499
	Sub-Total Construction Costs		$28,677,495
	GC Fee	6.00%	$1,720,650
	Design fee	8.00%	$2,294,200
Alternate 0B	**Total Construction Costs**		**$32,692,344**
			$32,692,000

AACE Class 5 ROM Budget Range:	High	50%	$49,038,516
	Low	-30%	$22,884,641

University of Houston
UH Alternative 0C
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power and Backup Steam Boiler
Conceptual Design Estimates
8/5/2022

Alternate 0C	31,400	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement				$0		$0		$0		$0
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	31,400	sf		$0		$0	$ 1.00	$31,400	$1.00	$31,400
Dump fee	291	cy		$0		$0	$ 25.00	$7,269	$25.00	$7,269
Haul off 12 cy/ld x 2 hr rt	73	hr		$0		$0	$ 68.00	$4,943	$68.00	$4,943
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
Excavation 3-0	3,489	cy		$0		$0	$ 18.00	$62,800	$18.00	$62,800
Import fill	3,489	cy	$ 6.00	$20,933	$ 9.00	$31,400	$ 10.00	$34,889	$25.00	$87,222
Fdn Struct exc	2,505	cy		$0		$0	$ 25.00	$62,631	$25.00	$62,631
Dump fee	5,994	cy		$0		$0	$ 25.00	$149,854	$25.00	$149,854
Hal off 12 cy/ld x 3 hr rt	1,499	hr		$0		$0	$ 68.00	$101,901	$68.00	$101,901
				$0		$0		$0	$0.00	$0
Div 3										
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	2,326	cy		$0		$0	650.00	$1,511,852	$650.00	$1,511,852
Misc concrete	100	cy		$0		$0	800.00	$80,000	$800.00	$80,000
Grade beam	79	cy		$0		$0	1000.00	$79,333	$1,000.00	$79,333
Slab on grade 12in	31,400	sf		$0		$0	14.00	$439,600	$14.00	$439,600
Til up skin 30 hi	21,420	sf		$0		$0	55.00	$1,178,100	$55.00	$1,178,100
Mechanical pads	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
				$0		$0		$0	$0.00	$0
Div 4										
CMU misc	1,800	sf		$0		$0	28.00	$50,400	$28.00	$50,400
									$0.00	
Metals										
Steel framing #15lb/sf	236	tn		$0		$0	$ 8,000.00	$1,884,000	$8,000.00	$1,884,000
Cooling tower framing 35#/sf		tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Galv grating		sf		$0		$0	$ 55.00	$0	$55.00	$0
Metal roof deck	31,400	sf		$0		$0	$ 5.00	$157,000	$5.00	$157,000
skin back u framing 4#/sf	43	tn		$0		$0	$ 8,000.00	$342,720	$8,000.00	$342,720
Misc metals	31,400	sf		$0		$0	$ 1.00	$31,400	$1.00	$31,400
Alum Handrail		lf		$0		$0	$ 300.00	$0	$300.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	31,400	sf	$ 1.00	$31,400	$ 1.00	$31,400		$0	$2.00	$62,800
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	12	lf		$0		$0	$ 350.00	$4,200	$350.00	$4,200
Counter top	30	sf		$0		$0	$ 58.00	$1,740	$58.00	$1,740
Wall cabinets	12	lf		$0		$0	$ 375.00	$4,500	$375.00	$4,500
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	31,400	sf		$0		$0	$ 0.40	$12,560	$0.40	$12,560
Fire stopping	31,400	sf		$0		$0	$ 0.50	$15,700	$0.50	$15,700
Waterproofing slab	31,400	sf		$0		$0	$ 8.00	$251,200	$8.00	$251,200
Waterproofing walls	1,800	sf		$0		$0	$ 9.00	$16,200	$9.00	$16,200
Roofing	31,400	sf		$0		$0	$ 18.00	$565,200	$18.00	$565,200
Sheet metal	31,400	sf		$0		$0	$ 4.75	$149,150	$4.75	$149,150
Canopies		sf		$0		$0	$ 100.00	$0	$100.00	$0
Fireproofing	31,400	sf		$0		$0	$ 5.00	$157,000	$5.00	$157,000
									$0.00	
Div 8										
HM Frame	7	ea	$150	$1,050	650	$4,550		$0	$800.00	$5,600
Hm Door	7	ea	$150	$1,050	700	$4,900		$0	$850.00	$5,950
Hardware	7	ea	$150	$1,050	1,000	$7,000		$0	$1,150.00	$8,050
Card key system	4	ea		$0		$0	$2,500	$10,000	$2,500.00	$10,000
Ext Glazing 10% of wall	2,142	sf		$0		$0	$125	$267,750	$125.00	$267,750
Int glazing	400	sf		$0		$0	$125	$50,000	$125.00	$50,000
Skylight	300	sf		$0		$0	$100	$30,000	$100.00	$30,000
Ohd dr	7	ea		$0		$0	$20,000	$140,000	$20,000.00	$140,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions						$0				
Furred wall est NA		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,430	sf		$0		$0	20.00	$28,600	$20.00	$28,600
Column covers		sf		$0		$0	20.00	$0	$20.00	$0
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	50	hr		$0		$0	125.00	$6,250	$125.00	$6,250
Firestopping at top of wall	600	lf		$0		$0	6.00	$3,600	$6.00	$3,600
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Open ceiling painted	16,750	sf		$0		$0	$ 1.50	$25,125	$1.50	$25,125
Drywall ceiling	2,000	sf		$0		$0	$ 18.00	$36,000	$18.00	$36,000
Acoustical sound panels (allow)	31,400	sf		$0		$0	$ 2.00	$62,800	$2.00	$62,800
				$0		$0		$0	$0.00	$0
Div 9 Flooring										
Flr prep minor	31,400	sf		$0		$0	$ 1.50	$47,100	$1.50	$47,100
Carpet, CPT		sf		$0		$0	$ 6.00	$0	$6.00	$0
LVT	1,500	sf		$0		$0	$ 8.00	$12,000	$8.00	$12,000
Epoxy sealer	29,900	sf		$0		$0	15.00	$448,500	$15.00	$448,500
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	2,860	sf		$0		$0	1.00	$2,860	$1.00	$2,860
Paint drs	7	ea		$0		$0	100.00	$700	$100.00	$700
Paint steel	31,400	sf		$0		$0	1.00	$31,400	$1.00	$31,400
Hoisting	16	hr		$0		$0	125.00	$2,000	$125.00	$2,000
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	31,400	sf		$0		$0	2.00	$62,800	$2.00	$62,800
Signage	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	31,400	sf		$0		$0	1.00	$31,400	$1.00	$31,400
Lab equipment	1	ls		$0		$0	10,000	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator Na		ea		$0		$0	50,000	$0	$50,000.00	$0
Overhead Crane allow	1	ls		$0		$0	66,000	$66,000	$66,000.00	$66,000
				$0		$0		$0	$0.00	$0
Option-1 Major Equipment (10,325 SF)										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Gen Set, 4 MW (4000 KW) xx Pri/ 480/277 Sec	7	EA	$ 53,000	$371,000	$ 3,000,000	$21,000,000		$0	$3,053,000.00	$21,371,000
Auto Transfer Switch, 3000A w Auto Bypass (size allw)	7	EA	$ 6,000	$42,000	$ 225,000	$1,575,000		$0	$231,000.00	$1,617,000
3000A Feeder, Gen Set to Elect Gear (125' ave x 6 ckts)	750	LF	$ 282	$211,500	$ 959	$719,250		$0	$1,241.00	$930,750
Gen Set Lube Oil System Tanks, Pumps, Accessories	2	EA	$ 8,000.00	$16,000	$ 85,000.00	$170,000		$0	$93,000.00	$186,000
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Air handler + Ops area	1	EA	$ 21,875	$21,875	$ 115,000	$115,000		$0	$136,875	$136,875
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000

University of Houston
UH Alternative 0C
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power and Backup Steam Boiler
Conceptual Design Estimates
8/5/2022

Alternate 0C	31,400	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
1000 Ton Magnetic Bearing Chiller	2	EA	$ 75,000	$150,000	$448,000	$896,000		$0	$523,000	$1,046,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	2	EA	$ 100,000	$200,000	$196,000	$392,000		$0	$296,000	$592,000
Primary CHW Pumps	3	EA	$ 15,000	$45,000	$60,000	$180,000		$0	$75,000	$225,000
Secondary CHW Pumps	3	EA	$ 25,000	$75,000	$150,000	$450,000		$0	$175,000	$525,000
Chilled Water Expansion Tank	1	EA	$ 5,000	$5,000	$40,000	$40,000		$0	$45,000	$45,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	2	EA	$ 25,000	$50,000	$150,000	$300,000		$0	$175,000	$350,000
85 Kpph Packaged Steam Boiler	1	EA	$ 200,000	$200,000	$1,475,000	$1,475,000		$0	$1,675,000	$1,675,000
Deaerator - 260,000 lb/h Capacity	1	EA	$ 75,000	$75,000	$275,000	$275,000		$0	$350,000	$350,000
Boiler Feed Water Pumps	2	EA	$ 50,000	$100,000	$75,000	$150,000		$0	$125,000	$250,000
Boiler Blowdown Tanks / System	1	LS	$ 10,000	$10,000	$50,000	$50,000		$0	$60,000	$60,000
Boiler Makeup Water Treatment System	1	LS	$ 750,000	$750,000	$1,000,000	$1,000,000		$0	$1,750,000	$1,750,000
Air handler - boiler area	1	EA	$ 26,250	$26,250	$105,000	$105,000		$0	$131,250	$131,250
Condensate Tank, (Surge tank 9,000 - 10,000 gallons)	1	EA	$ 30,000	$30,000	$130,000	$130,000		$0	$160,000	$160,000
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000
Condensate Pumps	2	EA	$ 10,000	$20,000	$20,000	$40,000		$0	$30,000	$60,000
Div 26 - for boiler										
100A Feeder Ckt - Boiler FD Fans, 1 each x 280' ave	280	lf		$0		$0	33.00	$9,240	$33.00	$9,240
100A Feeder Ckt - Stm Condensate Pumps, 2 each x 140' ave	280	lf		$0		$0	33.00	$9,240	$33.00	$9,240
225A Elect Ckt - Boiler Feedwater Pumps, 2 each x 260' ave allw	520	lf		$0		$0	53.00	$27,560	$53.00	$27,560
225A Elect Ckt - Btm Discharge FD Boiler Fan, 1 each x 280' ave allw	280	lf		$0		$0	53.00	$14,840	$53.00	$14,840
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	1	ea		$0		$0	6,500.00	$6,500	$6,500.00	$6,500
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	2	ea		$0		$0	6,500.00	$13,000	$6,500.00	$13,000
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	2	ea		$0		$0	8,100.00	$16,200	$8,100.00	$16,200
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls		$0		$0	2,897.40	$2,897	$2,897.40	$2,897
MEP General Conditions - 10,325 GSF										
Temp Power & Lighting - Building area	11,800	sf		$0		$0	$1.00	$11,800	$1.00	$11,800
MEP Hoisting - Crane Rental, HVAC Equipment	12	day		$0		$0	$ 1,800.00	$21,600	$1,800.00	$21,600
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	31,400	sf		$0		$0	5.10	$160,140	$5.10	$160,140
Fire Protection Pipe Sleeves & Fire Seal Penetrations	31,400	sf		$0		$0	0.10	$3,140	$0.10	$3,140
Fire Protection Seismic Restraints per NFPA 13	31,400	sf		$0		$0	0.15	$4,710	$0.15	$4,710
6" Entry Assy w valves & meters	1	ea		$0		$0	7,200.00	$7,200	$7,200.00	$7,200
6" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	5,060.00	$5,060	$5,060.00	$5,060
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 6" Entry assy	20	lf		$0		$0	110.00	$2,200	$110.00	$2,200
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	16	mh		$0		$0	115.00	$1,840	$115.00	$1,840
Fire Pump 100 HP, 1500 gpm - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	9,293.50	$9,294	$9,293.50	$9,294
Plumbing - 10,325 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	2	fix		$0		$0	137.00	$274	$137.00	$274
Sterilization, Chlorination, Domestic Water System	2	fix		$0		$0	45.00	$90	$45.00	$90
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	500.00	$500	$500.00	$500
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (5 ea x 2)	10	ea		$0		$0	100.00	$1,000	$100.00	$1,000
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	31,400	sf		$0		$0	0.80	$25,120	$0.80	$25,120
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	31,400	sf		$0		$0	0.10	$3,140	$0.10	$3,140
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	-	ea		$0		$0	120.00	$0	$120.00	$0
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	-	ea		$0		$0	57.00	$0	$57.00	$0
Domestic Water Plumbing Pipe Insulation	31,400	sf		$0		$0	1.00	$31,400	$1.00	$31,400
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	2	ea		$0		$0	2,950.00	$5,900	$2,950.00	$5,900
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	8,000.00	$8,000	$8,000.00	$8,000
Industrial Water IW system Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	3,098	sf		$0		$0	3.70	$11,463	$3.70	$11,463
Building Nat Gas Pipe Distribution	31,400	sf		$0		$0	1.25	$39,250	$1.25	$39,250
Natural Gas to Gen Sets	6	lsum		$0		$0	5,000.00	$30,000	$5,000.00	$30,000
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	-	ea		$0		$0	9,900.00	$0	$9,900.00	$0
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	31,400	sf		$0		$0	0.12	$3,768	$0.12	$3,768
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	31,400	sf		$0		$0	0.30	$9,420	$0.30	$9,420
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	-	ea		$0		$0	2,600.00	$0	$2,600.00	$0
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	-	ea		$0		$0	145.00	$0	$145.00	$0
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	-	ea		$0		$0	3,960.00	$0	$3,960.00	$0
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	2	ea		$0		$0	3,200.00	$6,400	$3,200.00	$6,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sanitary CI No Hub VTR Assy, 2"-3"	1	ea		$0		$0	400.00	$400	$400.00	$400
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	31,400	sf		$0		$0	0.30	$9,420	$0.30	$9,420
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	1	ea		$0		$0	340.00	$340	$340.00	$340
Floor Sink, Mech Equip area, qty allw	8	ea		$0		$0	575.00	$4,600	$575.00	$4,600
Floor C.O., 3" & 4" qty allw	1	ea		$0		$0	410.00	$410	$410.00	$410
Grade CO, 6" to 8" size	1	ea		$0		$0	750.00	$750	$750.00	$750
Trench Drain, 12" wide w grate, E-W Run	-	lf		$0		$0	210.00	$0	$210.00	$0
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	31,400	sf		$0		$0	2.20	$69,080	$2.20	$69,080
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 40 gallon, 10 KW	-	ea		$0		$0	4,700.00	$0	$4,700.00	$0

University of Houston
UH Alternative 0C
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power and Backup Steam Boiler
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Alternate 0C	31,400	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	1	ea		$0		$0	1,095.00	$1,095	$1,095.00	$1,095
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	1	ea		$0		$0	770.00	$770	$770.00	$770
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	-	ea		$0		$0	877.00	$0	$877.00	$0
Mop Service Basin	-	ea		$0		$0	855.00	$0	$855.00	$0
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	14,080.98	$14,081	$14,080.98	$14,081
				$0		$0		$0	$0.00	$0
HVAC - 10,325 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	31,400	sf		$0		$0	0.75	$23,550	$0.75	$23,550
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	-	ton		$0		$0	38.00	$0	$38.00	$0
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	31,400	sf		$0		$0	0.33	$10,362	$0.33	$10,362
Mech Contractor Assist 3rd Party - Cx Commissioning Support (2 men 1 week)	80	mh		$0		$0	130.00	$10,400	$130.00	$10,400
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	31,400	sf		$0		$0	1.50	$47,100	$1.50	$47,100
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	31,400	sf		$0		$0	3.00	$94,200	$3.00	$94,200
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	7,744	lb		$0		$0	0.15	$1,162	$0.15	$1,162
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	-	ton		$0		$0	88.00	$0	$88.00	$0
Plant HVAC Chilled Water Pipe Insulation	-	ton		$0		$0	110.00	$0	$110.00	$0
Cooling Tower Cell Overflow Drain Piping	-	ea		$0		$0	3,000.00	$0	$3,000.00	$0
Cooling Tower Equalizer & By-pass piping	-	ton		$0		$0	162.00	$0	$162.00	$0
Cooling Tower Chill & Condenser Water Plant Piping	-	ton		$0		$0	294.00	$0	$294.00	$0
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	4,646	sf		$0		$0	5.40	$25,088	$5.40	$25,088
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	-	ton		$0		$0	10.00	$0	$10.00	$0
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt		$0		$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (5 ea) allw	10	pt		$0		$0	2,000.00	$20,000	$2,000.00	$20,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (2) Qty allw	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea		$0		$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	31,400	sf		$0		$0	3.00	$94,200	$3.00	$94,200
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialities	-	ton		$0		$0	60.00	$0	$60.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	5	ea		$0		$0	170.00	$850	$170.00	$850
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 0 Ton)	-	lb		$0		$0	14.00	$0	$14.00	$0
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.75 lbs/ sf allw (10,325 sf)	7,744	lb		$0		$0	14.40	$111,514	$14.40	$111,514
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	31,400	sf		$0		$0	0.25	$7,850	$0.25	$7,850
Flex Duct (SF Basis) at 50% - SA Only	31,400	sf		$0		$0	0.14	$4,396	$0.14	$4,396
Fire/ Smoke Dampers (SF Basis)	31,400	sf		$0		$0	0.60	$18,840	$0.60	$18,840
Duct Access Door, insulated, (SF Basis)	31,400	sf		$0		$0	0.13	$4,082	$0.13	$4,082
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea		$0		$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	31,400	sf		$0		$0	2.00	$62,800	$2.00	$62,800
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	5	ea		$0		$0	1,480.00	$7,400	$1,480.00	$7,400
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	31,400	sf		$0		$0	0.70	$21,980	$0.70	$21,980
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Control Panel & Remote I/O Panels) 0.25)	1	ls		$0		$0	77,000	$77,000	$77,000	$77,000
Control System Hardware (2 Work Sta, 2 Servers, Server Racks Redundant Switches Firewall	1	ls		$0		$0	25,000	$25,000	$25,000	$25,000
Control Room Furniture (Console, 2 dual screen monitors)	1	ls		$0		$0	40,000	$40,000	$40,000	$40,000
Control System Software (License)	1	ls		$0		$0	50,000	$50,000	$50,000	$50,000
Control System Integration (Programming, Testing, Start-up, Commissioning) 0.25	1	ls		$0		$0	250,000	$250,000	$250,000	$250,000
Balance of Plant Instrumentation 0.25)	1	ls		$0		$0	43,000	$43,000	$43,000	$43,000
HVAC Foreman at 10% JM Hour (40/60 Lab/ Mat'l split allw)	1	ls		$0		$0	45,290.94	$45,291	$45,290.94	$45,291
Electrical - 10,325 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	31,400	sf		$0		$0	1.50	$47,100	$1.50	$47,100
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #500 - (2000A) 4 ckt x 4 set x 3w x 2 plcs, 210	-	ea		$0		$0	200.00	$0	$200.00	$0
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	31,400	sf		$0		$0	1.60	$50,240	$1.60	$50,240
Wire, copper, for Duplex Receptacles (Sqft Basis)	31,400	sf		$0		$0	1.05	$32,970	$1.05	$32,970
26-05-26.80 Grounding										
Building Ground Ring	470	lf		$0		$0	26.00	$12,220	$26.00	$12,220
Grounding New Panels & Switchboards	8	ea		$0		$0	300.00	$2,400	$300.00	$2,400
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	31,400	sf		$0		$0	0.60	$18,840	$0.60	$18,840
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	12	ea		$0		$0	475.00	$5,700	$475.00	$5,700
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	31,400	sf		$0		$0	5.00	$157,000	$5.00	$157,000
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	31,400	sf		$0		$0	2.25	$70,650	$2.25	$70,650
Conduit for Light Fixtures (Sqft Basis) -	31,400	sf		$0		$0	3.80	$119,320	$3.80	$119,320
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	31,400	sf		$0		$0	1.10	$34,540	$1.10	$34,540
20A Feeder Ckt. - FCU Term Unit x 80' ave (5 allw)	400	lf		$0		$0	13.30	$5,320	$13.30	$5,320
100A Feeder Ckt - Cool Tower Fans., 8 each x 140' each ave	-	lf		$0		$0	33.00	$0	$33.00	$0
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf		$0		$0	33.00	$5,280	$33.00	$5,280
150A Elect Ckt - CHW Primary Pumps, 4 each x 100' ave allw	-	lf		$0		$0	37.00	$0	$37.00	$0
400A Elect Ckt - CHW Secondary Pumps - 4 each x 120' ea ave	-	lf		$0		$0	121.00	$0	$121.00	$0
600A Elect Ckt - Cool Tower Pumps, 4 ea x 100' each ave	-	lf		$0		$0	183.00	$0	$183.00	$0
2000A Feeder Ckt - 2100 Ton Chiller - 4 each x 160' ave	-	lf		$0		$0	686.00	$0	$686.00	$0
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	123	ea		$0		$0	57.00	$7,011	$57.00	$7,011
Outlet boxes, pressed steel, 4" square - Card Readers - CR	3	ea		$0		$0	57.00	$171	$57.00	$171
Outlet boxes, pressed steel, 4" square - CCTV locations	4	ea		$0		$0	57.00	$228	$57.00	$228
26-05-33.65 Pull Boxes										
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Gen Set Ckt	6	ea		$0		$0	350.00	$2,100	$350.00	$2,100
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										

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Alternate 0C	31,400	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	31,400	sf		$0		$0	0.95	$29,830	$0.95	$29,830
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	31,400	sf		$0		$0	1.15	$36,110	$1.15	$36,110
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1, CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2, CUP size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP Allw	2	ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	1	ea		$0		$0	9,500.00	$9,500	$9,500.00	$9,500
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility CUP allw	2	ea		$0		$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration adsorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	-	ea		$0		$0	725.00	$0	$725.00	$0
Transformer vibration adsorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - Utility CUP allw	2	ea		$0		$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 2000 A - for 2100 ton Chillers (1 per)	-	ea		$0		$0	38,700.00	$0	$38,700.00	$0
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	31,400	sf		$0		$0	3.01	$94,514	$3.01	$94,514
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	31,400	sf		$0		$0	1.05	$32,970	$1.05	$32,970
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	31,400	sf		$0		$0	0.75	$23,550	$0.75	$23,550
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	31,400	sf		$0		$0	0.26	$8,164	$0.26	$8,164
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
26-24-19.30 Motor Control Center										
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	-	ea		$0		$0	205,000.00	$0	$205,000.00	$0
26-27-26.20 Wiring Devices Elements										
Duplex & Special Receptacle Devices CUP (SF Basis)	31,400	sf		$0		$0	1.00	$31,400	$1.00	$31,400
26-28-16.10 Circuit Breakers										
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	31,400	sf		$0		$0	1.12	$35,168	$1.12	$35,168
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	2	ea		$0		$0	8,500.00	$17,000	$8,500.00	$17,000
Circuit breaker, 3 pole, 600 volt, 2000 amp, enclosed (NEMA 1) Swbds	-	ea		$0		$0	21,400.00	$0	$21,400.00	$0
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	31,400	sf		$0		$0	0.60	$18,840	$0.60	$18,840
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	-	ea		$0		$0	5,900.00	$0	$5,900.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	-	ea		$0		$0	7,300.00	$0	$7,300.00	$0
Variable frequency drives, custom-engineered, 460 volt, 250 HP - labor only, CHW Sec Pumps	-	ea		$0		$0	9,400.00	$0	$9,400.00	$0
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	-	ea		$0		$0	10,800.00	$0	$10,800.00	$0
26-32-13.13 Diesel Generators										
Plant Emergency Generator set - see equipment above	0	ls		$0		$0	0.00	$0	$0.00	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	31,400	sf		$0		$0	0.70	$21,980	$0.70	$21,980
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	31,400	sf		$0		$0	11.00	$345,400	$11.00	$345,400
Interior Lighting 100% LED Fixtures (SF Basis) - Office	-	sf		$0		$0	13.50	$0	$13.50	$0
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	18	ea		$0		$0	170.00	$3,060	$170.00	$3,060
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	4	ea		$0		$0	400.00	$1,600	$400.00	$1,600
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	2	ea		$0		$0	435.00	$870	$435.00	$870
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	3,098	sf		$0		$0	2.00	$6,196	$2.00	$6,196
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	3	ea		$0		$0	325.00	$975	$325.00	$975
26-61-13.30 Fixture Whips										
Fixture Whips (SF Basis) -	31,400	sf		$0		$0	0.45	$14,130	$0.45	$14,130
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'lsplit allw)	1	ls		$0		$0	138,745.26	$138,745	$138,745.26	$138,745
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	31,400	sf		$0		$0	3.00	$94,200	$3.00	$94,200
Tel/ Data System, Engineer & Program (SF Basis)	31,400	sf		$0		$0	0.21	$6,594	$0.21	$6,594
Tel/ Data System, Backbone allw (SF Basis)	31,400	sf		$0		$0	0.30	$9,420	$0.30	$9,420
Tel/ Data Devices CUP (SF Basis)	31,400	sf		$0		$0	0.65	$20,410	$0.65	$20,410
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	12	ea		$0		$0	280.00	$3,360	$280.00	$3,360
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	24	lf		$0		$0	78.00	$1,872	$78.00	$1,872
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	31,400	sf		$0		$0	1.00	$31,400	$1.00	$31,400
Sound & PA Speaker 1 per 800 sf, qty allw	13	ea		$0		$0	250.00	$3,250	$250.00	$3,250
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	31,400	sf		$0		$0	0.50	$15,700	$0.50	$15,700
WAP - Wireless Access Paging Device - 1 per 2400 sf	4	ea		$0		$0	270.00	$1,080	$270.00	$1,080
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	31,400	sf		$0		$0	0.40	$12,560	$0.40	$12,560
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	10,860.05	$10,860	$10,860.05	$10,860
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	11,800	sf		$0		$0	0.80	$9,440	$0.80	$9,440
CCTV Camera Dome Fixed (4 ea) - interior qty allw	4	ea		$0		$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	-	ea		$0		$0	2,570.00	$0	$2,570.00	$0
Security Door Egress System Conduit and Cable (SF Basis)	31,400	sf		$0		$0	0.75	$23,550	$0.75	$23,550
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	3	ea		$0		$0	1,150.00	$3,450	$1,150.00	$3,450
Door Duress Pushbutton - PB , qty allw	3	ea		$0		$0	145.00	$435	$145.00	$435
Door Strike/ Contact	3	ea		$0		$0	220.00	$660	$220.00	$660
Door Position Switch	3	ea		$0		$0	200.00	$600	$200.00	$600
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	3	ea		$0		$0	680.00	$2,040	$680.00	$2,040
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea		$0		$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea		$0		$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	3	ea		$0		$0	55.00	$165	$55.00	$165
Door Large Pull Box/ J- Box 12"x12" x 4"	3	ea		$0		$0	190.00	$570	$190.00	$570
28-31-23.50 Alarm Panels And Devices										
Fire Alarm System Core & Shell (SF Basis)	31,400	sf		$0		$0	3.52	$110,528	$3.52	$110,528
Fire Alarm System Programming (SF Basis)	31,400	sf		$0		$0	0.32	$10,048	$0.32	$10,048
Fire Alarm System Test & Check Out	31,400	sf		$0		$0	0.15	$4,710	$0.15	$4,710
Fire Alarm Master Control Panel, Office up to 28,000 SF	1	ea		$0		$0	18,900.00	$18,900	$18,900.00	$18,900
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	13	ea		$0		$0	340.00	$4,420	$340.00	$4,420
Fire Alarm Pull Station (addressable), qty allw	2	ea		$0		$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	10,277.80	$10,278	$10,277.80	$10,278
Cost of Work Subtotal				$2,785,158		$30,870,090		$15,836,014		$49,491,262

Premium Time		
Direct Construction Costs		$49,491,262
General Conditions	10.00%	$4,949,126
Sub-Total Construction Costs		$54,440,389
P&P bonds	2.5%	$1,361,010
Building Permit	0.45%	$244,982
Sub-Total Construction Costs		$56,046,380

University of Houston
UH Alternate 0C
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power and Backup Steam Boiler
Conceptual Design Estimates
8/5/2022

Alternate 0C	31,400	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
							GL & Umbrella		1.00%	$560,464
							Professional liability		1.00%	$560,464
							Builder Risk		0.10%	$56,046
							Design Completion Uncertainty Factor		25.00%	$14,305,839
							Sub-Total Construction Costs			$71,529,193
							GC Fee		6.00%	$4,291,752
							Design Fee		8.00%	$5,722,335
Alternate 0C							**Total Construction Costs**			**$81,543,280**
										$81,543,000

AACE Class 5 ROM Budget Range:	High	50%	$122,314,919
	Low	-30%	$57,080,296

University of Houston
UH Alternate 1A
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW
Conceptual Design Estimates
8/5/2022

Alternate 1A	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement				$0		$0		$0		$0
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	27,316	sf		$0		$0	$ 1.00	$27,316	$1.00	$27,316
Dump fee	253	cy		$0		$0	$ 25.00	$6,323	$25.00	$6,323
Haul off 12 cy/ld x 2 hr rt	63	hr		$0		$0	$ 68.00	$4,300	$68.00	$4,300
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
Excavation 3-0	3,035	cy		$0		$0	$ 18.00	$54,632	$18.00	$54,632
Import fill	3,035	cy	$ 6.00	$18,211	$ 9.00	$27,316	$ 10.00	$30,351	$25.00	$75,878
Fdn Struct exc	2,203	cy		$0		$0	$ 25.00	$55,069	$25.00	$55,069
Dump fee	5,238	cy		$0		$0	$ 25.00	$130,946	$25.00	$130,946
Hal off 12 cy/ld x 3 hr rt	1,309	hr		$0		$0	$ 68.00	$89,043	$68.00	$89,043
				$0		$0		$0	$0.00	$0
Div 3										
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	2,023	cy		$0		$0	650.00	$1,315,215	$650.00	$1,315,215
Misc concrete	100	cy		$0		$0	800.00	$80,000	$800.00	$80,000
Grade beam	79	cy		$0		$0	1000.00	$79,333	$1,000.00	$79,333
Slab on grade 12in	27,316	sf		$0		$0	14.00	$382,424	$14.00	$382,424
Til up skin 30 hi	21,420	sf		$0		$0	55.00	$1,178,100	$55.00	$1,178,100
Mechanical pads	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
				$0		$0		$0	$0.00	$0
Div 4										
CMU misc	1,800	sf		$0		$0	28.00	$50,400	$28.00	$50,400
									$0.00	
Metals										
Steel framing #15lb/sf	205	tn		$0		$0	$ 8,000.00	$1,638,960	$8,000.00	$1,638,960
Cooling tower framing 35#/sf		tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Galv grating		sf		$0		$0	$ 55.00	$0	$55.00	$0
Metal roof deck	27,316	sf		$0		$0	$ 5.00	$136,580	$5.00	$136,580
skin back u framing 4#/sf	43	tn		$0		$0	$ 8,000.00	$342,720	$8,000.00	$342,720
Misc metals	27,316	sf		$0		$0	$ 1.00	$27,316	$1.00	$27,316
Alum Handrail		lf		$0		$0	$ 300.00	$0	$300.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	27,316	sf	$ 1.00	$27,316	$ 1.00	$27,316		$0	$2.00	$54,632
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	12	lf		$0		$0	$ 350.00	$4,200	$350.00	$4,200
Counter top	30	sf		$0		$0	$ 58.00	$1,740	$58.00	$1,740
Wall cabinets	12	lf		$0		$0	$ 375.00	$4,500	$375.00	$4,500
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	27,316	sf		$0		$0	$ 0.40	$10,926	$0.40	$10,926
Fire stopping	27,316	sf		$0		$0	$ 0.50	$13,658	$0.50	$13,658
Waterproofing slab	27,316	sf		$0		$0	$ 8.00	$218,528	$8.00	$218,528
Waterproofing walls	1,800	sf		$0		$0	$ 9.00	$16,200	$9.00	$16,200
Roofing	27,316	sf		$0		$0	$ 18.00	$491,688	$18.00	$491,688
Sheet metal	27,316	sf		$0		$0	$ 4.75	$129,751	$4.75	$129,751
Canopies		sf		$0		$0	$ 100.00	$0	$100.00	$0
Fireproofing	27,316	sf		$0		$0	$ 5.00	$136,580	$5.00	$136,580
									$0.00	
Div 8										
HM Frame	7	ea	$150	$1,050	650	$4,550		$0	$800.00	$5,600
Hm Door	7	ea	$150	$1,050	700	$4,900		$0	$850.00	$5,950
Hardware	7	ea	$150	$1,050	1,000	$7,000		$0	$1,150.00	$8,050
Card key system	4	ea		$0		$0	$2,500	$10,000	$2,500.00	$10,000
Ext Glazing 10% of wall	2,142	sf		$0		$0	$125	$267,750	$125.00	$267,750
Int glazing	400	sf		$0		$0	$125	$50,000	$125.00	$50,000
Skylight	300	sf		$0		$0	$100	$30,000	$100.00	$30,000
Ohd dr	7	ea		$0		$0	$20,000	$140,000	$20,000.00	$140,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions						$0				
Furred wall est NA		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,430	sf		$0		$0	20.00	$28,600	$20.00	$28,600
Column covers		sf		$0		$0	20.00	$0	$20.00	$0
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	50	hr		$0		$0	125.00	$6,250	$125.00	$6,250
Firestopping at top of wall	600	lf		$0		$0	6.00	$3,600	$6.00	$3,600
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Open ceiling painted	16,750	sf		$0		$0	$ 1.50	$25,125	$1.50	$25,125
Drywall ceiling	2,000	sf		$0		$0	$ 18.00	$36,000	$18.00	$36,000
Acoustical sound panels (allow)	27,316	sf		$0		$0	$ 2.00	$54,632	$2.00	$54,632
				$0		$0		$0	$0.00	$0
Div 9 Flooring										
Flr prep minor	27,316	sf		$0		$0	$ 1.50	$40,974	$1.50	$40,974
Carpet, CPT		sf		$0		$0	$ 6.00	$0	$6.00	$0
LVT	1,500	sf		$0		$0	$ 8.00	$12,000	$8.00	$12,000
Epoxy sealer	25,816	sf		$0		$0	15.00	$387,240	$15.00	$387,240
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	2,860	sf		$0		$0	1.00	$2,860	$1.00	$2,860
Paint drs	7	ea		$0		$0	100.00	$700	$100.00	$700
Paint steel	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Hoisting	16	hr		$0		$0	125.00	$2,000	$125.00	$2,000
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	27,316	sf		$0		$0	2.00	$54,632	$2.00	$54,632
Signage	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Lab equipment	1	ls		$0		$0	10,000	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator Na		ea		$0		$0	50,000	$0	$50,000.00	$0
Overhead Crane allow	1	ls		$0		$0	66,000	$66,000	$66,000.00	$66,000
				$0		$0		$0	$0.00	$0
Option-1 Major Equipment (10,325 SF)										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Gen Set, 4 MW (4000 KW) xx Pri/ 480/277 Sec	7	EA	$ 53,000	$371,000	$ 3,000,000	$21,000,000		$0	$3,053,000.00	$21,371,000
Auto Transfer Switch, 3000A w Auto Bypass (size allw)	7	EA	$ 6,000	$42,000	$ 225,000	$1,575,000		$0	$231,000.00	$1,617,000
3000A Feeder, Gen Set to Elect Gear (125' ave x 6 ckts)	750	LF	$ 282	$211,500	$ 959	$719,250		$0	$1,241.00	$930,750
Gen Set Lube Oil System Tanks, Pumps, Accessories	2	EA	$ 8,000.00	$16,000	$ 85,000.00	$170,000		$0	$93,000.00	$186,000
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Air handler + Ops area	1	EA	$ 21,875	$21,875	$ 115,000	$115,000		$0	$136,875	$136,875
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000

University of Houston
UH Alternate 1A
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW
Conceptual Design Estimates
8/5/2022

Alternate 1A	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
1000 Ton Magnetic Bearing Chiller	2	EA	$ 75,000	$150,000	$448,000	$896,000		$0	$523,000	$1,046,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	2	EA	$ 100,000	$200,000	$196,000	$392,000		$0	$296,000	$592,000
Primary CHW Pumps	3	EA	$ 15,000	$45,000	$60,000	$180,000		$0	$75,000	$225,000
Secondary CHW Pumps	3	EA	$ 25,000	$75,000	$150,000	$450,000		$0	$175,000	$525,000
Chilled Water Expansion Tank	1	EA	$ 5,000	$5,000	$40,000	$40,000		$0	$45,000	$45,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	2	EA	$ 25,000	$50,000	$150,000	$300,000		$0	$175,000	$350,000
MEP General Conditions - 10,325 GSF										
Temp Power & Lighting - Building area	27,316	sf		$0		$0	$1.00	$27,316	$1.00	$27,316
MEP Hoisting - Crane Rental, HVAC Equipment	12	day		$0		$0	$ 1,800.00	$21,600	$1,800.00	$21,600
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	27,316	sf		$0		$0	5.10	$139,312	$5.10	$139,312
Fire Protection Pipe Sleeves & Fire Seal Penetrations	27,316	sf		$0		$0	0.10	$2,732	$0.10	$2,732
Fire Protection Seismic Restraints per NFPA 13	27,316	sf		$0		$0	0.15	$4,097	$0.15	$4,097
6" Entry Assy w valves & meters	1	ea		$0		$0	7,200.00	$7,200	$7,200.00	$7,200
6" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	5,060.00	$5,060	$5,060.00	$5,060
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 6" Entry assy	20	lf		$0		$0	110.00	$2,200	$110.00	$2,200
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	16	mh		$0		$0	115.00	$1,840	$115.00	$1,840
Fire Pump 100 HP, 1500 gpm - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	8,201.03	$8,201	$8,201.03	$8,201
Plumbing - 10,325 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	2	fix		$0		$0	137.00	$274	$137.00	$274
Sterilization, Chlorination, Domestic Water System	2	fix		$0		$0	45.00	$90	$45.00	$90
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	500.00	$500	$500.00	$500
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (5 ea x 2)	10	ea		$0		$0	100.00	$1,000	$100.00	$1,000
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	27,316	sf		$0		$0	0.80	$21,853	$0.80	$21,853
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	27,316	sf		$0		$0	0.10	$2,732	$0.10	$2,732
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	-	ea		$0		$0	120.00	$0	$120.00	$0
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	-	ea		$0		$0	57.00	$0	$57.00	$0
Domestic Water Plumbing Pipe Insulation	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	2	ea		$0		$0	2,950.00	$5,900	$2,950.00	$5,900
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	8,000.00	$8,000	$8,000.00	$8,000
Industrial Water IW system Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	3,098	sf		$0		$0	3.70	$11,463	$3.70	$11,463
Building Nat Gas Pipe Distribution	27,316	sf		$0		$0	1.25	$34,145	$1.25	$34,145
Natural Gas to Gen Sets	6	lsum		$0		$0	5,000.00	$30,000	$5,000.00	$30,000
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	-	ea		$0		$0	9,900.00	$0	$9,900.00	$0
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	27,316	sf		$0		$0	0.12	$3,278	$0.12	$3,278
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	-	ea		$0		$0	2,600.00	$0	$2,600.00	$0
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	-	ea		$0		$0	145.00	$0	$145.00	$0
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	-	ea		$0		$0	3,960.00	$0	$3,960.00	$0
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	2	ea		$0		$0	3,200.00	$6,400	$3,200.00	$6,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sanitary Cl No Hub VTR Assy. 2"-3"	1	ea		$0		$0	400.00	$400	$400.00	$400
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	1	ea		$0		$0	340.00	$340	$340.00	$340
Floor Sink, Mech Equip area, qty allw	8	ea		$0		$0	575.00	$4,600	$575.00	$4,600
Floor C.O., 3" & 4" qty allw	1	ea		$0		$0	410.00	$410	$410.00	$410
Grade CO, 6" to 8" size	1	ea		$0		$0	750.00	$750	$750.00	$750
Trench Drain, 12" wide w grate, E-W Run	-	lf		$0		$0	210.00	$0	$210.00	$0
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	27,316	sf		$0		$0	2.20	$60,095	$2.20	$60,095
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 40 gallon, 10 KW	-	ea		$0		$0	4,700.00	$0	$4,700.00	$0
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	1	ea		$0		$0	1,095.00	$1,095	$1,095.00	$1,095
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	1	ea		$0		$0	770.00	$770	$770.00	$770
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	-	ea		$0		$0	877.00	$0	$877.00	$0
Mop Service Basin	-	ea		$0		$0	855.00	$0	$855.00	$0
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	12,841.49	$12,841	$12,841.49	$12,841
				$0		$0		$0	$0.00	$0
HVAC - 10,325 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	-	ton		$0		$0	38.00	$0	$38.00	$0
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	27,316	sf		$0		$0	0.33	$9,014	$0.33	$9,014
Mech Contractor Assist 3rd Party - Cx Commissioning Support (2 men 1 week)	80	mh		$0		$0	130.00	$10,400	$130.00	$10,400
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	27,316	sf		$0		$0	1.50	$40,974	$1.50	$40,974

University of Houston
UH Alternate 1A
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW
Conceptual Design Estimates
8/5/2022

Alternate 1A	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	7,744	lb		$0		$0	0.15	$1,162	$0.15	$1,162
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	-	ton		$0		$0	88.00	$0	$88.00	$0
Plant HVAC Chilled Water Pipe Insulation	-	ton		$0		$0	110.00	$0	$110.00	$0
Cooling Tower Cell Overflow Drain Piping	-	ea		$0		$0	3,000.00	$0	$3,000.00	$0
Cooling Tower Equalizer & By-pass piping	-	ton		$0		$0	162.00	$0	$162.00	$0
Cooling Tower Chill & Condenser Water Plant Piping	-	ton		$0		$0	294.00	$0	$294.00	$0
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	4,646	sf		$0		$0	5.40	$25,088	$5.40	$25,088
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	-	ton		$0		$0	10.00	$0	$10.00	$0
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt		$0		$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (5 ea) allw	10	pt		$0		$0	2,000.00	$20,000	$2,000.00	$20,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (2) Qty allw	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea		$0		$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialities	-	ton		$0		$0	60.00	$0	$60.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	5	ea		$0		$0	170.00	$850	$170.00	$850
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 0 Ton)	-	lb		$0		$0	14.00	$0	$14.00	$0
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.75 lbs/ sf allw (10,325 sf)	7,744	lb		$0		$0	14.40	$111,514	$14.40	$111,514
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	27,316	sf		$0		$0	0.25	$6,829	$0.25	$6,829
Flex Duct (SF Basis) at 50% - SA Only	27,316	sf		$0		$0	0.14	$3,824	$0.14	$3,824
Fire/ Smoke Dampers (SF Basis)	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
Duct Access Door, insulated, (SF Basis)	27,316	sf		$0		$0	0.13	$3,551	$0.13	$3,551
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea		$0		$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	27,316	sf		$0		$0	2.00	$54,632	$2.00	$54,632
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	5	ea		$0		$0	1,480.00	$7,400	$1,480.00	$7,400
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	27,316	sf		$0		$0	0.70	$19,121	$0.70	$19,121
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Control Panel & Remote I/O Panels) 0.25)	1	ls		$0		$0	77,000	$77,000	$77,000	$77,000
Control System Hardware (2 Work Sta, 2 Servers, Server Racks Redundant Switches Firewall	1	ls		$0		$0	25,000	$25,000	$25,000	$25,000
Control Room Furniture (Console, 2 dual screen monitors)	1	ls		$0		$0	40,000	$40,000	$40,000	$40,000
Control System Software (License)	1	ls		$0		$0	50,000	$50,000	$50,000	$50,000
Control System Integration (Programming, Testing, Start-up, Commissioning) 0.25	1	ls		$0		$0	250,000	$250,000	$250,000	$250,000
Balance of Plant Instrumentation 0.25)	1	ls		$0		$0	43,000	$43,000	$43,000	$43,000
HVAC Foreman at 10% JM Hour (40/60 Lab/ Mat'l split allw)	1	ls		$0		$0	43,183.60	$43,184	$43,183.60	$43,184
Electrical - 10,325 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	27,316	sf		$0		$0	1.50	$40,974	$1.50	$40,974
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #500 - (2000A) 4 ckt x 4 set x 3w x 2 plcs, 210	-	ea		$0		$0	200.00	$0	$200.00	$0
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	27,316	sf		$0		$0	1.60	$43,706	$1.60	$43,706
Wire, copper, for Duplex Receptacles (Sqft Basis)	27,316	sf		$0		$0	1.05	$28,682	$1.05	$28,682
26-05-26.80 Grounding										
Building Ground Ring	470	lf		$0		$0	26.00	$12,220	$26.00	$12,220
Grounding New Panels & Switchboards	8	ea		$0		$0	300.00	$2,400	$300.00	$2,400
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	12	ea		$0		$0	475.00	$5,700	$475.00	$5,700
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	27,316	sf		$0		$0	5.00	$136,580	$5.00	$136,580
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	27,316	sf		$0		$0	2.25	$61,461	$2.25	$61,461
Conduit for Light Fixtures (Sqft Basis) -	27,316	sf		$0		$0	3.80	$103,801	$3.80	$103,801
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	27,316	sf		$0		$0	1.10	$30,048	$1.10	$30,048
20A Feeder Ckt. - FCU Term Unit x 80' ave (5 allw)	400	lf		$0		$0	13.30	$5,320	$13.30	$5,320
100A Feeder Ckt - Cool Tower Fans., 8 each x 140' each ave	-	lf		$0		$0	33.00	$0	$33.00	$0
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf		$0		$0	33.00	$5,280	$33.00	$5,280
150A Elect Ckt - CHW Primary Pumps, 4 each x 100' ave allw	-	lf		$0		$0	37.00	$0	$37.00	$0
400A Elect Ckt - CHW Secondary Pumps - 4 each x 120' ea ave	-	lf		$0		$0	121.00	$0	$121.00	$0
600A Elect Ckt - Cool Tower Pumps, 4 ea x 100' each ave	-	lf		$0		$0	183.00	$0	$183.00	$0
2000A Feeder Ckt - 2100 Ton Chiller - 4 each x 160' ave	-	lf		$0		$0	686.00	$0	$686.00	$0
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	123	ea		$0		$0	57.00	$7,011	$57.00	$7,011
Outlet boxes, pressed steel, 4" square - Card Readers - CR	3	ea		$0		$0	57.00	$171	$57.00	$171
Outlet boxes, pressed steel, 4" square - CCTV locations	4	ea		$0		$0	57.00	$228	$57.00	$228
26-05-33.65 Pull Boxes										
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Gen Set Ckt	6	ea		$0		$0	350.00	$2,100	$350.00	$2,100
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	27,316	sf		$0		$0	0.95	$25,950	$0.95	$25,950
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	27,316	sf		$0		$0	1.15	$31,413	$1.15	$31,413
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1, CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2, CUP size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP Allw	2	ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	1	ea		$0		$0	9,500.00	$9,500	$9,500.00	$9,500
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility CUP allw	2	ea		$0		$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration adsorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	-	ea		$0		$0	725.00	$0	$725.00	$0
Transformer vibration adsorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - Utility CUP allw	2	ea		$0		$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 2000 A - for 2100 ton Chillers (1 per)	-	ea		$0		$0	38,700.00	$0	$38,700.00	$0
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	27,316	sf		$0		$0	3.01	$82,221	$3.01	$82,221
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	27,316	sf		$0		$0	1.05	$28,682	$1.05	$28,682
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	27,316	sf		$0		$0	0.26	$7,102	$0.26	$7,102
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400

University of Houston
UH Alternate 1A
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW
Conceptual Design Estimates
8/5/2022

Alternate 1A	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
26-24-19.30 Motor Control Center										
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	-	ea		$0		$0	205,000.00	$0	$205,000.00	$0
26-27-26.20 Wiring Devices Elements										
Duplex & Special Receptacle Devices CUP (SF Basis)	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
26-28-16.10 Circuit Breakers										
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	27,316	sf		$0		$0	1.12	$30,594	$1.12	$30,594
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	2	ea		$0		$0	8,500.00	$17,000	$8,500.00	$17,000
Circuit breaker, 3 pole, 600 volt, 2000 amp, enclosed (NEMA 1) Swbds	-	ea		$0		$0	21,400.00	$0	$21,400.00	$0
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	-	ea		$0		$0	5,900.00	$0	$5,900.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	-	ea		$0		$0	7,300.00	$0	$7,300.00	$0
Variable frequency drives, custom-engineered, 460 volt, 250 HP - labor only, CHW Sec Pumps	-	ea		$0		$0	9,400.00	$0	$9,400.00	$0
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	-	ea		$0		$0	10,800.00	$0	$10,800.00	$0
26-32-13.13 Diesel Generators										
Plant Emergency Generator set - see equipment above	0	ls		$0		$0	0.00	$0	$0.00	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	27,316	sf		$0		$0	0.70	$19,121	$0.70	$19,121
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	27,316	sf		$0		$0	11.00	$300,476	$11.00	$300,476
Interior Lighting 100% LED Fixtures (SF Basis) - Office	-	sf		$0		$0	13.50	$0	$13.50	$0
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	18	ea		$0		$0	170.00	$3,060	$170.00	$3,060
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	4	ea		$0		$0	400.00	$1,600	$400.00	$1,600
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	2	ea		$0		$0	435.00	$870	$435.00	$870
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	3,098	sf		$0		$0	2.00	$6,196	$2.00	$6,196
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	3	ea		$0		$0	325.00	$975	$325.00	$975
26-61-13.30 Fixture Whips										
Fixture Whips (SF Basis) -	27,316	sf		$0		$0	0.45	$12,292	$0.45	$12,292
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'lsplit allw)	1	ls		$0		$0	133,790.55	$133,791	$133,790.55	$133,791
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
Tel/ Data System, Engineer & Program (SF Basis)	27,316	sf		$0		$0	0.21	$5,736	$0.21	$5,736
Tel/ Data System, Backbone allw (SF Basis)	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
Tel/ Data Devices CUP (SF Basis)	27,316	sf		$0		$0	0.65	$17,755	$0.65	$17,755
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	12	ea		$0		$0	280.00	$3,360	$280.00	$3,360
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	24	lf		$0		$0	78.00	$1,872	$78.00	$1,872
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Sound & PA Speaker 1 per 800 sf, qty allw	13	ea		$0		$0	250.00	$3,250	$250.00	$3,250
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
WAP - Wireless Access Paging Device - 1 per 2400 sf	4	ea		$0		$0	270.00	$1,080	$270.00	$1,080
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	27,316	sf		$0		$0	0.40	$10,926	$0.40	$10,926
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	9,622.60	$9,623	$9,622.60	$9,623
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	27,316	sf		$0		$0	0.80	$21,853	$0.80	$21,853
CCTV Camera Dome Fixed (4 ea) - interior qty allw	4	ea		$0		$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	-	ea		$0		$0	2,570.00	$0	$2,570.00	$0
Security Door Egress System Conduit and Cable (SF Basis)	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	3	ea		$0		$0	1,150.00	$3,450	$1,150.00	$3,450
Door Duress Pushbutton - PB , qty allw	3	ea		$0		$0	145.00	$435	$145.00	$435
Door Strike/ Contact	3	ea		$0		$0	220.00	$660	$220.00	$660
Door Position Switch	3	ea		$0		$0	200.00	$600	$200.00	$600
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	3	ea		$0		$0	680.00	$2,040	$680.00	$2,040
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea		$0		$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea		$0		$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	3	ea		$0		$0	55.00	$165	$55.00	$165
Door Large Pull Box/ J- Box 12"x12" x 4"	3	ea		$0		$0	190.00	$570	$190.00	$570
28-31-23.50 Alarm Panels And Devices										
Fire Alarm System Core & Shell (SF Basis)	27,316	sf		$0		$0	3.52	$96,152	$3.52	$96,152
Fire Alarm System Programming (SF Basis)	27,316	sf		$0		$0	0.32	$8,741	$0.32	$8,741
Fire Alarm System Test & Check Out	27,316	sf		$0		$0	0.15	$4,097	$0.15	$4,097
Fire Alarm Master Control Panel, Office up to 28,000 SF	1	ea		$0		$0	18,900.00	$18,900	$18,900.00	$18,900
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	13	ea		$0		$0	340.00	$4,420	$340.00	$4,420
Fire Alarm Pull Station (addressable), qty allw	2	ea		$0		$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	9,930.53	$9,931	$9,930.53	$9,931
Cost of Work Subtotal				$1,487,102		$27,286,922		$14,618,185		$43,392,208

	Premium Time	
Direct Construction Costs		$43,392,208
General Conditions	10.00%	$4,339,221
Sub-Total Construction Costs		$47,731,429
P&P bonds	2.5%	$1,193,286
Building Permit	0.45%	$214,791
Sub-Total Construction Costs		$49,139,506
GL & Umbrella	1.00%	$491,395
Professional liability	1.00%	$491,395
Builder Risk	0.10%	$49,140
Design Completion Uncertainty Factor	25.00%	$12,542,859
Sub-Total Construction Costs		$62,714,295
GC Fee	6.00%	$3,762,858
Design Fee	8.00%	$5,017,144
Alternate 1A **Total Construction Costs**		**$71,494,296**
		$71,494,000

AACE Class 5 ROM Budget Range:		
High	50%	$107,241,444
Low	-30%	$50,046,007

University of Houston
UH Alternate 1B
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power Only
Conceptual Design Estimates
8/5/2022

Alternate 1B	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement				$0		$0		$0		$0
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	27,316	sf		$0		$0	$ 1.00	$27,316	$1.00	$27,316
Dump fee	253	cy		$0		$0	$ 25.00	$6,323	$25.00	$6,323
Haul off 12 cy/ld x 2 hr rt	63	hr		$0		$0	$ 68.00	$4,300	$68.00	$4,300
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
Excavation 3-0	3,035	cy		$0		$0	$ 18.00	$54,632	$18.00	$54,632
Import fill	3,035	cy	$ 6.00	$18,211	$ 9.00	$27,316	$ 10.00	$30,351	$25.00	$75,878
Fdn Struct exc	2,203	cy		$0		$0	$ 25.00	$55,069	$25.00	$55,069
Dump fee	5,238	cy		$0		$0	$ 25.00	$130,946	$25.00	$130,946
Hal off 12 cy/ld x 3 hr rt	1,309	hr		$0		$0	$ 68.00	$89,043	$68.00	$89,043
				$0		$0		$0	$0.00	$0
Div 3										
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	2,023	cy		$0		$0	650.00	$1,315,215	$650.00	$1,315,215
Misc concrete	100	cy		$0		$0	800.00	$80,000	$800.00	$80,000
Grade beam	79	cy		$0		$0	1000.00	$79,333	$1,000.00	$79,333
Slab on grade 12in	27,316	sf		$0		$0	14.00	$382,424	$14.00	$382,424
Til up skin 30 hi	21,420	sf		$0		$0	55.00	$1,178,100	$55.00	$1,178,100
Mechanical pads	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
				$0		$0		$0	$0.00	$0
Div 4										
CMU misc	1,800	sf		$0		$0	28.00	$50,400	$28.00	$50,400
									$0.00	
Metals										
Steel framing #15lb/sf	205	tn		$0		$0	$ 8,000.00	$1,638,960	$8,000.00	$1,638,960
Cooling tower framing 35#/sf		tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Galv grating		sf		$0		$0	$ 55.00	$0	$55.00	$0
Metal roof deck	27,316	sf		$0		$0	$ 5.00	$136,580	$5.00	$136,580
skin back u framing 4#/sf	43	tn		$0		$0	$ 8,000.00	$342,720	$8,000.00	$342,720
Misc metals	27,316	sf		$0		$0	$ 1.00	$27,316	$1.00	$27,316
Alum Handrail		lf		$0		$0	$ 300.00	$0	$300.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	27,316	sf	$ 1.00	$27,316	$ 1.00	$27,316		$0	$2.00	$54,632
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	12	lf		$0		$0	$ 350.00	$4,200	$350.00	$4,200
Counter top	30	sf		$0		$0	$ 58.00	$1,740	$58.00	$1,740
Wall cabinets	12	lf		$0		$0	$ 375.00	$4,500	$375.00	$4,500
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	27,316	sf		$0		$0	$ 0.40	$10,926	$0.40	$10,926
Fire stopping	27,316	sf		$0		$0	$ 0.50	$13,658	$0.50	$13,658
Waterproofing slab	27,316	sf		$0		$0	$ 8.00	$218,528	$8.00	$218,528
Waterproofing walls	1,800	sf		$0		$0	$ 9.00	$16,200	$9.00	$16,200
Roofing	27,316	sf		$0		$0	$ 18.00	$491,688	$18.00	$491,688
Sheet metal	27,316	sf		$0		$0	$ 4.75	$129,751	$4.75	$129,751
Canopies		sf		$0		$0	$ 100.00	$0	$100.00	$0
Fireproofing	27,316	sf		$0		$0	$ 5.00	$136,580	$5.00	$136,580
									$0.00	
Div 8										
HM Frame	7	ea	$150	$1,050	650	$4,550		$0	$800.00	$5,600
Hm Door	7	ea	$150	$1,050	700	$4,900		$0	$850.00	$5,950
Hardware	7	ea	$150	$1,050	1,000	$7,000		$0	$1,150.00	$8,050
Card key system	4	ea		$0		$0	$2,500	$10,000	$2,500.00	$10,000
Ext Glazing 10% of wall	2,142	sf		$0		$0	$125	$267,750	$125.00	$267,750
Int glazing	400	sf		$0		$0	$125	$50,000	$125.00	$50,000
Skylight	300	sf		$0		$0	$100	$30,000	$100.00	$30,000
Ohd dr	7	ea		$0		$0	$20,000	$140,000	$20,000.00	$140,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions						$0				
Furred wall est NA		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,430	sf		$0		$0	20.00	$28,600	$20.00	$28,600
Column covers		sf		$0		$0	20.00	$0	$20.00	$0
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	50	hr		$0		$0	125.00	$6,250	$125.00	$6,250
Firestopping at top of wall	600	lf		$0		$0	6.00	$3,600	$6.00	$3,600
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Open ceiling painted	16,750	sf		$0		$0	$ 1.50	$25,125	$1.50	$25,125
Drywall ceiling	2,000	sf		$0		$0	$ 18.00	$36,000	$18.00	$36,000
Acoustical sound panels (allow)	27,316	sf		$0		$0	$ 2.00	$54,632	$2.00	$54,632
				$0		$0		$0	$0.00	$0
Div 9 Flooring										
Flr prep minor	27,316	sf		$0		$0	$ 1.50	$40,974	$1.50	$40,974
Carpet, CPT		sf		$0		$0	$ 6.00	$0	$6.00	$0
LVT	1,500	sf		$0		$0	$ 8.00	$12,000	$8.00	$12,000
Epoxy sealer	25,816	sf		$0		$0	15.00	$387,240	$15.00	$387,240
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	2,860	sf		$0		$0	1.00	$2,860	$1.00	$2,860
Paint drs	7	ea		$0		$0	100.00	$700	$100.00	$700
Paint steel	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Hoisting	16	hr		$0		$0	125.00	$2,000	$125.00	$2,000
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	27,316	sf		$0		$0	2.00	$54,632	$2.00	$54,632
Signage	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Lab equipment	1	ls		$0		$0	10,000	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator Na		ea		$0		$0	50,000	$0	$50,000.00	$0
Overhead Crane allow	1	ls		$0		$0	66,000	$66,000	$66,000.00	$66,000
				$0		$0		$0	$0.00	$0
Option-1 Major Equipment (10,325 SF)										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Gen Set, 4 MW (4000 KW) xx Pri/ 480/277 Sec	7	EA	$ 53,000	$371,000	$ 3,000,000	$21,000,000		$0	$3,053,000.00	$21,371,000
Auto Transfer Switch, 3000A w Auto Bypass (size allw)	7	EA	$ 6,000	$42,000	$ 225,000	$1,575,000		$0	$231,000.00	$1,617,000
3000A Feeder, Gen Set to Elect Gear (125' ave x 6 ckts)	750	LF	$ 282	$211,500	$ 959	$719,250		$0	$1,241.00	$930,750
Gen Set Lube Oil System Tanks, Pumps, Accessories	2	EA	$ 8,000.00	$16,000	$ 85,000.00	$170,000		$0	$93,000.00	$186,000
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Air handler + Ops area	1	EA	$ 21,875	$21,875	$ 115,000	$115,000		$0	$136,875	$136,875
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000

University of Houston
UH Alternate 1B
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power Only
Conceptual Design Estimates
8/5/2022

Alternate 1B	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
1000 Ton Magnetic Bearing Chiller	2	EA	$ 75,000	$150,000	$448,000	$896,000		$0	$523,000	$1,046,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	2	EA	$ 100,000	$200,000	$196,000	$392,000		$0	$296,000	$592,000
Primary CHW Pumps	3	EA	$ 15,000	$45,000	$60,000	$180,000		$0	$75,000	$225,000
Secondary CHW Pumps	3	EA	$ 25,000	$75,000	$150,000	$450,000		$0	$175,000	$525,000
Chilled Water Expansion Tank	1	EA	$ 5,000	$5,000	$40,000	$40,000		$0	$45,000	$45,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	2	EA	$ 25,000	$50,000	$150,000	$300,000		$0	$175,000	$350,000
MEP General Conditions - 10,325 GSF										
Temp Power & Lighting - Building area	27,316	sf		$0		$0	$1.00	$27,316	$1.00	$27,316
MEP Hoisting - Crane Rental, HVAC Equipment	12	day		$0		$0	$ 1,800.00	$21,600	$1,800.00	$21,600
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	27,316	sf		$0		$0	5.10	$139,312	$5.10	$139,312
Fire Protection Pipe Sleeves & Fire Seal Penetrations	27,316	sf		$0		$0	0.10	$2,732	$0.10	$2,732
Fire Protection Seismic Restraints per NFPA 13	27,316	sf		$0		$0	0.15	$4,097	$0.15	$4,097
6" Entry Assy w valves & meters	1	ea		$0		$0	7,200.00	$7,200	$7,200.00	$7,200
6" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	5,060.00	$5,060	$5,060.00	$5,060
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 6" Entry assy	20	lf		$0		$0	110.00	$2,200	$110.00	$2,200
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	16	mh		$0		$0	115.00	$1,840	$115.00	$1,840
Fire Pump 100 HP, 1500 gpm - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	8,201.03	$8,201	$8,201.03	$8,201
Plumbing - 10,325 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	2	fix		$0		$0	137.00	$274	$137.00	$274
Sterilization, Chlorination, Domestic Water System	2	fix		$0		$0	45.00	$90	$45.00	$90
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	500.00	$500	$500.00	$500
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (5 ea x 2)	10	ea		$0		$0	100.00	$1,000	$100.00	$1,000
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	27,316	sf		$0		$0	0.80	$21,853	$0.80	$21,853
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	27,316	sf		$0		$0	0.10	$2,732	$0.10	$2,732
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	-	ea		$0		$0	120.00	$0	$120.00	$0
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	-	ea		$0		$0	57.00	$0	$57.00	$0
Domestic Water Plumbing Pipe Insulation	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	2	ea		$0		$0	2,950.00	$5,900	$2,950.00	$5,900
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	8,000.00	$8,000	$8,000.00	$8,000
Industrial Water IW system Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	3,098	sf		$0		$0	3.70	$11,463	$3.70	$11,463
Building Nat Gas Pipe Distribution	27,316	sf		$0		$0	1.25	$34,145	$1.25	$34,145
Natural Gas to Gen Sets	6	lsum		$0		$0	5,000.00	$30,000	$5,000.00	$30,000
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	-	ea		$0		$0	9,900.00	$0	$9,900.00	$0
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	27,316	sf		$0		$0	0.12	$3,278	$0.12	$3,278
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	-	ea		$0		$0	2,600.00	$0	$2,600.00	$0
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	-	ea		$0		$0	145.00	$0	$145.00	$0
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	-	ea		$0		$0	3,960.00	$0	$3,960.00	$0
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	2	ea		$0		$0	3,200.00	$6,400	$3,200.00	$6,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sanitary Cl No Hub VTR Assy. 2"-3"	1	ea		$0		$0	400.00	$400	$400.00	$400
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	1	ea		$0		$0	340.00	$340	$340.00	$340
Floor Sink, Mech Equip area, qty allw	8	ea		$0		$0	575.00	$4,600	$575.00	$4,600
Floor C.O., 3" & 4" qty allw	1	ea		$0		$0	410.00	$410	$410.00	$410
Grade CO, 6" to 8" size	1	ea		$0		$0	750.00	$750	$750.00	$750
Trench Drain, 12" wide w grate, E-W Run	-	lf		$0		$0	210.00	$0	$210.00	$0
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	27,316	sf		$0		$0	2.20	$60,095	$2.20	$60,095
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 40 gallon, 10 KW	-	ea		$0		$0	4,700.00	$0	$4,700.00	$0
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	1	ea		$0		$0	1,095.00	$1,095	$1,095.00	$1,095
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	1	ea		$0		$0	770.00	$770	$770.00	$770
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	-	ea		$0		$0	877.00	$0	$877.00	$0
Mop Service Basin	-	ea		$0		$0	855.00	$0	$855.00	$0
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	12,841.49	$12,841	$12,841.49	$12,841
				$0		$0		$0	$0.00	$0
HVAC - 10,325 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	-	ton		$0		$0	38.00	$0	$38.00	$0
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	27,316	sf		$0		$0	0.33	$9,014	$0.33	$9,014
Mech Contractor Assist 3rd Party - Cx Commissioning Support (2 men 1 week)	80	mh		$0		$0	130.00	$10,400	$130.00	$10,400
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	27,316	sf		$0		$0	1.50	$40,974	$1.50	$40,974

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Alternate 1B	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	7,744	lb		$0		$0	0.15	$1,162	$0.15	$1,162
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	-	ton		$0		$0	88.00	$0	$88.00	$0
Plant HVAC Chilled Water Pipe Insulation	-	ton		$0		$0	110.00	$0	$110.00	$0
Cooling Tower Cell Overflow Drain Piping	-	ea		$0		$0	3,000.00	$0	$3,000.00	$0
Cooling Tower Equalizer & By-pass piping	-	ton		$0		$0	162.00	$0	$162.00	$0
Cooling Tower Chill & Condenser Water Plant Piping	-	ton		$0		$0	294.00	$0	$294.00	$0
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	4,646	sf		$0		$0	5.40	$25,088	$5.40	$25,088
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	-	ton		$0		$0	10.00	$0	$10.00	$0
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt		$0		$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (5 ea) allw	10	pt		$0		$0	2,000.00	$20,000	$2,000.00	$20,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (2) Qty allw	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea		$0		$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialities	-	ton		$0		$0	60.00	$0	$60.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	5	ea		$0		$0	170.00	$850	$170.00	$850
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 0 Ton)	-	lb		$0		$0	14.00	$0	$14.00	$0
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.75 lbs/ sf allw (10,325 sf)	7,744	lb		$0		$0	14.40	$111,514	$14.40	$111,514
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	27,316	sf		$0		$0	0.25	$6,829	$0.25	$6,829
Flex Duct (SF Basis) at 50% - SA Only	27,316	sf		$0		$0	0.14	$3,824	$0.14	$3,824
Fire/ Smoke Dampers (SF Basis)	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
Duct Access Door, insulated, (SF Basis)	27,316	sf		$0		$0	0.13	$3,551	$0.13	$3,551
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea		$0		$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	27,316	sf		$0		$0	2.00	$54,632	$2.00	$54,632
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	5	ea		$0		$0	1,480.00	$7,400	$1,480.00	$7,400
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	27,316	sf		$0		$0	0.70	$19,121	$0.70	$19,121
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Control Panel & Remote I/O Panels) 0.25)	1	ls		$0		$0	77,000	$77,000	$77,000	$77,000
Control System Hardware (2 Work Sta, 2 Servers, Server Racks Redundant Switches Firewall	1	ls		$0		$0	25,000	$25,000	$25,000	$25,000
Control Room Furniture (Console, 2 dual screen monitors)	1	ls		$0		$0	40,000	$40,000	$40,000	$40,000
Control System Software (License)	1	ls		$0		$0	50,000	$50,000	$50,000	$50,000
Control System Integration (Programming, Testing, Start-up, Commissioning) 0.25	1	ls		$0		$0	250,000	$250,000	$250,000	$250,000
Balance of Plant Instrumentation 0.25)	1	ls		$0		$0	43,000	$43,000	$43,000	$43,000
HVAC Foreman at 10% JM Hour (40/60 Lab/ Mat'l split allw)	1	ls		$0		$0	43,183.60	$43,184	$43,183.60	$43,184
Electrical - 10,325 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	27,316	sf		$0		$0	1.50	$40,974	$1.50	$40,974
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #500 - (2000A) 4 ckt x 4 set x 3w x 2 plcs, 210	-	ea		$0		$0	200.00	$0	$200.00	$0
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	27,316	sf		$0		$0	1.60	$43,706	$1.60	$43,706
Wire, copper, for Duplex Receptacles (Sqft Basis)	27,316	sf		$0		$0	1.05	$28,682	$1.05	$28,682
26-05-26.80 Grounding										
Building Ground Ring	470	lf		$0		$0	26.00	$12,220	$26.00	$12,220
Grounding New Panels & Switchboards	8	ea		$0		$0	300.00	$2,400	$300.00	$2,400
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	12	ea		$0		$0	475.00	$5,700	$475.00	$5,700
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	27,316	sf		$0		$0	5.00	$136,580	$5.00	$136,580
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	27,316	sf		$0		$0	2.25	$61,461	$2.25	$61,461
Conduit for Light Fixtures (Sqft Basis) -	27,316	sf		$0		$0	3.80	$103,801	$3.80	$103,801
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	27,316	sf		$0		$0	1.10	$30,048	$1.10	$30,048
20A Feeder Ckt. - FCU Term Unit x 80' ave (5 allw)	400	lf		$0		$0	13.30	$5,320	$13.30	$5,320
100A Feeder Ckt - Cool Tower Fans., 8 each x 140' each ave	-	lf		$0		$0	33.00	$0	$33.00	$0
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf		$0		$0	33.00	$5,280	$33.00	$5,280
150A Elect Ckt - CHW Primary Pumps, 4 each x 100' ave allw	-	lf		$0		$0	37.00	$0	$37.00	$0
400A Elect Ckt - CHW Secondary Pumps - 4 each x 120' ea ave	-	lf		$0		$0	121.00	$0	$121.00	$0
600A Elect Ckt - Cool Tower Pumps, 4 ea x 100' each ave	-	lf		$0		$0	183.00	$0	$183.00	$0
2000A Feeder Ckt - 2100 Ton Chiller - 4 each x 160' ave	-	lf		$0		$0	686.00	$0	$686.00	$0
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	123	ea		$0		$0	57.00	$7,011	$57.00	$7,011
Outlet boxes, pressed steel, 4" square - Card Readers - CR	3	ea		$0		$0	57.00	$171	$57.00	$171
Outlet boxes, pressed steel, 4" square - CCTV locations	4	ea		$0		$0	57.00	$228	$57.00	$228
26-05-33.65 Pull Boxes										
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Gen Set Ckt	6	ea		$0		$0	350.00	$2,100	$350.00	$2,100
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	27,316	sf		$0		$0	0.95	$25,950	$0.95	$25,950
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	27,316	sf		$0		$0	1.15	$31,413	$1.15	$31,413
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1, CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2, CUP size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP Allw	2	ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	1	ea		$0		$0	9,500.00	$9,500	$9,500.00	$9,500
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility CUP allw	2	ea		$0		$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration adsorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	-	ea		$0		$0	725.00	$0	$725.00	$0
Transformer vibration adsorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - Utility CUP allw	2	ea		$0		$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 2000 A - for 2100 ton Chillers (1 per)	-	ea		$0		$0	38,700.00	$0	$38,700.00	$0
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	27,316	sf		$0		$0	3.01	$82,221	$3.01	$82,221
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	27,316	sf		$0		$0	1.05	$28,682	$1.05	$28,682
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	27,316	sf		$0		$0	0.26	$7,102	$0.26	$7,102
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400

University of Houston
UH Alternate 1B
Non-CHP: Simple Cycle Reciprocating Engine Generator, 24 MW Backup Power Only
Conceptual Design Estimates
8/5/2022

Alternate 1B	27,316	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
26-24-19.30 Motor Control Center										
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	-	ea		$0		$0	205,000.00	$0	$205,000.00	$0
26-27-26.20 Wiring Devices Elements										
Duplex & Special Receptacle Devices CUP (SF Basis)	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
26-28-16.10 Circuit Breakers										
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	27,316	sf		$0		$0	1.12	$30,594	$1.12	$30,594
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	2	ea		$0		$0	8,500.00	$17,000	$8,500.00	$17,000
Circuit breaker, 3 pole, 600 volt, 2000 amp, enclosed (NEMA 1) Swbds	-	ea		$0		$0	21,400.00	$0	$21,400.00	$0
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	27,316	sf		$0		$0	0.60	$16,390	$0.60	$16,390
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	-	ea		$0		$0	5,900.00	$0	$5,900.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	-	ea		$0		$0	7,300.00	$0	$7,300.00	$0
Variable frequency drives, custom-engineered, 460 volt, 250 HP - labor only, CHW Sec Pumps	-	ea		$0		$0	9,400.00	$0	$9,400.00	$0
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	-	ea		$0		$0	10,800.00	$0	$10,800.00	$0
26-32-13.13 Diesel Generators										
Plant Emergency Generator set - see equipment above	0	ls		$0		$0	0.00	$0	$0.00	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	27,316	sf		$0		$0	0.70	$19,121	$0.70	$19,121
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	27,316	sf		$0		$0	11.00	$300,476	$11.00	$300,476
Interior Lighting 100% LED Fixtures (SF Basis) - Office	-	sf		$0		$0	13.50	$0	$13.50	$0
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	18	ea		$0		$0	170.00	$3,060	$170.00	$3,060
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	4	ea		$0		$0	400.00	$1,600	$400.00	$1,600
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	2	ea		$0		$0	435.00	$870	$435.00	$870
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	3,098	sf		$0		$0	2.00	$6,196	$2.00	$6,196
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	3	ea		$0		$0	325.00	$975	$325.00	$975
26-61-13.30 Fixture Whips										
Fixture Whips (SF Basis) -	27,316	sf		$0		$0	0.45	$12,292	$0.45	$12,292
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'lsplit allw)	1	ls		$0		$0	133,790.55	$133,791	$133,790.55	$133,791
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	27,316	sf		$0		$0	3.00	$81,948	$3.00	$81,948
Tel/ Data System, Engineer & Program (SF Basis)	27,316	sf		$0		$0	0.21	$5,736	$0.21	$5,736
Tel/ Data System, Backbone allw (SF Basis)	27,316	sf		$0		$0	0.30	$8,195	$0.30	$8,195
Tel/ Data Devices CUP (SF Basis)	27,316	sf		$0		$0	0.65	$17,755	$0.65	$17,755
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	12	ea		$0		$0	280.00	$3,360	$280.00	$3,360
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	24	lf		$0		$0	78.00	$1,872	$78.00	$1,872
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	27,316	sf		$0		$0	1.00	$27,316	$1.00	$27,316
Sound & PA Speaker 1 per 800 sf, qty allw	13	ea		$0		$0	250.00	$3,250	$250.00	$3,250
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	27,316	sf		$0		$0	0.50	$13,658	$0.50	$13,658
WAP - Wireless Access Paging Device - 1 per 2400 sf	4	ea		$0		$0	270.00	$1,080	$270.00	$1,080
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	27,316	sf		$0		$0	0.40	$10,926	$0.40	$10,926
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	9,622.60	$9,623	$9,622.60	$9,623
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	27,316	sf		$0		$0	0.80	$21,853	$0.80	$21,853
CCTV Camera Dome Fixed (4 ea) - interior qty allw	4	ea		$0		$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	-	ea		$0		$0	2,570.00	$0	$2,570.00	$0
Security Door Egress System Conduit and Cable (SF Basis)	27,316	sf		$0		$0	0.75	$20,487	$0.75	$20,487
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	3	ea		$0		$0	1,150.00	$3,450	$1,150.00	$3,450
Door Duress Pushbutton - PB , qty allw	3	ea		$0		$0	145.00	$435	$145.00	$435
Door Strike/ Contact	3	ea		$0		$0	220.00	$660	$220.00	$660
Door Position Switch	3	ea		$0		$0	200.00	$600	$200.00	$600
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	3	ea		$0		$0	680.00	$2,040	$680.00	$2,040
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea		$0		$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea		$0		$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	3	ea		$0		$0	55.00	$165	$55.00	$165
Door Large Pull Box/ J- Box 12"x12" x 4"	3	ea		$0		$0	190.00	$570	$190.00	$570
28-31-23.50 Alarm Panels And Devices										
Fire Alarm System Core & Shell (SF Basis)	27,316	sf		$0		$0	3.52	$96,152	$3.52	$96,152
Fire Alarm System Programming (SF Basis)	27,316	sf		$0		$0	0.32	$8,741	$0.32	$8,741
Fire Alarm System Test & Check Out	27,316	sf		$0		$0	0.15	$4,097	$0.15	$4,097
Fire Alarm Master Control Panel, Office up to 28,000 SF	1	ea		$0		$0	18,900.00	$18,900	$18,900.00	$18,900
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	13	ea		$0		$0	340.00	$4,420	$340.00	$4,420
Fire Alarm Pull Station (addressable), qty allw	2	ea		$0		$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	9,930.53	$9,931	$9,930.53	$9,931
Cost of Work Subtotal				$1,487,102		$27,286,922		$14,618,185		$43,392,208

	Premium Time	
Direct Construction Costs		$43,392,208
General Conditions	10.00%	$4,339,221
Sub-Total Construction Costs		$47,731,429
P&P bonds	2.5%	$1,193,286
Building Permit	0.45%	$214,791
Sub-Total Construction Costs		$49,139,506
GL & Umbrella	1.00%	$491,395
Professional liability	1.00%	$491,395
Builder Risk	0.10%	$49,140
Design Completion Uncertainty Factor	25.00%	$12,542,859
Sub-Total Construction Costs		$62,714,295
GC Fee	6.00%	$3,762,858
Design Fee	8.00%	$5,017,144
Alternate 1B **Total Construction Costs**		**$71,494,296**
		$71,494,000

AACE Class 5 ROM Budget Range:			
	High	50%	$107,241,444
	Low	-30%	$50,046,007

University of Houston
UH Alternate 2
CHP: Reciprocating Engine Generator, 24 MW with Absorption Chillers
Conceptual Design Estimates
8/5/2022

Alternate 2	30,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement				$0		$0		$0		$0
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	30,000	sf		$0		$0	$ 1.00	$30,000	$1.00	$30,000
Dump fee	278	cy		$0		$0	$ 25.00	$6,944	$25.00	$6,944
Haul off 12 cy/ld x 2 hr rt	69	hr		$0		$0	$ 68.00	$4,722	$68.00	$4,722
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	3,333	cy		$0		$0	$ 18.00	$60,000	$18.00	$60,000
Import fill	3,333	cy	$ 6.00	$20,000	$ 9.00	$30,000	$ 10.00	$33,333	$25.00	$83,333
Fdn Struct exc	2,400	cy		$0		$0	$ 25.00	$60,000	$25.00	$60,000
Dump fee	5,733	cy		$0		$0	$ 25.00	$143,333	$25.00	$143,333
Hal off 12 cy/ld x 3 hr rt	1,433	hr		$0		$0	$ 68.00	$97,467	$68.00	$97,467
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	2,222	cy		$0		$0	650.00	$1,444,444	$650.00	$1,444,444
Misc concrete	100	cy		$0		$0	800.00	$80,000	$800.00	$80,000
Grade beam	78	cy		$0		$0	1000.00	$77,778	$1,000.00	$77,778
Slab on grade 12in	30,000	sf		$0		$0	14.00	$420,000	$14.00	$420,000
tilt up skin 30 hi	21,000	sf		$0		$0	55.00	$1,155,000	$55.00	$1,155,000
Mechanical pads	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
				$0		$0		$0	$0.00	$0
Div 4										
CMU misc	9,090	sf		$0		$0	28.00	$254,520	$28.00	$254,520
									$0.00	
Metals										
Steel framing #15lb/sf	225	tn		$0		$0	$ 8,000.00	$1,800,000	$8,000.00	$1,800,000
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Metal roof deck	30,000	sf		$0		$0	$ 5.00	$150,000	$5.00	$150,000
Skin back u framing 4#/sf	42	tn		$0		$0	$ 8,000.00	$336,000	$8,000.00	$336,000
Misc metals	30,000	sf		$0		$0	$ 1.00	$30,000	$1.00	$30,000
Alum Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
				$0		$0		$0	$0.00	$0
Div 6 Carpenter										
Blocking and backing	30,000	sf	$ 1.00	$30,000	$ 1.00	$30,000		$0	$2.00	$60,000
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	49	lf		$0		$0	$ 350.00	$17,150	$350.00	$17,150
Counter top	123	sf		$0		$0	$ 58.00	$7,105	$58.00	$7,105
Wall cabinets	49	lf		$0		$0	$ 375.00	$18,375	$375.00	$18,375
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	30,000	sf		$0		$0	$ 0.40	$12,000	$0.40	$12,000
Fire stopping	30,000	sf		$0		$0	$ 0.50	$15,000	$0.50	$15,000
Waterproofing slab	30,000	sf		$0		$0	$ 8.00	$240,000	$8.00	$240,000
Waterproofing walls	1,800	sf		$0		$0	$ 9.00	$16,200	$9.00	$16,200
Roofing	30,000	sf		$0		$0	$ 18.00	$540,000	$18.00	$540,000
Sheet metal	30,000	sf		$0		$0	$ 4.75	$142,500	$4.75	$142,500
Canopys		sf		$0		$0	$ 100.00	$0	$100.00	$0
Fireproofing	30,000	sf		$0		$0	$ 4.50	$135,000	$4.50	$135,000
				$0		$0		$0	$0.00	$0
Div 8										
HM Frame	25	ea	$150	$3,750	650	$16,250		$0	$800.00	$20,000
Hm Door	25	ea	$150	$3,750	700	$17,500		$0	$850.00	$21,250
Hardware	25	ea	$150	$3,750	1,000	$25,000		$0	$1,150.00	$28,750
Glass dr	2	ea		$0		$0	$3,800	$7,600	$3,800.00	$7,600
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	3,000	sf		$0		$0	$125	$375,000	$125.00	$375,000
Int glazing	600	sf		$0		$0	$125	$75,000	$125.00	$75,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	9	ea		$0		$0	$20,000	$180,000	$20,000.00	$180,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	4,450	sf		$0		$0	20.00	$89,000	$20.00	$89,000
Column covers	500	sf		$0		$0	20.00	$10,000	$20.00	$10,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	80	hr		$0		$0	125.00	$10,000	$125.00	$10,000
Firestopping at top of wall	600	lf		$0		$0	6.00	$3,600	$6.00	$3,600
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	5,000	sf		$0		$0	$ 10.00	$50,000	$10.00	$50,000
Open ceiling painted	25,000	sf		$0		$0	$ 2.00	$50,000	$2.00	$50,000
Drywall ceiling		sf		$0		$0	$ 18.00	$0	$18.00	$0
Acoustical sound panels (allow)	30,000	sf		$0		$0	$ 2.00	$60,000	$2.00	$60,000
				$0		$0		$0	$0.00	$0
Div 9 Flooring										
Flr prep minor	30,000	sf		$0		$0	$ 1.50	$45,000	$1.50	$45,000
Carpet, CPT	2,000	sf		$0		$0	$ 6.00	$12,000	$6.00	$12,000
LVT	3,000	sf		$0		$0	$ 8.00	$24,000	$8.00	$24,000
Epoxy sealer	25,000	sf		$0		$0	15.00	$375,000	$15.00	$375,000
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	10,900	sf		$0		$0	1.00	$10,900	$1.00	$10,900
Paint drs	25	ea		$0		$0	150.00	$3,750	$150.00	$3,750
Paint steel	30,000	sf		$0		$0	1.00	$30,000	$1.00	$30,000
Hoisting	40	hr		$0		$0	125.00	$5,000	$125.00	$5,000
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	30,000	sf		$0		$0	2.00	$60,000	$2.00	$60,000
Signage	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
Toilet accessories	2	ea		$0		$0	$ 1,200.00	$2,400	$1,200.00	$2,400
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	2	ea	500.00	$1,000	2000.00	$4,000		$0	$2,500.00	$5,000
Microwave	2	ea	100.00	$200	350.00	$700		$0	$450.00	$900
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	30,000	sf		$0		$0	1.00	$30,000	$1.00	$30,000
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator Na		ea		$0		$0	50,000	$0	$50,000.00	$0
Overhead Crane allow	1	ls		$0		$0	90,000	$90,000	$90,000.00	$90,000
				$0		$0		$0	$0.00	$0
Option-2 Major Equipment (30,000 SF)										
		Ea	$ -	$0	$ -	$0		$0	$0.00	$0
Gen Set, 4 MW (4000 KW) xx Pri/ 480/277 Sec	7	EA	$ 53,000	$371,000	$ 3,000,000	$21,000,000		$0	$3,053,000.00	$21,371,000
Auto Transfer Switch, 3000A w Auto Bypass (size allw)	7	EA	$ 6,000	$42,000	$ 225,000	$1,575,000		$0	$231,000.00	$1,617,000
3000A Feeder, Gen Set to Elect Gear (245' ave x 6 ckts)	1,470	LF	$ 282	$414,540	$ 959	$1,409,730		$0	$1,241.00	$1,824,270
Gen Set Lube Oil System Tanks, Pumps, Accessories	2	EA	$ 8,000	$16,000	$ 85,000	$170,000		$0	$93,000.00	$186,000
		Ea	$ -	$0	$ -	$0		$0	$0.00	$0
Absorption Chiller, 1000 Ton	4	EA	$ 82,000	$328,000	$ 615,000	$2,460,000		$0	$697,000.00	$2,788,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$ 70,000	$70,000		$0	$90,000.00	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$ 60,000	$120,000		$0	$75,000.00	$150,000

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UH Alternate 2
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Alternate 2	30,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Air handler - ops area	1	EA	$ 22,050	$22,050	$ 88,200	$88,200		$0	$110,250	$110,250
Air handler - chiller area	1	EA	$ 12,250	$12,250	$ 115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$ 20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	4	EA	$ 100,000	$400,000	$ 196,000	$784,000		$0	$296,000	$1,184,000
Primary CHW Pumps	4	EA	$ 15,000	$60,000	$ 60,000	$240,000		$0	$75,000	$300,000
Secondary CHW Pumps	4	EA	$ 25,000	$100,000	$ 150,000	$600,000		$0	$175,000	$700,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$ 40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$ 350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$ 150,000	$600,000		$0	$175,000	$700,000
Continuous Emissions Monitoring Equipment	1	LS	80000	$80,000	$ 350,000	$350,000		$0	$430,000	$430,000
MEP General Conditions - 30,000 GSF										
Temp Power & Lighting - Building area	30,000	sf		$0		$0	$1.00	$30,000	$1.00	$30,000
MEP Hoisting - Crane Rental, HVAC Equipment	32	day		$0		$0	$ 1,800.00	$57,600	$1,800.00	$57,600
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	30,000	sf		$0		$0	5.10	$153,000	$5.10	$153,000
Fire Protection Pipe Sleeves & Fire Seal Penetrations	30,000	sf		$0		$0	0.10	$3,000	$0.10	$3,000
Fire Protection Seismic Restraints per NFPA 13	30,000	sf		$0		$0	0.15	$4,500	$0.15	$4,500
6" Entry Assy w valves & meters	1	ea		$0		$0	7,200.00	$7,200	$7,200.00	$7,200
6" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	5,060.00	$5,060	$5,060.00	$5,060
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 6" Entry assy	20	lf		$0		$0	110.00	$2,200	$110.00	$2,200
Sprinkler System Flow Switch - qty allw	3	ea		$0		$0	185.00	$555	$185.00	$555
Sprinkler System Tamper Switch - qty allw	3	ea		$0		$0	180.00	$540	$180.00	$540
Test new System Internally and w AHJ or Fire Marshall (32 MH)	32	mh		$0		$0	115.00	$3,680	$115.00	$3,680
Fire Pump 100 HP, 1500 gpm - allw	1	ls		$0		$0	78,700.00	$78,700	$78,700.00	$78,700
Jockey Pump 3-5 HP - allw	1	ls		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	13,214.25	$13,214	$13,214.25	$13,214
Plumbing - 30,000 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	8	fix		$0		$0	137.00	$1,096	$137.00	$1,096
Sterilization, Chlorination, Domestic Water System	8	fix		$0		$0	45.00	$360	$45.00	$360
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,000.00	$2,000	$2,000.00	$2,000
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	2	ea		$0		$0	2,200.00	$4,400	$2,200.00	$4,400
HVAC Equip Vib Isolators per - FCU's/ VAV's (14 ea x 4)	64	ea		$0		$0	100.00	$6,400	$100.00	$6,400
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	30,000	sf		$0		$0	0.80	$24,000	$0.80	$24,000
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	30,000	sf		$0		$0	0.10	$3,000	$0.10	$3,000
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	30,000	sf		$0		$0	1.00	$30,000	$1.00	$30,000
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	8	ea		$0		$0	2,950.00	$23,600	$2,950.00	$23,600
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	8,000.00	$8,000	$8,000.00	$8,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (2)	60	lf		$0		$0	41.00	$2,460	$41.00	$2,460
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	9,000	sf		$0		$0	3.70	$33,300	$3.70	$33,300
Building Nat Gas Pipe Distribution	30,000	sf		$0		$0	1.00	$30,000	$1.00	$30,000
Natural Gas to Gen Sets	6	lsum		$0		$0	5,000.00	$30,000	$5,000.00	$30,000
Natural Gas to Gas Turbine Generators	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	2	ea		$0		$0	9,900.00	$19,800	$9,900.00	$19,800
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	30,000	sf		$0		$0	0.30	$9,000	$0.30	$9,000
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	8	ea		$0		$0	3,200.00	$25,600	$3,200.00	$25,600
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	12	ea		$0		$0	450.00	$5,400	$450.00	$5,400
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	30,000	sf		$0		$0	0.30	$9,000	$0.30	$9,000
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	10	ea		$0		$0	575.00	$5,750	$575.00	$5,750
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	140	lf		$0		$0	210.00	$29,400	$210.00	$29,400
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	30,000	sf		$0		$0	2.20	$66,000	$2.20	$66,000
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 40 gallon, 10 KW	1	ea		$0		$0	4,700.00	$4,700	$4,700.00	$4,700
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	1	ea		$0		$0	840.00	$840	$840.00	$840
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	22,070.60	$22,071	$22,070.60	$22,071
				$0		$0		$0	$0.00	$0
HVAC - 30,000 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	30,000	sf		$0		$0	0.75	$22,500	$0.75	$22,500
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	4,000	ton		$0		$0	38.00	$152,000	$38.00	$152,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	30,000	sf		$0		$0	0.33	$9,900	$0.33	$9,900
Mech Contractor Assist 3rd Party - Cx Commissioning Support (3 men 1 week)	120	mh		$0		$0	130.00	$15,600	$130.00	$15,600
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	30,000	sf		$0		$0	1.50	$45,000	$1.50	$45,000
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	30,000	sf		$0		$0	3.00	$90,000	$3.00	$90,000
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	21,000	lb		$0		$0	0.15	$3,150	$0.15	$3,150
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240

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Alternate 2	30,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Chill Wtr & Condsr Water Special Hangers & Supports	4,000	ton		$0		$0	88.00	$352,000	$88.00	$352,000
Plant HVAC Chilled Water Pipe Insulation	4,000	ton		$0		$0	110.00	$440,000	$110.00	$440,000
Cooling Tower Cell Overflow Drain Piping	4	ea		$0		$0	3,000.00	$12,000	$3,000.00	$12,000
Cooling Tower Equalizer & By-pass piping	4,000	ton		$0		$0	162.00	$648,000	$162.00	$648,000
Cooling Tower Chill & Condenser Water Plant Piping	4,000	ton		$0		$0	294.00	$1,176,000	$294.00	$1,176,000
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	12,600	sf		$0		$0	5.40	$68,040	$5.40	$68,040
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	4,000	ton		$0		$0	10.00	$40,000	$10.00	$40,000
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (2 ea)	32	pt		$0		$0	2,000.00	$64,000	$2,000.00	$65,051
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (6 ea) allw	12	pt		$0		$0	2,000.00	$24,000	$2,000.00	$24,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (2) Qty allw	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea		$0		$0	3600	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	30,000	sf		$0		$0	2.00	$60,000	$2.00	$60,000
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialities	4,000	ton		$0		$0	64.00	$256,000	$64.00	$256,000
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	14	ea		$0		$0	170.00	$2,380	$170.00	$2,380
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 4000 Ton)	10,000	lb		$0		$0	14.00	$140,000	$14.00	$140,000
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.70 lbs/ sf allw (30,000 sf)	21,000	lb		$0		$0	14.40	$302,400	$14.40	$302,400
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	30,000	sf		$0		$0	0.25	$7,500	$0.25	$7,500
Flex Duct (SF Basis) at 50% - SA Only	30,000	sf		$0		$0	0.14	$4,200	$0.14	$4,200
Fire/ Smoke Dampers (SF Basis)	30,000	sf		$0		$0	0.60	$18,000	$0.60	$18,000
Duct Access Door, insulated, (SF Basis)	30,000	sf		$0		$0	0.13	$3,900	$0.13	$3,900
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	4	ea		$0		$0	1,300.00	$5,200	$1,300.00	$5,200
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	30,000	sf		$0		$0	2.00	$60,000	$2.00	$60,000
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	14	ea				$0	1480	$20,720	$1,480.00	$20,720
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	30,000	sf		$0		$0	0.70	$21,000	$0.70	$21,000
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Panel & Remote I/O Panels) 0.30	1	ls		$0		$0	93,000	$93,000	$93,000	$93,000
Control System Hardware (2 Work Sta, 2 Server, Server Racks Redundant Switches Firewall (0.40)	1	ls		$0		$0	40,000	$40,000	$40,000	$40,000
Control Room Furniture (Console, 3 dual screen monitors) (0.30)	1	ls		$0		$0	45,000	$45,000	$45,000	$45,000
Control System Software (License)	1	ls		$0		$0	50,000	$50,000	$50,000	$50,000
Control System Integration (Programming, Testing, Start-up, Commissioning) (0.30)	1	ls		$0		$0	336,000	$336,000	$336,000	$336,000
Balance of Plant Instrumentation (0.30)	1	ls		$0		$0	61,000	$61,000	$61,000	$61,000
HVAC Foreman at 10% JM Hour (40/60 Lab/ Mat'l split allw)	1	ls		$0		$0	189,928.84	$189,929	$189,928.84	$189,929
Electrical - 30,000 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	30,000	sf		$0		$0	0.65	$19,500	$0.65	$19,500
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #600 - (800A) 4 ckt x 2 set x 3w x 2 plcs, 970 T Chille	48	ea		$0		$0	225.00	$10,800	$225.00	$10,800
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	30,000	sf		$0		$0	1.60	$48,000	$1.60	$48,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	30,000	sf		$0		$0	1.05	$31,500	$1.05	$31,500
26-05-26.80 Grounding										
Building Ground Ring	700	lf		$0		$0	26.00	$18,200	$26.00	$18,200
Grounding New Panels & Switchboards	12	ea		$0		$0	300.00	$3,600	$300.00	$3,600
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	30,000	sf		$0		$0	0.60	$18,000	$0.60	$18,000
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	12	ea		$0		$0	475.00	$5,700	$475.00	$5,700
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	30,000	sf		$0		$0	4.00	$120,000	$4.00	$120,000
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	30,000	sf		$0		$0	2.25	$67,500	$2.25	$67,500
Conduit for Light Fixtures (Sqft Basis) -	30,000	sf		$0		$0	3.80	$114,000	$3.80	$114,000
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	30,000	sf		$0		$0	1.10	$33,000	$1.10	$33,000
20A Feeder Ckt. - FCU Term Unit x 80' ave (14 allw)	1,120	lf		$0		$0	13.30	$14,896	$13.30	$14,896
100A Feeder Ckt - Cool Tower Fans., 4 each x **140'** each ave	560	lf		$0		$0	33.00	$18,480	$33.00	$18,480
100A Feeder Ckt - AHU Circuits, 2 each x 160' ave	320	lf		$0		$0	33.00	$10,560	$33.00	$10,560
150A Elect Ckt - CHW Primary Pumps, 4 each x 200' ave allw	800	lf		$0		$0	37.00	$29,600	$37.00	$29,600
400A Elect Ckt - CHW Secondary Pumps - 4 each x 140' ea ave	560	lf		$0		$0	121.00	$67,760	$121.00	$67,760
600A Elect Ckt - Cool Tower Pumps, 4 ea x 220' each ave	880	lf		$0		$0	183.00	$161,040	$183.00	$161,040
1000A Elect Ckt - 970 Ton Chillers, 4 each x 125' each ave	500	lf		$0		$0	344.00	$172,000	$344.00	$172,000
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	357	ea		$0		$0	57.00	$20,349	$57.00	$20,349
Outlet boxes, pressed steel, 4" square - Card Readers - CR	8	ea		$0		$0	57.00	$456	$57.00	$456
Outlet boxes, pressed steel, 4" square - CCTV locations	6	ea		$0		$0	57.00	$342	$57.00	$342
26-05-33.65 Pull Boxes								$0	$0.00	$0
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	4	ea		$0		$0	350.00	$1,400	$350.00	$1,400
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	30,000	sf		$0		$0	0.95	$28,500	$0.95	$28,500
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	30,000	sf		$0		$0	1.15	$34,500	$1.15	$34,500
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1, CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2, CUP size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP Allw	2	ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	4	ea		$0		$0	9,500.00	$38,000	$9,500.00	$38,000
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility CUP allw	2	ea		$0		$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration adsorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	4	ea		$0		$0	725.00	$2,900	$725.00	$2,900
Transformer vibration adsorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - Utility CUP allw	2	ea		$0		$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 970 ton Chillers (1 per)	4	ea		$0		$0	22,700.00	$90,800	$22,700.00	$90,800
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	30,000	sf		$0		$0	3.01	$90,300	$3.01	$90,300
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	30,000	sf		$0		$0	1.05	$31,500	$1.05	$31,500
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	30,000	sf		$0		$0	0.75	$22,500	$0.75	$22,500
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	30,000	sf		$0		$0	0.26	$7,800	$0.26	$7,800
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6400	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12	ea		$0		$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center										
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea		$0		$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements								$0	$0.00	$0
Duplex & Special Receptacle Devices CUP (SF Basis)	30,000	sf		$0		$0	1.00			
26-28-16.10 Circuit Breakers								$0	$0.00	$0
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	30,000	sf		$0		$0	1.12			

University of Houston
UH Alternate 2
CHP: Reciprocating Engine Generator, 24 MW with Absorption Chillers
Conceptual Design Estimates
8/5/2022

Alternate 2	30,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbd sections	4	ea		$0		$0	8,500.00	$34,000	$8,500.00	$34,000
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	30,000	sf		$0		$0	0.60	$18,000	$0.60	$18,000
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	4	ea		$0		$0	5,900.00	$23,600	$5,900.00	$23,600
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	4	ea		$0		$0	7,300.00	$29,200	$7,300.00	$29,200
Variable frequency drives, custom-engineered, 460 volt, 250 HP - labor only, CHW Sec Pumps	4	ea		$0		$0	9,400.00	$37,600	$9,400.00	$37,600
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4	ea		$0		$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators										
Chill Plant Emergency Generator set - see above	0	ls		$0		$0	0.00	$0	$0.00	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	30,000	sf		$0		$0	0.70	$21,000	$0.70	$21,000
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	30,000	sf		$0		$0	11.00	$330,000	$11.00	$330,000
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	54	ea		$0		$0	170.00	$9,180	$170.00	$9,180
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	6	ea		$0		$0	400.00	$2,400	$400.00	$2,400
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	4	ea		$0		$0	435.00	$1,740	$435.00	$1,740
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	9,000	sf		$0		$0	2.00	$18,000	$2.00	$18,000
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	5	ea		$0		$0	325			
26-61-13.30 Fixture Whips								$0	$0.00	$0
Fixture Whips (SF Basis) -	30,000	sf		$0		$0	0.45	$13,500	$0.45	$13,500
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls		$0		$0	163,262.94	$163,263	$163,262.94	$163,263
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	30,000	sf		$0		$0	3.00	$90,000	$3.00	$90,000
Tel/ Data System, Engineer & Program (SF Basis)	30,000	sf		$0		$0	0.21	$6,300	$0.21	$6,300
Tel/ Data System, Backbone allw (SF Basis)	30,000	sf		$0		$0	0.30	$9,000	$0.30	$9,000
Tel/ Data Devices CUP (SF Basis)	30,000	sf		$0		$0	0.65	$19,500	$0.65	$19,500
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	12	ea		$0		$0	280.00	$3,360	$280.00	$3,360
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	24	lf		$0		$0	78.00	$1,872	$78.00	$1,872
				$0		$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	30,000	sf		$0		$0	1.00	$30,000	$1.00	$30,000
Sound & PA Speaker 1 per 800 sf, qty allw	38	ea		$0		$0	250.00	$9,500	$250.00	$9,500
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	30,000	sf		$0		$0	0.50	$15,000	$0.50	$15,000
WAP - Wireless Access Paging Device - 1 per 2400 sf	12	ea		$0		$0	270.00	$3,240	$270.00	$3,240
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	30,000	sf		$0		$0	0.40	$12,000	$0.40	$12,000
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	10,856.35	$10,856	$10,856.35	$10,856
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	30,000	sf		$0		$0	0.80	$24,000	$0.80	$24,000
CCTV Camera Dome Fixed (5 ea) - interior + Exterior qty allw	6	ea		$0		$0	2,030.00	$12,180	$2,030.00	$12,180
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	-	ea		$0		$0	2,570.00	$0	$2,570.00	$0
Security Door Egress System Conduit and Cable (SF Basis)	30,000	sf		$0		$0	0.75	$22,500	$0.75	$22,500
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	8	ea		$0		$0	1,150.00	$9,200	$1,150.00	$9,200
Door Duress Pushbutton - PB , qty allw	4	ea		$0		$0	145.00	$580	$145.00	$580
Door Strike/ Contact	8	ea		$0		$0	220.00	$1,760	$220.00	$1,760
Door Position Switch	8	ea		$0		$0	200.00	$1,600	$200.00	$1,600
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	8	ea		$0		$0	680.00	$5,440	$680.00	$5,440
Door Electrified Lever Set & Transfer Hinge - qty allw	4	ea		$0		$0	960.00	$3,840	$960.00	$3,840
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	4	ea		$0		$0	550.00	$2,200	$550.00	$2,200
Door Deep J- Box 4"x4" x 2-1'8"	8	ea		$0		$0	55.00	$440	$55.00	$440
Door Large Pull Box/ J- Box 12"x12" x 4"	8	ea		$0		$0	190.00	$1,520	$190.00	$1,520
28-31-23.50 Alarm Panels And Devices										
Fire Alarm System Core & Shell (SF Basis)	30,000	sf		$0		$0	3.52	$105,600	$3.52	$105,600
Fire Alarm System Programming (SF Basis)	30,000	sf		$0		$0	0.32	$9,600	$0.32	$9,600
Fire Alarm System Test & Check Out	30,000	sf		$0		$0	0.15	$4,500	$0.15	$4,500
Fire Alarm Master Control Panel, Office up to 28,000 SF	1	ea		$0		$0	18,900.00	$18,900	$18,900.00	$18,900
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	38	ea		$0		$0	340.00	$12,920	$340.00	$12,920
Fire Alarm Pull Station (addressable), qty allw	4	ea		$0		$0	255.00	$1,020	$255.00	$1,020
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	12,185.00	$12,185	$12,185.00	$12,185
Cost of Work Subtotal				$2,176,490		$30,506,620		$21,194,752		$53,878,913

	Premium Time		
Direct Construction Costs			$53,878,913
General Conditions		10.00%	$5,387,891
Sub-Total Construction Costs			$59,266,805
P&P bonds		2.5%	$1,481,670
Building Permit		0.45%	$266,701
Sub-Total Construction Costs			$61,015,175
GL & Umbrella		1.00%	$610,152
Professional liability		1.00%	$610,152
Builder Risk		0.10%	$61,015
Design Completion Uncertainty Factor		25.00%	$15,574,123
Sub-Total Construction Costs			$77,870,617
GC Fee		6.00%	$4,672,237
Design Fee		8.00%	$6,229,649
Alternate 2	**Total Construction Costs**	Total	**$88,772,504**
			$88,773,000

AACE Class 5 ROM Budget Range:	High	50%	$133,158,756
	Low	-30%	$62,140,753

University of Houston
UH Alternate 3
CHP: Combustion Turbine, 9 MW with Heat Recovery Steam Generator
Conceptual Design Estimates
8/5/2022

Alternate 3	25,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement				$0		$0		$0		$0
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	25,000	sf		$0		$0	$ 1.00	$25,000	$1.00	$25,000
Dump fee	231	cy		$0		$0	$ 25.00	$5,787	$25.00	$5,787
Haul off 12 cy/ld x 2 hr rt	58	hr		$0		$0	$ 68.00	$3,935	$68.00	$3,935
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	2,778	cy		$0		$0	$ 18.00	$50,000	$18.00	$50,000
Import fill	2,778	cy	$ 6.00	$16,667	$ 9.00	$25,000	$ 10.00	$27,778	$25.00	$69,444
Fdn Struct exc	2,024	cy		$0		$0	$ 25.00	$50,602	$25.00	$50,602
Dump fee	4,802	cy		$0		$0	$ 25.00	$120,046	$25.00	$120,046
Hal off 12 cy/ld x 3 hr rt	1,200	hr		$0		$0	$ 68.00	$81,631	$68.00	$81,631
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	1,852	cy		$0		$0	650.00	$1,203,704	$650.00	$1,203,704
Misc concrete	100	cy		$0		$0	800.00	$80,000	$800.00	$80,000
Grade beam	72	cy		$0		$0	1000.00	$72,222	$1,000.00	$72,222
Slab on grade 12in	25,000	sf		$0		$0	14.00	$350,000	$14.00	$350,000
Tilt up skin 30 hi	19,500	sf		$0		$0	55.00	$1,072,500	$55.00	$1,072,500
Mechanical pads	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
				$0		$0		$0	$0.00	$0
Div 4										
CMU misc	2,490	sf		$0		$0	28.00	$69,720	$28.00	$69,720
									$0.00	
Metals										
Steel framing #15lb/sf	188	tn		$0		$0	$ 8,000.00	$1,500,000	$8,000.00	$1,500,000
Cooling tower framing 35#/sf		tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Galv grating		sf		$0		$0	$ 55.00	$0	$55.00	$0
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	25,000	sf		$0		$0	$ 5.00	$125,000	$5.00	$125,000
skin back u framing 4#/sf	39	tn		$0		$0	$ 8,000.00	$312,000	$8,000.00	$312,000
Misc metals	25,000	sf		$0		$0	$ 1.00	$25,000	$1.00	$25,000
Handrail		lf		$0		$0	$ 300.00	$0	$300.00	$0
Steel framing #15lb/sf Mezzanine NA	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine NA	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	25,000	sf	$ 1.00	$25,000	$ 1.00	$25,000		$0	$2.00	$50,000
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	12	lf		$0		$0	$ 350.00	$4,200	$350.00	$4,200
Counter top	30	sf		$0		$0	$ 58.00	$1,740	$58.00	$1,740
Wall cabinets	12	lf		$0		$0	$ 375.00	$4,500	$375.00	$4,500
									$0.00	
Div 7										
Caulking	25,000	sf		$0		$0	$ 0.40	$10,000	$0.40	$10,000
Fire stopping	25,000	sf		$0		$0	$ 0.50	$12,500	$0.50	$12,500
Waterproofing slab	27,750	sf		$0		$0	$ 8.00	$222,000	$8.00	$222,000
Waterproofing walls	1,950	sf		$0		$0	$ 9.00	$17,550	$9.00	$17,550
Roofing	27,750	sf		$0		$0	$ 18.00	$499,500	$18.00	$499,500
Sheet metal	27,750	sf		$0		$0	$ 4.75	$131,813	$4.75	$131,813
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	25,000	sf		$0		$0	$ 4.50	$112,500	$4.50	$112,500
									$0.00	
Div 8										
HM Frame	5	ea	$150	$750	650	$3,250		$0	$800.00	$4,000
Hm Door	5	ea	$150	$750	700	$3,500		$0	$850.00	$4,250
Hardware	5	ea	$150	$750	1,000	$5,000		$0	$1,150.00	$5,750
Card key system	5	ea		$0		$0	$2,500	$12,500	$2,500.00	$12,500
Ext Glazing 10% of wall	1,950	sf		$0		$0	$125	$243,750	$125.00	$243,750
Int glazing	500	sf		$0		$0	$125	$62,500	$125.00	$62,500
Skylight	400	sf		$0		$0	$75	$30,000	$75.00	$30,000
Ohd dr	5	ea		$0		$0	$20,000	$100,000	$20,000.00	$100,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	930	sf		$0		$0	20.00	$18,600	$20.00	$18,600
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	80	hr		$0		$0	125.00	$10,000	$125.00	$10,000
Firestopping at top of wall	93	lf		$0		$0	6.00	$558	$6.00	$558
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	2,000	sf		$0		$0	$ 10.00	$20,000	$10.00	$20,000
Open ceiling painted	23,000	sf		$0		$0	$ 1.50	$34,500	$1.50	$34,500
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	25,000	sf		$0		$0	$ 2.00	$50,000	$2.00	$50,000
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	25,000	sf		$0		$0	$ 1.50	$37,500	$1.50	$37,500
Carpet, CPT		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT	2,000	sf		$0		$0	$ 8.00	$16,000	$8.00	$16,000
Epoxy sealer	23,000	sf		$0		$0	15.00	$345,000	$15.00	$345,000
Epoxy sealer mezzanine flr	-	sf		$0		$0	15.00	$0	$15.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	1,860	sf		$0		$0	1.00	$1,860	$1.00	$1,860
Paint drs	5	ea		$0		$0	150.00	$750	$150.00	$750
Paint steel	25,000	sf		$0		$0	1.00	$25,000	$1.00	$25,000
Hoisting	24	hr		$0		$0	125.00	$3,000	$125.00	$3,000
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	25,000	sf		$0		$0	2.00	$50,000	$2.00	$50,000
Signage	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
Toilet accessories		ea		$0		$0	$ 1,000.00	$0	$1,000.00	$0
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	25,000	sf		$0		$0	1.00	$25,000	$1.00	$25,000
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Overhead Crane allow	1	ls		$0		$0	100,000	$100,000	$100,000.00	$100,000
Option-3 Major Equipment (25,000 SF)										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Combustion Turbine Generator 4.6 MW per Data Base, includes freight Includes Inlet Filter Silencer, Controls/Instrumentation, Gas Fuel Pkg, Lube Oil Pkg, water wash	3	EA	$ 164,220	$492,660	$ 3,282,000	$9,846,000		$0	$3,446,220.00	$10,338,660
Heat Recovery Steam Generator (52 kpph) includes DA, blowdown, and SCR systems	1	EA	$ 405,000.00	$405,000	**$ 3,960,000**	$3,960,000		$0	$4,365,000.00	$4,365,000
Inlet Air Chilling Equipment	1	LS	$ -	$0	$ 1,109,000	$1,109,000		$0	$1,109,000.00	$1,109,000
Fuel Gas Compressor	3	EA	$ -	$0	**$ 908,700**	$2,726,100		$0	$908,700.00	$2,726,100

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Alternate 3	25,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000
Pumps										
includes feedwater, inlet air chiller, oil pumps	1	LS	$ -	$0	$482,290	$482,290		$0	$482,290	$482,290
Service & Instrument Air Compressor Package	1	LS	$ 20,000.00	$20,000	$ 70,000	$70,000		$0	$90,000.00	$90,000
Boiler Makeup Water Treatment System	1	LS	$ 750,000.00	$750,000	$ 1,000,000	$1,000,000		$0	$1,750,000.00	$1,750,000
Air handler - boiler area	1	EA	$ 26,250.00	$26,250	$ 105,000	$105,000		$0	$131,250.00	$131,250
Air handler - ops area	1	EA	$ 22,050.00	$22,050	$ 88,200	$88,200		$0	$110,250.00	$110,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Condensate Tank, (Surge tank 9,000 - 10,000 gallons)	1	EA	$ 30,000	$30,000	$130,000	$130,000		$0	$160,000	$160,000
Condensate Pumps	3	EA	$ 10,000	$30,000	$20,000	$60,000		$0	$30,000	$90,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$ 70,000	$70,000		$0	$90,000.00	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$ 60,000	$120,000		$0	$75,000.00	$150,000
1000 Ton Magnetic Bearing Chiller	2	EA	$ 75,000	$150,000	$448,000	$896,000		$0	$523,000	$1,046,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$ 115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$ 20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	2	EA	$ 100,000	$200,000	$ 196,000	$392,000		$0	$296,000	$592,000
Primary CHW Pumps	3	EA	$ 15,000	$45,000	$ 60,000	$180,000		$0	$75,000	$225,000
Secondary CHW Pumps	3	EA	$ 25,000	$75,000	$ 150,000	$450,000		$0	$175,000	$525,000
Chilled Water Expansion Tank	1	EA	$ 5,000	$5,000	$ 40,000	$40,000		$0	$45,000	$45,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$ 350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	2	EA	$ 25,000	$50,000	$ 150,000	$300,000		$0	$175,000	$350,000
MEP General Conditions - 25,000 GSF										
Temp Power & Lighting - mods area	25,000	sf		$0		$0	$1.00	$25,000	$1.00	$25,000
MEP Hoisting - Crane Rental, HVAC Equipment	16	day		$0		$0	$ 1,800.00	$28,800	$1,800.00	$28,800
MEP Hoisting - Crane Rental, Elect Equipment	6	day		$0		$0	$ 1,800.00	$10,800	$1,800	$10,800
Fire Sprinkler				$0						
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	25,000	sf		$0		$0	5.10	$127,500	$5.10	$127,500
Fire Protection Pipe Sleeves & Fire Seal Penetrations	25,000	sf		$0		$0	0.10	$2,500	$0.10	$2,500
Fire Protection Seismic Restraints per NFPA 13	25,000	sf		$0		$0	0.15	$3,750	$0.15	$3,750
6" Entry Assy w valves & meters	1	ea		$0		$0	7,200.00	$7,200	$7,200.00	$7,200
6" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	5,060.00	$5,060	$5,060.00	$5,060
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 6" Entry assy	20	lf		$0		$0	110.00	$2,200	$110.00	$2,200
Sprinkler System Flow Switch - qty allw	3	ea		$0		$0	185.00	$555	$185.00	$555
Sprinkler System Tamper Switch - qty allw	3	ea		$0		$0	180.00	$540	$180.00	$540
Test new System Internally and w AHJ or Fire Marshall (32 MH)	32	mh		$0		$0	115.00	$3,680	$115.00	$3,680
Fire Pump 100 HP, 1500 gpm - allw	1	ls		$0		$0	78,700.00	$78,700	$78,700.00	$78,700
Jockey Pump 3-5 HP - allw	1	ls		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	11,876.75	$11,877	$11,876.75	$11,877
Plumbing - 25,000 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	2	fix		$0		$0	137.00	$274	$137.00	$274
Sterilization, Chlorination, Domestic Water System	2	fix		$0		$0	45.00	$90	$45.00	$90
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	500.00	$500	$500.00	$500
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (6 ea x 4)	24	ea		$0		$0	100.00	$2,400	$100.00	$2,400
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	25,000	sf		$0		$0	0.80	$20,000	$0.80	$20,000
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	25,000	sf		$0		$0	0.10	$2,500	$0.10	$2,500
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	1	ea		$0		$0	120.00	$120	$120.00	$120
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	1	ea		$0		$0	57.00	$57	$57.00	$57
Domestic Water Plumbing Pipe Insulation	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	2	ea		$0		$0	2,950.00	$5,900	$2,950.00	$5,900
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	2,000.00	$2,000	$2,000.00	$2,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (2)	60	lf		$0		$0	41.00	$2,460	$41.00	$2,460
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	-	lsum		$0		$0	10,000.00	$0	$10,000.00	$0
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	7,500	sf		$0		$0	3.70	$27,750	$3.70	$27,750
Building Nat Gas Pipe Distribution	25,000	sf		$0		$0	1.25	$31,250	$1.25	$31,250
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	3	lsum		$0		$0	8,000.00	$24,000	$8,000.00	$24,000
Natural Gas to HRSG Units	1	lsum		$0		$0	8,000.00	$8,000	$8,000.00	$8,000
22-11-13.48 Equipment Connections										
AHU 2 1/2" Coil Connection Assy - Htg HW	2	ea		$0		$0	9,100.00	$18,200	$9,100.00	$18,200
AHU 3" Coil Connection Assy - Chill Wtr	2	ea		$0		$0	9,900.00	$19,800	$9,900.00	$19,800
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	25,000	sf		$0		$0	0.30	$7,500	$0.30	$7,500
22-11-19.38 Water Supply Meters										
HPS & LPC Flow Meters (2 ea)	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	1	ea		$0		$0	145.00	$145	$145.00	$145
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	2	ea		$0		$0	3,200.00	$6,400	$3,200.00	$6,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	2,500.00	$2,500	$2,500.00	$2,500
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	8	ea		$0		$0	450.00	$3,600	$450.00	$3,600
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	25,000	sf		$0		$0	0.30	$7,500	$0.30	$7,500
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	1	ea		$0		$0	340.00	$340	$340.00	$340
Floor Sink, Mech Equip area, qty allw	8	ea		$0		$0	575.00	$4,600	$575.00	$4,600
Floor C.O., 3" & 4" qty allw	1	ea		$0		$0	410.00	$410	$410.00	$410
Grade CO, 6" to 8" size	1	ea		$0		$0	750.00	$750	$750.00	$750
Trench Drain, 12" wide w grate, E-W Run	-	lf		$0		$0	210.00	$0	$210.00	$0
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	25,000	sf		$0		$0	2.20	$55,000	$2.20	$55,000
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 40 gallon, 10 KW	1	ea		$0		$0	4,700.00	$4,700	$4,700.00	$4,700
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	1	ea		$0		$0	1,095.00	$1,095	$1,095.00	$1,095
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	1	ea		$0		$0	770.00	$770	$770.00	$770
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	-	ea		$0		$0	877.00	$0	$877.00	$0
Mop Service Basin	-	ea		$0		$0	855.00	$0	$855.00	$0
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	-	ea		$0		$0	260.00	$0	$260.00	$0

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Alternate 3	25,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	15,748.55	$15,749	$15,748.55	$15,749
				$0		$0		$0	$0.00	$0
HVAC - 25,000 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	25,000	sf		$0		$0	0.75	$18,750	$0.75	$18,750
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	25,000	sf		$0		$0	0.33	$8,250	$0.33	$8,250
Mech Contractor Assist 3rd Party - Cx Commissioning Support (2 men 1 week)	80	mh		$0		$0	130.00	$10,400	$130.00	$10,400
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	25,000	sf		$0		$0	1.50	$37,500	$1.50	$37,500
Commissioning Cx of HVAC systems - Boilers, Pumps, Systems	25,000	sf		$0		$0	3.00	$75,000	$3.00	$75,000
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	16,250	lb		$0		$0	0.15	$2,438	$0.15	$2,438
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	1	lsum		$0		$0	600,000.00	$600,000	$600,000.00	$600,000
Boiler Install - Loose Piping from Vendor	1	ea		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	25,000	sf		$0		$0	11.00	$275,000	$11.00	$275,000
Boiler Feedwater Piping & Insulation	25,000	sf		$0		$0	22.00	$550,000	$22.00	$550,000
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	9,750	sf		$0		$0	5.40	$52,650	$5.40	$52,650
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (2 ea)	32	pt		$0		$0	2,000.00	$64,000	$2,000.00	$64,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (6 ea) allw	12	pt		$0		$0	2,000.00	$24,000	$2,000.00	$24,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (2) Qty allw	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	3	pt		$0		$0	2,000.00	$6,000	$2,000.00	$6,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	4	pt		$0		$0	2,000.00	$8,000	$2,000.00	$8,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea		$0		$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	25,000	sf		$0		$0	2.00	$50,000	$2.00	$50,000
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
23-09-53.10 Control Components										
Control Components, Steam & Stm Condensate Control Valves & Specialties	1	ls		$0		$0	200,000.00	$200,000	$200,000.00	$200,000
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	6	ea		$0		$0	170.00	$1,020	$170.00	$1,020
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (25,000 sf)	16,250	lb		$0		$0	14.40	$234,000	$14.40	$234,000
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 1 ea	50	lf		$0		$0	280.00	$14,000	$280.00	$14,000
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	25,000	sf		$0		$0	0.25	$6,250	$0.25	$6,250
Flex Duct (SF Basis) at 50% - SA Only	25,000	sf		$0		$0	0.14	$3,500	$0.14	$3,500
Fire/ Smoke Dampers (SF Basis)	25,000	sf		$0		$0	0.60	$15,000	$0.60	$15,000
Duct Access Door, insulated, (SF Basis)	25,000	sf		$0		$0	0.13	$3,250	$0.13	$3,250
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	4	ea		$0		$0	1,300.00	$5,200	$1,300.00	$5,200
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	25,000	sf		$0		$0	2.00	$50,000	$2.00	$50,000
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	6	ea				$0	1480	$8,880	$1,480.00	$8,880
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	25,000	sf		$0		$0	0.70	$17,500	$0.70	$17,500
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Panel & Remote I/O Panels) - included in CTG Unit cost	1	ls		$0		$0	371,452	$371,452	$371,452	$371,452
Control System Hardware (2 Work Sta, 5 Server, Server Racks Redundant Switches Firewall	1	ls		$0		$0	100,000	$100,000	$100,000	$100,000
Control Room Furniture (Console, 8 dual screen monitors)	1	ls		$0		$0	150,000	$150,000	$150,000	$150,000
Control System Software (License)	1	ls		$0		$0	55,000	$55,000	$55,000	$55,000
Control System Integration (Programming, Testing, Start-up, Commissioning)	1	ls		$0		$0	1,326,380	$1,326,380	$1,326,380	$1,326,380
Balance of Plant Instrumentation	1	ls		$0		$0	304,693	$304,693	$304,693	$304,693
HVAC Foreman at 10% JM Hour (40/60 Lab/ Mat'l split allw)	1	ls		$0		$0	187,562.10	$187,562	$187,562.10	$187,562
				$0		$0		$0	$0.00	$0
Electrical - 25,000 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	25,000	sf		$0		$0	0.65	$16,250	$0.65	$16,250
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #750 - 2 set x 3w x 2 plcs Boiler Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	25,000	sf		$0		$0	1.60	$40,000	$1.60	$40,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	25,000	sf		$0		$0	1.05	$26,250	$1.05	$26,250
26-05-26.80 Grounding										
Building Ground Ring	650	lf		$0		$0	26.00	$16,900	$26.00	$16,900
Grounding New Panels & Switchboards	10	ea		$0		$0	300.00	$3,000	$300.00	$3,000
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	2	ea		$0		$0	600.00	$1,200	$600.00	$1,200
Grounding & Bonding System, SF Basis, CUP	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	25,000	sf		$0		$0	0.60	$15,000	$0.60	$15,000
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	11	ea		$0		$0	475.00	$5,225	$475.00	$5,225
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	25,000	sf		$0		$0	4.2	$105,000	$4.20	$105,000
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	25,000	sf		$0		$0	2.25	$56,250	$2.25	$56,250
Conduit for Light Fixtures (Sqft Basis) -	25,000	sf		$0		$0	3.80	$95,000	$3.80	$95,000
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	25,000	sf		$0		$0	1.10	$27,500	$1.10	$27,500
20A Feeder Ckt. - FCU Term Unit x 80' ave (6 allw)	480	lf		$0		$0	13.30	$6,384	$13.30	$6,384
30A Feeder Ckt. -	-	lf		$0		$0	15.70	$0	$15.70	$0
100A Feeder Ckt - AHU Circuits, 2 each x 160' ave	320	lf		$0		$0	33.00	$10,560	$33.00	$10,560
100A Feeder Ckt - Boiler FD Fans, 1 each x 120' ave	120	lf		$0		$0	33.00	$3,960	$33.00	$3,960
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 120' ave	360	lf		$0		$0	33.00	$11,880	$33.00	$11,880
225A Elect Ckt - Boiler Feedwater Pumps, 1 each x 120' ave allw	120	lf		$0		$0	53.00	$6,360	$53.00	$6,360
225A Elect Ckt - Btm Discharge FD Boiler Fan, 1 each x 120' ave allw	120	lf		$0		$0	53.00	$6,360	$53.00	$6,360
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 112 GSF	223	ea		$0		$0	57.00	$12,711	$57.00	$12,711
Outlet boxes, pressed steel, 4" square - Card Readers - CR	5	ea		$0		$0	57.00	$285	$57.00	$285
Outlet boxes, pressed steel, 4" square - CCTV locations	7	ea		$0		$0	57.00	$399	$57.00	$399
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36"wide, CUP	25,000	sf		$0		$0	0.85	$21,250	$0.85	$21,250
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	25,000	sf		$0		$0	0.95	$23,750	$0.95	$23,750
26-13-00.00 Medium Voltage Switchgear/ Substations										
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses	2	ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
3000A Double Ended Substation #1 (Steam Plant) - CUP allw	1	ea		$0		$0	**737,000.00**	$737,000	$737,000.00	$737,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	1	ea		$0		$0	35,000.00	$35,000	$35,000.00	$35,000
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 2 MVA,	1	ea		$0		$0	73,000.00	$73,000	$73,000.00	$73,000
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	1	ea		$0		$0	1,170.00	$1,170	$1,170.00	$1,170
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA	1	ea		$0		$0	1,500.00	$1,500	$1,500.00	$1,500
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 800 A - for Boilers	1	ea		$0		$0	**22,700.00**	$22,700	$22,700.00	$22,700
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	25,000	sf		$0		$0	3.01	$75,250	$3.01	$75,250
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	25,000	sf		$0		$0	1.05	$26,250	$1.05	$26,250
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	25,000	sf		$0		$0	0.75	$18,750	$0.75	$18,750
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	25,000	sf		$0		$0	0.26	$6,500	$0.26	$6,500
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	10	ea		$0		$0	450.00	$4,500	$450.00	$4,500
26-24-19.30 Motor Control Center										

University of Houston
UH Alternate 3
CHP: Combustion Turbine, 9 MW with Heat Recovery Steam Generator
Conceptual Design Estimates
8/5/2022

Alternate 3	25,000	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Motor Control Center 1600A - Boiler Plant, size allw	1	ea		$0		$0	117,000.00	$117,000	$117,000.00	$117,000
26-27-26.20 Wiring Devices Elements										
Duplex & Special Receptacle Devices CUP (SF Basis)	25,000	sf		$0		$0	0.85	$21,250	$0.85	$21,250
26-28-16.10 Circuit Breakers										
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	25,000	sf		$0		$0	1.12	$28,000	$1.12	$28,000
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	-	ea		$0		$0	8,500.00	$0	$8,500.00	$0
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	25,000	sf		$0		$0	0.60	$15,000	$0.60	$15,000
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	1	ea		$0		$0	6,500.00	$6,500	$6,500.00	$6,500
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	3	ea		$0		$0	6,500.00	$19,500	$6,500.00	$19,500
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	1	ea		$0		$0	8,100.00	$8,100	$8,100.00	$8,100
26-32-13.13 Diesel Generators										
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly tank	-	ea		$0		$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2)	-	ea		$0		$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel	-	gal		$0		$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	25,000	sf		$0		$0	0.70	$17,500	$0.70	$17,500
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	25,000	sf		$0		$0	11.00	$275,000	$11.00	$275,000
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 112 GSF	33	ea		$0		$0	170.00	$5,610	$170.00	$5,610
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	6	ea		$0		$0	400.00	$2,400	$400.00	$2,400
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	4	ea		$0		$0	435.00	$1,740	$435.00	$1,740
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	7,500	sf		$0		$0	2.00	$15,000	$2.00	$15,000
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	5	ea		$0		$0	325.00	$1,625	$325.00	$1,625
26-61-13.30 Fixture Whips										
Fixture Whips (SF Basis) -	25,000	sf		$0		$0	0.45	$11,250	$0.45	$11,250
							$0			
Elect Foreman MH's at 10% JM Qty (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	116,003.20	$116,003	$116,003.20	$116,003
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	25,000	sf		$0		$0	3.00	$75,000	$3.00	$75,000
Tel/ Data System, Engineer & Program (SF Basis)	25,000	sf		$0		$0	0.21	$5,250	$0.21	$5,250
Tel/ Data System, Backbone allw (SF Basis)	25,000	sf		$0		$0	0.30	$7,500	$0.30	$7,500
Tel/ Data Devices CUP (SF Basis)	25,000	sf		$0		$0	0.65	$16,250	$0.65	$16,250
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	16	ea		$0		$0	280.00	$4,480	$280.00	$4,480
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	32	lf		$0		$0	78.00	$2,496	$78.00	$2,496
				$0		$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	25,000	sf		$0		$0	1.00	$25,000	$1.00	$25,000
Sound & PA Speaker 1 per 800 sf, qty allw	31	ea		$0		$0	250.00	$7,750	$250.00	$7,750
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	25,000	sf		$0		$0	0.50	$12,500	$0.50	$12,500
WAP - Wireless Access Paging Device - 1 per 2400 sf	10	ea		$0		$0	270.00	$2,700	$270.00	$2,700
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	25,000	sf		$0		$0	0.40	$10,000	$0.40	$10,000
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	9,314.05	$9,314	$9,314.05	$9,314
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	25,000	sf		$0		$0	0.80	$20,000	$0.80	$20,000
CCTV Camera Dome Fixed (5 ea) - interior qty allw	5	ea		$0		$0	2,030.00	$10,150	$2,030.00	$10,150
CCTV Camera P-T-Z 180 Degree w support, 8 megapixel, Exterior allw	2	ea		$0		$0	2,570.00	$5,140	$2,570.00	$5,140
Security Door Egress System Conduit and Cable (SF Basis)	25,000	sf		$0		$0	0.75	$18,750	$0.75	$18,750
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	5	ea		$0		$0	1,150.00	$5,750	$1,150.00	$5,750
Door Duress Pushbutton - PB , qty allw	5	ea		$0		$0	145.00	$725	$145.00	$725
Door Strike/ Contact	5	ea		$0		$0	220.00	$1,100	$220.00	$1,100
Door Position Switch	5	ea		$0		$0	200.00	$1,000	$200.00	$1,000
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	5	ea		$0		$0	680.00	$3,400	$680.00	$3,400
Door Electrified Lever Set & Transfer Hinge - qty allw	5	ea		$0		$0	960.00	$4,800	$960.00	$4,800
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	5	ea		$0		$0	550.00	$2,750	$550.00	$2,750
Door Deep J- Box 4"x4" x 2-1'8"	5	ea		$0		$0	55.00	$275	$55.00	$275
Door Large Pull Box/ J- Box 12"x12" x 4"	5	ea		$0		$0	190.00	$950	$190.00	$950
28-31-23.50 Alarm Panels And Devices										
Fire Alarm System Core & Shell (SF Basis)	25,000	sf		$0		$0	3.52	$88,000	$3.52	$88,000
Fire Alarm System Programming (SF Basis)	25,000	sf		$0		$0	0.32	$8,000	$0.32	$8,000
Fire Alarm System Test & Check Out	25,000	sf		$0		$0	0.15	$3,750	$0.15	$3,750
Fire Alarm Master Control Panel, Office up to 28,000 SF	1	ea		$0		$0	18,900.00	$18,900	$18,900.00	$18,900
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	31	ea		$0		$0	340.00	$10,540	$340.00	$10,540
Fire Alarm Pull Station (addressable), qty allw	4	ea		$0		$0	255.00	$1,020	$255.00	$1,020
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	10,545.00	$10,545	$10,545.00	$10,545
				$0		$0		$0		$0
Cost of Work Subtotal				$2,600,927		$23,294,930		$15,818,199		$41,714,056

	Premium Time		
Direct Construction Costs			$41,714,056
General Conditions		10.00%	$4,171,406
Sub-Total Construction Costs			$45,885,461
P&P bonds		2.5%	$1,147,137
Building Permit		0.45%	$206,485
Sub-Total Construction Costs			$47,239,083
GL & Umbrella		1.00%	$472,391
Professional liability		1.00%	$472,391
Builder Risk		0.10%	$47,239
Design Completion Uncertainty Factor		25.00%	$12,057,776
Sub-Total Construction Costs			$60,288,879
GC Fee		6.00%	$3,617,333
Design fee		8.00%	$4,823,110
Alternate 3	**Total Construction Costs**		**$68,729,322**
			$68,729,000

AACE Class 5 ROM Budget Range:	High	50%	$103,093,983
	Low	-30%	$48,110,526

University of Houston
UH Alternate 4
CHP: Combustion Turbine, 26 MW with Heat Recovery Steam Generator and Absorption Chillers
Conceptual Design Estimates
8/5/2022

Alternate 4	73,125 UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
			$0		$0		$0		$0
Div 1 General Requirement			$0		$0		$0		$0
Misc Hoisting	200 hr		$0		$0	$125	$25,000	$125.00	$25,000
			$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation									
Demolition minor	73,125 sf		$0		$0	$ 1.00	$73,125	$1.00	$73,125
Dump fee	677 cy		$0		$0	$ 25.00	$16,927	$25.00	$16,927
Haul off 12 cy/ld x 2 hr rt	169 hr		$0		$0	$ 68.00	$11,510	$68.00	$11,510
Traffic control	40 hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
			$0		$0		$0	$0.00	$0
Excavation 3-0	8,125 cy		$0		$0	$ 18.00	$146,250	$18.00	$146,250
Import fill	8,125 cy	$ 6.00	$48,750	$ 9.00	$73,125	$ 10.00	$81,250	$25.00	$203,125
Fdn Struct exc	5,711 cy		$0		$0	$ 25.00	$142,778	$25.00	$142,778
Dump fee	13,836 cy		$0		$0	$ 25.00	$345,903	$25.00	$345,903
Hal off 12 cy/ld x 3 hr rt	3,459 hr		$0		$0	$ 68.00	$235,214	$68.00	$235,214
			$0		$0		$0	$0.00	$0
Div 3			$0		$0		$0	$0.00	$0
			$0		$0		$0	$0.00	$0
Concrete Drilled Piers ??	cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	5,417 cy		$0		$0	650.00	$3,520,833	$650.00	$3,520,833
Misc concrete	200 cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	94 cy		$0		$0	1000.00	$94,444	$1,000.00	$94,444
Slab on grade 12in	73,125 sf		$0		$0	14.00	$1,023,750	$14.00	$1,023,750
Tilt up skin 30 hi	25,500 sf		$0		$0	55.00	$1,402,500	$55.00	$1,402,500
Mechanical pads	73,125 sf		$0		$0	0.50	$36,563	$0.50	$36,563
			$0		$0		$0	$0.00	$0
Div 4			$0		$0		$0	$0.00	$0
CMU misc	14,760 sf		$0		$0	28.00	$413,280	$28.00	$413,280
								$0.00	
Metals								$0.00	
Steel framing #15lb/sf	548 tn		$0		$0	$ 8,000.00	$4,387,500	$8,000.00	$4,387,500
Cooling tower framing 35#/sf	19 tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100 sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine	ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	73,125 sf		$0		$0	$ 5.00	$365,625	$5.00	$365,625
Skin back u framing 4#/sf	51 tn		$0		$0	$ 8,000.00	$408,000	$8,000.00	$408,000
Misc metals	73,125 sf		$0		$0	$ 1.00	$73,125	$1.00	$73,125
Handrail	200 lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	- tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	- sf		$0		$0	$ 9.00	$0	$9.00	$0
								$0.00	
Div 6 Carpenter			$0		$0		$0	$0.00	$0
Blocking and backing	73,125 sf	$ 1.00	$73,125	$ 1.00	$73,125		$0	$2.00	$146,250
Plywood elect and tel data	1,000 sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	25 lf		$0		$0	$ 350.00	$8,750	$350.00	$8,750
Counter top	63 sf		$0		$0	$ 58.00	$3,625	$58.00	$3,625
Wall cabinets	25 lf		$0		$0	$ 375.00	$9,375	$375.00	$9,375
			$0		$0		$0	$0.00	$0
Div 7			$0		$0		$0	$0.00	$0
Caulking	73,125 sf		$0		$0	$ 0.40	$29,250	$0.40	$29,250
Fire stopping	73,125 sf		$0		$0	$ 0.50	$36,563	$0.50	$36,563
Waterproofing slab	73,125 sf		$0		$0	$ 8.00	$585,000	$8.00	$585,000
Waterproofing walls	2,550 sf		$0		$0	$ 9.00	$22,950	$9.00	$22,950
Roofing	73,125 sf		$0		$0	$ 18.00	$1,316,250	$18.00	$1,316,250
Sheet metal	73,125 sf		$0		$0	$ 4.75	$347,344	$4.75	$347,344
Canopys	sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	73,125 sf		$0		$0	$ 4.50	$329,063	$4.50	$329,063
			$0		$0		$0	$0.00	$0
Div 8			$0		$0		$0	$0.00	$0
HM Frame	20 ea	$150	$3,000	650	$13,000		$0	$800.00	$16,000
Hm Door	20 ea	$150	$3,000	700	$14,000		$0	$850.00	$17,000
Hardware	20 ea	$150	$3,000	1,000	$20,000		$0	$1,150.00	$23,000
Glass dr	4 ea		$0		$0	$3,800	$15,200	$3,800.00	$15,200
Card key system	8 ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	2,550 sf		$0		$0	$125	$318,750	$125.00	$318,750
Int glazing	600 sf		$0		$0	$125	$75,000	$125.00	$75,000
Skylight	600 sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	8 ea		$0		$0	$20,000	$160,000	$20,000.00	$160,000
			$0		$0		$0	$0.00	$0
Div 9 Partitions			$0		$0		$0	$0.00	$0
Furred wall	sf		$0		$0	9.00	$0	$9.00	$0
Int walls	5,260 sf		$0		$0	20.00	$105,200	$20.00	$105,200
Column covers	600 sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500 sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	240 hr		$0		$0	125.00	$30,000	$125.00	$30,000
Firestopping at top of wall	526 lf		$0		$0	6.00	$3,156	$6.00	$3,156
			$0		$0		$0	$0.00	$0
Div 9 Ceiling			$0		$0		$0	$0.00	$0
Acoustical ceiling	7,125 sf		$0		$0	$ 10.00	$71,250	$10.00	$71,250
Open ceiling painted	66,000 sf		$0		$0	$ 1.50	$99,000	$1.50	$99,000
Drywall ceiling	sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	73,125 sf		$0		$0	$ 2.00	$146,250	$2.00	$146,250
Mezzanine paint decking	sf		$0		$0	$1.50	$0	$1.50	$0
								$0.00	$0
Div 9 Flooring								$0.00	$0
Flr prep minor	73,125 sf		$0		$0	$ 1.50	$109,688	$1.50	$109,688
Carpet,	sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	2,000 sf		$0		$0	$ 8.00	$16,000	$8.00	$16,000
Epoxy sealer	71,125 sf		$0		$0	15.00	$1,066,875	$15.00	$1,066,875
Epoxy sealer mezzanine	- sf		$0		$0	15.00	$0	$15.00	$0
			$0		$0		$0	$0.00	$0
Div 9 Painting									
Furred wall	- sf		$0		$0	0.60	$0	$0.60	$0
Int walls	10,520 sf		$0		$0	1.00	$10,520	$1.00	$10,520
Paint drs	20 ea		$0		$0	100.00	$2,000	$100.00	$2,000
Paint steel	73,125 sf		$0		$0	1.00	$73,125	$1.00	$73,125
Hoisting	24 hr		$0		$0	125.00	$3,000	$125.00	$3,000
Paint mezzanine	- sf		$0		$0	1.00	$0	$1.00	$0
			$0		$0		$0	$0.00	$0
Div 10			$0		$0		$0	$0.00	$0
Misc items	73,125 sf		$0		$0	2.00	$146,250	$2.00	$146,250
Signage	73,125 sf		$0		$0	0.50	$36,563	$0.50	$36,563
Toilet accessories	2 ea		$0		$0	$ 1,200.00	$2,400	$1,200.00	$2,400
			$0		$0		$0	$0.00	$0
Div 11 Equipment			$0		$0		$0	$0.00	$0
Refrigerator	1 ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1 ea	100.00	$100	350.00	$350		$0	$450.00	$450
			$0		$0		$0	$0.00	$0
Div 12 Furnishings			$0		$0		$0	$0.00	$0
Misc items	73,125 sf		$0		$0	1.00	$73,125	$1.00	$73,125
Lab equipment	1 ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
			$0		$0		$0	$0.00	$0
Div 14 Elevator Protection			$0		$0		$0	$0.00	$0
Elevator 2stp	stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1 ls		$0		$0	100,000	$100,000	$100,000.00	$100,000
			$0		$0		$0	$0.00	$0
Option-4 Major Equipment 73,125 GSF								$0.00	

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Alternate 4	73,125	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Absorption Chiller, 1000 Ton	5	EA	$ 82,000	$410,000	$ 615,000	$3,075,000		$0	$697,000	$3,485,000
Combustion Turbine Generator 4.6 MW per Data Base, includes freight Includes Inlet Filter Silencer, Controls/Instrumentation, Gas Fuel Pkg, Lube Oil Pkg, water wash	7	EA	$ 164,220	$1,149,540	$ 3,282,000	$22,974,000		$0	$3,446,220	$24,123,540
Heat Recovery Steam Generator (65 kpph)	2	EA	$ 405,000	$810,000	$ 3,960,000	$7,920,000		$0	$4,365,000	$8,730,000
Fuel Gas Compressor	7	EA	$ -	$0	$ 908,700	$6,360,900		$0	$908,700.00	$6,360,900
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000
Pumps includes feedwater, inlet air chiller, oil pumps	2	LS	$ -	$0	$482,290	$964,580		$0	$482,290	$964,580
Service & Instrument Air Compressor Package	1	LS	$ 20,000.00	$20,000	$ 70,000	$70,000		$0	$90,000.00	$90,000
Boiler Makeup Water Treatment System	1	LS	$ 750,000.00	$750,000	$ 1,000,000	$1,000,000		$0	$1,750,000.00	$1,750,000
Air handler - boiler area	1	EA	$ 26,250	$26,250	$ 105,000	$105,000		$0	$131,250.00	$131,250
Air handler - ops area	1	EA	$ 22,050	$22,050	$ 88,200	$88,200		$0	$110,250.00	$110,250
Air handler - chiller area	1	EA	$ 12,250	$12,250	$ 64,000	$64,000		$0	$76,250	$76,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Condensate Tank, (Surge tank 9,000 - 10,000 gallons)	1	EA	$ 30,000	$30,000	$130,000	$130,000		$0	$160,000	$160,000
Condensate Pumps	3	EA	$ 10,000	$30,000	$20,000	$60,000		$0	$30,000	$90,000
Cooling Towers - 1000 Ton Nominal	5	EA	$ 100,000	$500,000	$187,500	$937,500		$0	$287,500	$1,437,500
Primary CHW Pumps	5	EA	$ 15,000	$75,000	$60,000	$300,000		$0	$75,000	$375,000
Secondary CHW Pumps	5	EA	$ 25,000	$125,000	$125,000	$625,000		$0	$150,000	$750,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$100,000	$400,000		$0	$125,000	$500,000
MEP General Conditions - 73,125 GSF									$0.00	
Temp Power & Lighting - mods area	73,125	sf		$0		$0	$0.90	$65,813	$0.90	$65,813
MEP Hoisting - Crane Rental, HVAC Equipment	60	day		$0		$0	$ 1,800.00	$108,000	$1,800.00	$108,000
MEP Hoisting - Crane Rental, Elect Equipment	16	day		$0		$0	$ 1,800.00	$28,800	$1,800	$28,800
Fire Sprinkler				$0		$0		$0	$0.00	$0
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	73,125	sf		$0		$0	5.10	$372,938	$5.10	$372,938
Fire Protection Pipe Sleeves & Fire Seal Penetrations	73,125	sf		$0		$0	0.10	$7,313	$0.10	$7,313
Fire Protection Seismic Restraints per NFPA 13	73,125	sf		$0		$0	0.15	$10,969	$0.15	$10,969
8" Entry Assy w valves & meters -	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	40	lf		$0		$0	145.00	$5,800	$145.00	$5,800
Sprinkler System Flow Switch - qty allw	5	ea		$0		$0	185.00	$925	$185.00	$925
Sprinkler System Tamper Switch - qty allw	5	ea		$0		$0	180.00	$900	$180.00	$900
Test new System Internally and w AHJ or Fire Marshall (48 MH)	48	mh		$0		$0	115.00	$5,520	$115.00	$5,520
Fire Pump 100 HP, 1500 gpm - allw	1	ls		$0		$0	78,700.00	$78,700	$78,700.00	$78,700
Jockey Pump 3-5 HP - allw	1	ls		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	25,305.69	$25,306	$25,305.69	$25,306
Plumbing - 73,125 SF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	8	fix		$0		$0	137.00	$1,096	$137.00	$1,096
Sterilization, Chlorination, Domestic Water System	8	fix		$0		$0	45.00	$360	$45.00	$360
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,500.00	$2,500	$2,500.00	$2,500
22-05-29.10 Hangers And Supports For Plumbing/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	3	ea		$0		$0	2,200.00	$6,600	$2,200.00	$6,600
HVAC Equip Vib Isolators per - FCU's/ VAV's (22 ea x 4)	88	ea		$0		$0	100.00	$8,800	$100.00	$8,800
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	73,125	sf		$0		$0	0.80	$58,500	$0.80	$58,500
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	73,125	sf		$0		$0	0.10	$7,313	$0.10	$7,313
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	73,125	sf		$0		$0	1.00	$73,125	$1.00	$73,125
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	8	ea		$0		$0	2,950.00	$23,600	$2,950.00	$23,600
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (3)	90	lf		$0		$0	41.00	$3,690	$41.00	$3,690
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	21,938	sf		$0		$0	3.70	$81,171	$3.70	$81,171
Building Nat Gas Pipe Distribution	73,125	sf		$0		$0	0.60	$43,875	$0.60	$43,875
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	6	lsum		$0		$0	8,000.00	$48,000	$8,000.00	$48,000
Natural Gas to HRSG Units	2	lsum		$0		$0	8,000.00	$16,000	$8,000.00	$16,000
22-11-13.48 Equipment Connections										
AHU 2 1/2" Coil Connection Assy - Htg HW	3	ea		$0		$0	9,100.00	$27,300	$9,100.00	$27,300
AHU 3" Coil Connection Assy - Chill Wtr	3	ea		$0		$0	9,900.00	$29,700	$9,900.00	$29,700
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	73,125	sf		$0		$0	0.30	$21,938	$0.30	$21,938
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters (2 ea)	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	8	ea		$0		$0	3,200.00	$25,600	$3,200.00	$25,600
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	16	ea		$0		$0	450.00	$7,200	$450.00	$7,200
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	73,125	sf		$0		$0	0.30	$21,938	$0.30	$21,938
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	16	ea		$0		$0	575.00	$9,200	$575.00	$9,200
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	260	lf		$0		$0	210.00	$54,600	$210.00	$54,600
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	73,125	sf		$0		$0	2.20	$160,875	$2.20	$160,875

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Alternate 4	73,125	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	1	ea		$0		$0	840.00	$840	$840.00	$840
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	42,510.38	$42,510	$42,510.38	$42,510
				$0		$0		$0	$0.00	$0
HVAC - 73,125 SF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	73,125	sf		$0		$0	0.75	$54,844	$0.75	$54,844
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	5,000	ton		$0		$0	38.00	$190,000	$38.00	$190,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	73,125	sf		$0		$0	0.33	$24,131	$0.33	$24,131
Mech Contractor Assist 3rd Party - Cx Commissioning Support (4 men 1 week)	160	mh		$0		$0	130.00	$20,800	$130.00	$20,800
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	73,125	sf		$0		$0	1.50	$109,688	$1.50	$109,688
Commissioning Cx of HVAC systems - Boilers, Chillers, Pumps, Systems	73,125	sf		$0		$0	3.00	$219,375	$3.00	$219,375
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	47,530	lb		$0		$0	0.15	$7,130	$0.15	$7,130
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Chill Wtr & Condsr Water Special Hangers & Supports	5,000	ton		$0		$0	88.00	$440,000	$88.00	$440,000
Plant HVAC Chilled Water Pipe Insulation	5,000	ton		$0		$0	110.00	$550,000	$110.00	$550,000
Cooling Tower Cell Overflow Drain Piping	6	ea		$0		$0	3,000.00	$18,000	$3,000.00	$18,000
Cooling Tower Equalizer & By-pass piping	5,000	ton		$0		$0	162.00	$810,000	$162.00	$810,000
Cooling Tower Chill & Condenser Water Plant Piping	5,000	ton		$0		$0	294.00	$1,470,000	$294.00	$1,470,000
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	2	lsum		$0		$0	600,000.00	$1,200,000	$600,000.00	$1,200,000
Boiler Install - Loose Piping from Vendor	2	ea		$0		$0	7,000.00	$14,000	$7,000.00	$14,000
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	73,125	sf		$0		$0	11.00	$804,375	$11.00	$804,375
Boiler Feedwater Piping & Insulation	73,125	sf		$0		$0	14.00	$1,023,750	$14.00	$1,023,750
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	28,518	sf		$0		$0	5.40	$153,997	$5.40	$153,997
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	5,000	ton		$0		$0	10.00	$50,000	$10.00	$50,000
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (3 ea)	48	pt		$0		$0	2,000.00	$96,000	$2,000.00	$96,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (22 ea) allw	44	pt		$0		$0	2,000.00	$88,000	$2,000.00	$88,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt		$0		$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	3	pt		$0		$0	2,000.00	$6,000	$2,000.00	$6,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	3	ea		$0		$0	3,600.00	$10,800	$3,600.00	$10,800
Control Components/BACnet Systems, front end costs, Programming & Engineering	73,125	sf		$0		$0	2.00	$146,250	$2.00	$146,250
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialties	5,000	ton		$0		$0	64.00	$320,000	$64.00	$320,000
Control Components, Steam & Stm Condensate Control Valves & Specialties	2	ls		$0		$0	200,000.00	$400,000	$200,000.00	$400,000
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	22	ea		$0		$0	170.00	$3,740	$170.00	$3,740
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 5000 Ton)	12,500	lb		$0		$0	14.00	$175,000	$14.00	$175,000
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (73,125 sf)	47,530	lb		$0		$0	14.40	$684,432	$14.40	$684,432
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 2 ea	100	lf		$0		$0	280.00	$28,000	$280.00	$28,000
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	73,125	sf		$0		$0	0.25	$18,281	$0.25	$18,281
Flex Duct (SF Basis) at 50% - SA Only	73,125	sf		$0		$0	0.14	$10,238	$0.14	$10,238
Fire/ Smoke Dampers (SF Basis)	73,125	sf		$0		$0	0.60	$43,875	$0.60	$43,875
Duct Access Door, insulated, (SF Basis)	73,125	sf		$0		$0	0.13	$9,506	$0.13	$9,506
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	6	ea		$0		$0	1,300.00	$7,800	$1,300.00	$7,800
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	73,125	sf		$0		$0	2.00	$146,250	$2.00	$146,250
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	22	ea		$0		$0	1480.00	$32,560	$1,480.00	$32,560
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	73,125	sf		$0		$0	0.70	$51,188	$0.70	$51,188
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Panel & Remote I/O Panels) - **included in CTG unit cost**	1	ls		$0		$0	515,905	$515,905	$515,905	$515,905
Control System Hardware (2 Work Sta, 5 Server, Server Racks Redundant Switches Firewall	1	ls		$0		$0	120,000	$120,000	$120,000	$120,000
Control Room Furniture (Console, 8 dual screen monitors)	1	ls		$0		$0	200,000	$200,000	$200,000	$200,000
Control System Software (License)	1	ls		$0		$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning)	1	ls		$0		$0	1,836,527	$1,836,527	$1,836,527	$1,836,527
Balance of Plant Instrumentation	1	ls		$0		$0	431649	$431,649	$431,649	$431,649
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls		$0		$0	380,628.19	$380,628	$380,628.19	$380,628
Electrical - 73,125 SF				$0		$0		$0	$0.00	$0
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	73,125	sf		$0		$0	0.65	$47,531	$0.65	$47,531
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #500 - (2000A) 5 ckt x 4 set x 3w x 2 plcs, 2100	120	ea		$0		$0	200.00	$24,000	$200.00	$24,000
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	73,125	sf		$0		$0	1.60	$117,000	$1.60	$117,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	73,125	sf		$0		$0	1.05	$76,781	$1.05	$76,781
26-05-26.80 Grounding										
Building Ground Ring	1,100	lf		$0		$0	26.00	$28,600	$26.00	$28,600
Grounding New Panels & Switchboards	12	ea		$0		$0	300.00	$3,600	$300.00	$3,600
Ground New Substation (Dbl Ended)	4	ea		$0		$0	680.00	$2,720	$680.00	$2,720
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	73,125	sf		$0		$0	0.60	$43,875	$0.60	$43,875
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	23	ea		$0		$0	475.00	$10,925	$475.00	$10,925
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	73,125	sf		$0		$0	3	$219,375	$3.00	$219,375
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	73,125	sf		$0		$0	2.25	$164,531	$2.25	$164,531
Conduit for Light Fixtures (Sqft Basis) -	73,125	sf		$0		$0	3.80	$277,875	$3.80	$277,875
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	73,125	sf		$0		$0	1.10	$80,438	$1.10	$80,438
20A Feeder Ckt. - FCU Term Unit x 80' ave (22 allw)	1,760	lf		$0		$0	13.30	$23,408	$13.30	$23,408
100A Feeder Ckt - Cool Tower Fans., 6 each x 140' each ave	840	lf		$0		$0	33.00	$27,720	$33.00	$27,720
100A Feeder Ckt - AHU Circuits, 3 each x 160' ave	480	lf		$0		$0	33.00	$15,840	$33.00	$15,840
100A Feeder Ckt - Boiler FD Fans, 2 each x 280' ave	560	lf		$0		$0	33.00	$18,480	$33.00	$18,480
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 140' ave	420	lf		$0		$0	33.00	$13,860	$33.00	$13,860
150A Elect Ckt - CHW Primary Pumps, 6 each x 140' ave allw	840	lf		$0		$0	37.00	$31,080	$37.00	$31,080
225A Elect Ckt - Boiler Feedwater Pumps, 2 each x 260' ave allw	520	lf		$0		$0	53.00	$27,560	$53.00	$27,560

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225A Elect Ckt - Btm Discharge FD Boiler Fan, 2 each x 280' ave allw	560	lf		$0		$0	53.00	$29,680	$53.00	$29,680
400A Elect Ckt - CHW Secondary Pumps - 6 each x 120' ea ave	720	lf		$0		$0	121.00	$87,120	$121.00	$87,120
600A Elect Ckt - Cool Tower Pumps, 6 ea x 140' each ave	840	lf		$0		$0	183.00	$153,720	$183.00	$153,720
1000A Feeder Ckt - 1000 Ton Chiller - 6 each x 220' ave	1,320	lf		$0		$0	344.00	$454,080	$344.00	$454,080
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 144 GSF	508	ea		$0		$0	57.00	$28,956	$57.00	$28,956
Outlet boxes, pressed steel, 4" square - Card Readers - CR	10	ea		$0		$0	57.00	$570	$57.00	$570
Outlet boxes, pressed steel, 4" square - CCTV locations	10	ea		$0		$0	57.00	$570	$57.00	$570
26-05-33.65 Pull Boxes										
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	6	ea		$0		$0	350.00	$2,100	$350.00	$2,100
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	73,125	sf		$0		$0	0.95	$69,469	$0.95	$69,469
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	73,125	sf		$0		$0	0.95	$69,469	$0.95	$69,469
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1, CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2 CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 15 KV, CUP Size allw	1	ea		$0		$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses	4	ea		$0		$0	29,400.00	$117,600	$29,400.00	$117,600
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type										
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	-	ea		$0		$0	9,500.00	$0	$9,500.00	$0
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	2	ea		$0		$0	35,000.00	$70,000	$35,000.00	$70,000
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility - CUP size allw	4	ea		$0		$0	140,000.00	$560,000	$140,000.00	$560,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	-	ea		$0		$0	725.00	$0	$725.00	$0
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	2	ea		$0		$0	1,170.00	$2,340	$1,170.00	$2,340
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA CUP Size allw	4	ea		$0		$0	1,500.00	$6,000	$1,500.00	$6,000
Utility Xfmr Short Ckt & arc flash study	1	ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards										
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 100 ton Chillers (1 per)	5	ea		$0		$0	22,700.00	$113,500	$22,700.00	$113,500
26-24-16.30 Panelboards Commercial Applications										
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	73,125	sf		$0		$0	3.01	$220,106	$3.01	$220,106
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	73,125	sf		$0		$0	1.05	$76,781	$1.05	$76,781
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	73,125	sf		$0		$0	0.75	$54,844	$0.75	$54,844
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	73,125	sf		$0		$0	0.26	$19,013	$0.26	$19,013
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	4	ea		$0		$0	3,000.00	$12,000	$3,000.00	$12,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12	ea		$0		$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center										
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea		$0		$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements										
Duplex & Special Receptacle Devices CUP (SF Basis)	73,125	sf		$0		$0	0.85	$62,156	$0.85	$62,156
26-28-16.10 Circuit Breakers										
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	73,125	sf		$0		$0	1.12	$81,900	$1.12	$81,900
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds Chillers	5	ea		$0		$0	8,500.00	$42,500	$8,500.00	$42,500
Switchboards, Distribution, 4 wire, 277/480, 800 A - for Boilers	2	ea		$0		$0	8,500.00	$17,000	$8,500.00	$17,000
26-28-16.20 Safety Switches										
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	73,125	sf		$0		$0	0.60	$43,875	$0.60	$43,875
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives										
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	6	ea		$0		$0	5,900.00	$35,400	$5,900.00	$35,400
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	2	ea		$0		$0	6,500.00	$13,000	$6,500.00	$13,000
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	3	ea		$0		$0	6,500.00	$19,500	$6,500.00	$19,500
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	6	ea		$0		$0	7,300.00	$43,800	$7,300.00	$43,800
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	2	ea		$0		$0	8,100.00	$16,200	$8,100.00	$16,200
Variable frequency drives, custom-engineered, 460 volt, 250 HP - labor only, CHW Sec Pumps	6	ea		$0		$0	9,400.00	$56,400	$9,400.00	$56,400
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4	ea		$0		$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators										
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly tank	-	ea		$0		$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2)	-	ea		$0		$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel	-	gal		$0		$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection										
Building Lightning Protection CUP (SF Basis)	73,125	sf		$0		$0	0.70	$51,188	$0.70	$51,188
26-51-13.50 Interior Lighting Fixtures										
Interior Networked EMCS Light Control Points, Conduit & wire	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	73,125	sf		$0		$0	11.00	$804,375	$11.00	$804,375
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	130	ea		$0		$0	170.00	$22,100	$170.00	$22,100
26-52-13.10 Emergency Lighting And Battery Units										
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8	ea		$0		$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures										
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	6	ea		$0		$0	435.00	$2,610	$435.00	$2,610
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices										
Lighting Controls, Conduit and wire - Office area - 30% of Plant	21,938	sf		$0		$0	2.00	$43,876	$2.00	$43,876
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8	ea		$0		$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips										
Fixture Whips (SF Basis) -	73,125	sf		$0		$0	0.45	$32,906	$0.45	$32,906
							$0			
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls		$0		$0	242,508.75	$242,509	$242,508.75	$242,509
27-00-00.00 COMMUNICATIONS										
27-11-19.10 Termination Blocks And Patch Panels										
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber										
Tel/ Data System CUP Conduit & Cable (SF Basis)	73,125	sf		$0		$0	3.00	$219,375	$3.00	$219,375
Tel/ Data System, Engineer & Program (SF Basis)	73,125	sf		$0		$0	0.21	$15,356	$0.21	$15,356
Tel/ Data System, Backbone allw (SF Basis)	73,125	sf		$0		$0	0.30	$21,938	$0.30	$21,938
Tel/ Data Devices CUP (SF Basis)	73,125	sf		$0		$0	0.65	$47,531	$0.65	$47,531
Tel./ Data Equipment Rack complete allw	2	ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	16	ea		$0		$0	280.00	$4,480	$280.00	$4,480
Wire Management, Vertical & Horiz per Rack	2	ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	32	lf		$0		$0	78.00	$2,496	$78.00	$2,496
				$0		$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System										
Sound & Public Address System Conduit & cable - CUP (SF Basis)	73,125	sf		$0		$0	1.00	$73,125	$1.00	$73,125
Sound & PA Speaker 1 per 800 sf, qty allw	91	ea		$0		$0	250.00	$22,750	$250.00	$22,750
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	73,125	sf		$0		$0	0.50	$36,563	$0.50	$36,563
WAP - Wireless Access Paging Device - 1 per 2400 sf	30	ea		$0		$0	270.00	$8,100	$270.00	$8,100
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	73,125	sf		$0		$0	0.40	$29,250	$0.40	$29,250
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	24,915.93	$24,916	$24,915.93	$24,916
28-05-00.00 ELECTRONIC SAFETY & SECURITY										
28-23-13.10 CCTV Security & Door Egress System										
CCTV Security Monitoring System Conduit & Cable (SF Basis)	73,125	sf		$0		$0	0.80	$58,500	$0.80	$58,500
CCTV Camera Dome Fixed (7 ea) - interior qty allw	7	ea		$0		$0	2,030.00	$14,210	$2,030.00	$14,210
CCTV Camera P-T-Z 180 Degree w support, 8 megapixel, Exterior allw	3	ea		$0		$0	2,570.00	$7,710	$2,570.00	$7,710
Security Door Egress System Conduit and Cable (SF Basis)	73,125	sf		$0		$0	0.75	$54,844	$0.75	$54,844
Door Card Reader Control/ Alarm Panel	1	ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	10	ea		$0		$0	1,150.00	$11,500	$1,150.00	$11,500
Door Duress Pushbutton - PB , qty allw	5	ea		$0		$0	145.00	$725	$145.00	$725
Door Strike/ Contact	10	ea		$0		$0	220.00	$2,200	$220.00	$2,200
Door Position Switch	10	ea		$0		$0	200.00	$2,000	$200.00	$2,000

University of Houston
UH Alternate 4
CHP: Combustion Turbine, 26 MW with Heat Recovery Steam Generator and Absorption Chillers
Conceptual Design Estimates
8/5/2022

Alternate 4	73,125 UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	10 ea		$0		$0	680.00	$6,800	$680.00	$6,800
Door Electrified Lever Set & Transfer Hinge - qty allw	5 ea		$0		$0	960.00	$4,800	$960.00	$4,800
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	5 ea		$0		$0	550.00	$2,750	$550.00	$2,750
Door Deep J- Box 4"x4" x 2-1'8"	10 ea		$0		$0	55.00	$550	$55.00	$550
Door Large Pull Box/ J- Box 12"x12" x 4"	10 ea		$0		$0	190.00	$1,900	$190.00	$1,900
28-31-23.50 Alarm Panels And Devices									
Fire Alarm System Core & Shell (SF Basis)	73,125 sf		$0		$0	3.52	$257,400	$3.52	$257,400
Fire Alarm System Programming (SF Basis)	73,125 sf		$0		$0	0.32	$23,400	$0.32	$23,400
Fire Alarm System Test & Check Out	73,125 sf		$0		$0	0.15	$10,969	$0.15	$10,969
Fire Alarm Master Control Panel, Office > 28,000 SF	1 ea		$0		$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	91 ea		$0		$0	340.00	$30,940	$340.00	$30,940
Fire Alarm Pull Station (addressable), qty allw	6 ea		$0		$0	255.00	$1,530	$255.00	$1,530
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1 ls		$0		$0	26,066.38	$26,066	$26,066.38	$26,066
			$0		$0		$0		$0
Cost of Work Subtotal			$4,389,765		$46,421,020		$42,772,343		$93,583,128

	Premium Time		
	Direct Construction Costs		$93,583,128
	General Conditions	10.00%	$9,358,313
	Sub-Total Construction Costs		$102,941,441
	P&P bonds	2.5%	$2,573,536
	Building Permit	0.45%	$463,236
	Sub-Total Construction Costs		$105,978,214
	GL & Umbrella	1.00%	$1,059,782
	Professional liability	1.00%	$1,059,782
	Builder Risk	0.10%	$105,978
	Design Completion Uncertainty Factor	25.00%	$27,050,939
	Sub-Total Construction Costs		$135,254,695
	GC Fee	6.00%	$8,115,282
	Design fee	8.00%	$10,820,376
Alternate 4	**Total Construction Costs**		**$154,190,353**
			$154,190,000

AACE Class 5 ROM Budget Range:	High	50%	$231,285,529
	Low	-30%	$107,933,247

University of Houston
UH Alternate 5
CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following
Conceptual Design Estimates
8/5/2022

Alternate 5	48,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement										
Misc Hoisting	180	hr		$0		$0	$125	$22,500	$125.00	$22,500
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	48,750	sf		$0		$0	$ 1.00	$48,750	$1.00	$48,750
Dump fee	451	cy		$0		$0	$ 25.00	$11,285	$25.00	$11,285
Haul off 12 cy/ld x 2 hr rt	113	hr		$0		$0	$ 68.00	$7,674	$68.00	$7,674
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	5,417	cy		$0		$0	$ 18.00	$97,500	$18.00	$97,500
Import fill	5,417	cy	$ 6.00	$32,500	$ 9.00	$48,750	$ 10.00	$54,167	$25.00	$135,417
Fdn Struct exc	3,917	cy		$0		$0	$ 25.00	$97,917	$25.00	$97,917
Dump fee	9,333	cy		$0		$0	$ 25.00	$233,333	$25.00	$233,333
Hal off 12 cy/ld x 3 hr rt	2,333	hr		$0		$0	$ 68.00	$158,667	$68.00	$158,667
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete Drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	3,611	cy		$0		$0	650.00	$2,347,222	$650.00	$2,347,222
Misc concrete	200	cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	106	cy		$0		$0	1000.00	$105,556	$1,000.00	$105,556
Slab on grade 12in	48,750	sf		$0		$0	14.00	$682,500	$14.00	$682,500
Tilt skin 30 hi	28,500	sf		$0		$0	55.00	$1,567,500	$55.00	$1,567,500
Mechanical pads	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
				$0		$0		$0	$0.00	$0
Div 34										
CMU misc	13,470	sf		$0		$0	28.00	$377,160	$28.00	$377,160
									$0.00	
Metals										
Steel framing #15lb/sf	366	tn		$0		$0	$ 8,000.00	$2,925,000	$8,000.00	$2,925,000
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	48,750	sf		$0		$0	$ 5.00	$243,750	$5.00	$243,750
skin back u framing 4#/sf	57	tn		$0		$0	$ 8,000.00	$456,000	$8,000.00	$456,000
Misc metals	48,750	sf		$0		$0	$ 1.00	$48,750	$1.00	$48,750
Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
				$0		$0		$0	$0.00	$0
Div 6 Carpenter										
Blocking and backing	48,750	sf	$ 1.00	$48,750	$ 1.00	$48,750		$0	$2.00	$97,500
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	46	lf		$0		$0	$ 350.00	$16,100	$350.00	$16,100
Counter top	115	sf		$0		$0	$ 58.00	$6,670	$58.00	$6,670
Wall cabinets	46	lf		$0		$0	$ 375.00	$17,250	$375.00	$17,250
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	48,750	sf		$0		$0	$ 0.40	$19,500	$0.40	$19,500
Fire stopping	48,750	sf		$0		$0	$ 0.50	$24,375	$0.50	$24,375
Waterproofing slab	48,750	sf		$0		$0	$ 8.00	$390,000	$8.00	$390,000
Waterproofing walls	2,850	sf		$0		$0	$ 9.00	$25,650	$9.00	$25,650
Roofing	48,750	sf		$0		$0	$ 18.00	$877,500	$18.00	$877,500
Sheet metal	48,750	sf		$0		$0	$ 4.75	$231,563	$4.75	$231,563
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	48,750	sf		$0		$0	$ 4.50	$219,375	$4.50	$219,375
				$0		$0		$0	$0.00	$0
Div 8										
HM Frame	19	ea	$150	$2,850	650	$12,350		$0	$800.00	$15,200
Hm Door	19	ea	$150	$2,850	700	$13,300		$0	$850.00	$16,150
Hardware	19	ea	$150	$2,850	1,000	$19,000		$0	$1,150.00	$21,850
Glass dr	4	ea		$0		$0	$3,800	$15,200	$3,800.00	$15,200
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	2,850	sf		$0		$0	$125	$356,250	$125.00	$356,250
Int glazing	800	sf		$0		$0	$125	$100,000	$125.00	$100,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	14	ea		$0		$0	$20,000	$280,000	$20,000.00	$280,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	5,210	sf		$0		$0	18.00	$93,780	$18.00	$93,780
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	180	hr		$0		$0	125.00	$22,500	$125.00	$22,500
Firestopping at top of wall	521	lf		$0		$0	6.00	$3,126	$6.00	$3,126
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	6,500	sf		$0		$0	$ 10.00	$65,000	$10.00	$65,000
Open ceiling painted	34,750	sf		$0		$0	$ 1.50	$52,125	$1.50	$52,125
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	41,250	sf		$0		$0	$ 2.00	$82,500	$2.00	$82,500
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	48,750	sf		$0		$0	$ 1.50	$73,125	$1.50	$73,125
Carpet,		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	6,500	sf		$0		$0	$ 8.00	$52,000	$8.00	$52,000
Epoxy sealer	34,750	sf		$0		$0	15.00	$521,250	$15.00	$521,250
Epoxy sealer mezzanine	-	sf		$0		$0	15.00	$0	$15.00	$0
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	10,420	sf		$0		$0	1.00	$10,420	$1.00	$10,420
Paint drs	19	ea		$0		$0	150.00	$2,850	$150.00	$2,850
Paint steel	48,750	sf		$0		$0	1.00	$48,750	$1.00	$48,750
Hoisting	24	hr		$0		$0	125.00	$3,000	$125.00	$3,000
Paint mezzanine	-	sf		$0		$0	1.00	$0	$1.00	$0
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	48,750	sf		$0		$0	2.00	$97,500	$2.00	$97,500
Signage	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
Toilet accessories	2	ea		$0		$0	$ 1,200.00	$2,400	$1,200.00	$2,400
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings				$0		$0		$0	$0.00	$0
Misc items	48,750	sf		$0		$0	1.00	$48,750	$1.00	$48,750
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1	ls		$0		$0	100,000	$100,000	$100,000.00	$100,000
				$0		$0		$0	$0.00	$0
Option-5 Major Equipment 48,750 GSF										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Gen Set, 4 MW (4000 KW) xx Pri/ 480/277 Sec	12	EA	$ 53,000	$636,000	$ 3,000,000	$36,000,000		$0	$3,053,000.00	$36,636,000

University of Houston
UH Alternate 5
CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following
Conceptual Design Estimates
8/5/2022

Alternate 5	48,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Auto Transfer Switch, 3000A w Auto Bypass (size allw)	12	EA	$ 6,000	$72,000	$ 225,000	$2,700,000		$0	$231,000.00	$2,772,000
3000A Feeder, Gen Set to Elect Gear (140' ave x 11 ckts)	1,540	LF	$ 282	$434,280	$ 959	$1,476,860		$0	$1,241.00	$1,911,140
Gen Set Lube Oil System Tanks, Pumps, Accessories	2	EA	$ 8,000	$16,000	$ 85,000	$170,000		$0	$93,000.00	$186,000
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Absorption Chiller, 1000 Ton	7	EA	$ 82,000	$574,000	$ 615,000	$4,305,000		$0	$697,000.00	$4,879,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Makeup Water Treatment System	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - boiler/ Gen set area	1	EA	$ 26,250	$26,250	$136,000	$136,000		$0	$162,250	$162,250
Air handler - ops area	1	EA	$ 22,050	$22,050	$88,000	$88,000		$0	$110,050	$110,050
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	7	EA	$ 100,000	$700,000	$196,000	$1,372,000		$0	$296,000	$2,072,000
Primary CHW Pumps	5	EA	$ 15,000	$75,000	$60,000	$300,000		$0	$75,000	$375,000
Secondary CHW Pumps	5	EA	$ 25,000	$125,000	$150,000	$750,000		$0	$175,000	$875,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$150,000	$600,000		$0	$175,000	$700,000
Continuous Emissions Monitoring Equipment	1	LS	$ 80,000	$80,000	$350,000	$350,000		$0	$430,000	$430,000
				$0		$0		$0	$0	$0
MEP General Conditions - 48,750 GSF										
Temp Power & Lighting - mods area	48,750	sf		$0		$0	$1.00	$48,750	$1.00	$48,750
MEP Hoisting - Crane Rental, HVAC Equipment	60	day		$0		$0	$ 1,800.00	$108,000	$1,800.00	$108,000
MEP Hoisting - Crane Rental, Elect Equipment	16	day		$0		$0	$ 1,800.00	$28,800	$1,800	$28,800
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	48,750	sf		$0		$0	5.10	$248,625	$5.10	$248,625
Fire Protection Pipe Sleeves & Fire Seal Penetrations	48,750	sf		$0		$0	0.10	$4,875	$0.10	$4,875
Fire Protection Seismic Restraints per NFPA 13	48,750	sf		$0		$0	0.15	$7,313	$0.15	$7,313
8" Entry Assy w valves & meters -	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	20	lf		$0		$0	145.00	$2,900	$145.00	$2,900
Sprinkler System Flow Switch - qty allw	5	ea		$0		$0	185.00	$925	$185.00	$925
Sprinkler System Tamper Switch - qty allw	5	ea		$0		$0	180.00	$900	$180.00	$900
Test new System Internally and w AHJ or Fire Marshall (32 MH)	40	mh		$0		$0	115.00	$4,600	$115.00	$4,600
Fire Pump 100 HP, 1500 gpm - allw	1	ls		$0		$0	78,700.00	$78,700	$78,700.00	$78,700
Jockey Pump 3-5 HP - allw	1	ls		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	18,594.38	$18,594	$18,594.38	$18,594
Plumbing - 48,750 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	8	fix		$0		$0	137.00	$1,096	$137.00	$1,096
Sterilization, Chlorination, Domestic Water System	8	fix		$0		$0	45.00	$360	$45.00	$360
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,500.00	$2,500	$2,500.00	$2,500
22-05-29.10 Hangers And Supports For Plumbing/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	3	ea		$0		$0	2,200.00	$6,600	$2,200.00	$6,600
HVAC Equip Vib Isolators per - FCU's/ VAV's (15 ea x 4)	60	ea		$0		$0	100.00	$6,000	$100.00	$6,000
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	48,750	sf		$0		$0	0.80	$39,000	$0.80	$39,000
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	48,750	sf		$0		$0	0.10	$4,875	$0.10	$4,875
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	48,750	sf		$0		$0	1.00	$48,750	$1.00	$48,750
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	8	ea		$0		$0	2,950.00	$23,600	$2,950.00	$23,600
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (3)	90	lf		$0		$0	41.00	$3,690	$41.00	$3,690
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	14,625	sf		$0		$0	3.70	$54,113	$3.70	$54,113
Building Nat Gas Pipe Distribution	48,750	sf		$0		$0	0.70	$34,125	$0.70	$34,125
Natural Gas to Gen Sets	11	lsum		$0		$0	5,000.00	$55,000	$5,000.00	$55,000
Natural Gas to Gas Turbine Generators	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	3	ea		$0		$0	9,900.00	$29,700	$9,900.00	$29,700
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	48,750	sf		$0		$0	0.30	$14,625	$0.30	$14,625
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	8	ea		$0		$0	3,200.00	$25,600	$3,200.00	$25,600
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	12	ea		$0		$0	450.00	$5,400	$450.00	$5,400
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	48,750	sf		$0		$0	0.30	$14,625	$0.30	$14,625
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	12	ea		$0		$0	575.00	$6,900	$575.00	$6,900
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	245	lf		$0		$0	210.00	$51,450	$210.00	$51,450
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	48,750	sf		$0		$0	2.20	$107,250	$2.20	$107,250
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	1	ea		$0		$0	840.00	$840	$840.00	$840
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	32,014.98	$32,015	$32,014.98	$32,015
				$0		$0		$0	$0.00	$0
HVAC - 48,750 GSF										

University of Houston
UH Alternate 5
CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following
Conceptual Design Estimates
8/5/2022

Alternate 5	48,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	48,750	sf		$0		$0	0.75	$36,563	$0.75	$36,563
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	6,000	ton		$0		$0	38.00	$228,000	$38.00	$228,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	48,750	sf		$0		$0	0.33	$16,088	$0.33	$16,088
Mech Contractor Assist 3rd Party - Cx Commissioning Support (3 men 1 week)	120	mh		$0		$0	130.00	$15,600	$130.00	$15,600
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	48,750	sf		$0		$0	1.00	$48,750	$1.00	$48,750
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	48,750	sf		$0		$0	4.00	$195,000	$4.00	$195,000
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	31,687	lb		$0		$0	0.15	$4,753	$0.15	$4,753
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	6,000	ton		$0		$0	88.00	$528,000	$88.00	$528,000
Plant HVAC Chilled Water Pipe Insulation	6,000	ton		$0		$0	110.00	$660,000	$110.00	$660,000
Cooling Tower Cell Overflow Drain Piping	6	ea		$0		$0	3,000.00	$18,000	$3,000.00	$18,000
Cooling Tower Equalizer & By-pass piping	6,000	ton		$0		$0	162.00	$972,000	$162.00	$972,000
Cooling Tower Chill & Condenser Water Plant Piping	6,000	ton		$0		$0	294.00	$1,764,000	$294.00	$1,764,000
HPS/ MPS Piping System w Hgrs & Supports	-	lsum		$0		$0	1,500,000.00	$0	$1,500,000.00	$0
Boiler Install - Loose Piping from Vendor	-	ea		$0		$0	7,000.00	$0	$7,000.00	$0
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	-	sf		$0		$0	11.00	$0	$11.00	$0
Boiler Feedwater Piping & Insulation	-	sf		$0		$0	14.00	$0	$14.00	$0
23-07-13.10 Duct Thermal Insulation										
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	19,012	sf		$0		$0	5.40	$102,665	$5.40	$102,665
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	6,000	ton		$0		$0	10.00	$60,000	$10.00	$60,000
23-09-23.10 Control Components/DDC Systems										
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (3 ea)	48	pt		$0		$0	2,000.00	$96,000	$2,000.00	$96,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (15 ea) allw	30	pt		$0		$0	2,000.00	$60,000	$2,000.00	$60,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt		$0		$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	3	pt		$0		$0	2,000.00	$6,000	$2,000.00	$6,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt		$0		$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	3	ea		$0		$0	3,600.00	$10,800	$3,600.00	$10,800
Control Components/BACnet Systems, front end costs, Programming & Engineering	48,750	sf		$0		$0	2.00	$97,500	$2.00	$97,500
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
23-09-53.10 Control Components										
Control Components, Chill & Condsr Control Valves & Specialities	6,000	ton		$0		$0	60.00	$360,000	$60.00	$360,000
Control Components, Steam & Stm Condensate Control Valves & Specialities	-	ls		$0		$0	200,000.00	$0	$200,000.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	15	ea		$0		$0	170.00	$2,550	$170.00	$2,550
23-23-16.10 Refrigerant Piping Component Specialties										
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 6000 Ton)	15,000	lb		$0		$0	14.00	$210,000	$14.00	$210,000
23-31-13.13 Rectangular Metal Ducts										
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (48,750 sf)	31,687	lb		$0		$0	14.40	$456,293	$14.40	$456,293
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 4 ea	-	lf		$0		$0	280.00	$0	$280.00	$0
23-31-13.19 Duct Accessories										
Balance Dampers & Turning Vanes (SF Basis) at 50%	48,750	sf		$0		$0	0.25	$12,188	$0.25	$12,188
Flex Duct (SF Basis) at 50% - SA Only	48,750	sf		$0		$0	0.14	$6,825	$0.14	$6,825
Fire/ Smoke Dampers (SF Basis)	48,750	sf		$0		$0	0.60	$29,250	$0.60	$29,250
Duct Access Door, insulated, (SF Basis)	48,750	sf		$0		$0	0.13	$6,338	$0.13	$6,338
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	6	ea		$0		$0	1,300.00	$7,800	$1,300.00	$7,800
23-34-16.10 Centrifugal Type HVAC Fans										
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	48,750	sf		$0		$0	2.00	$97,500	$2.00	$97,500
23-36-13.10 Constant Volume Mixing Boxes										
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	15	ea				$0	1480	$22,200	$1,480.00	$22,200
23-37-13.10 Diffusers										
Grilles, Registers & Diffusers (SF Basis)	48,750	sf		$0		$0	0.70	$34,125	$0.70	$34,125
25-10-10.10 Integrated Automation - Instrumentation & Controls										
Controllers (Redundant PLC, Panel & Remote I/O Panels) (0.50)	1	ls		$0		$0	257,000	$257,000	$257,000	$257,000
Control System Hardware (2 Work Sta, 2 Server, Server Racks Redundant Switches Firewall (0.40)	1	ls		$0		$0	120,000	$120,000	$120,000	$120,000
Control Room Furniture (Console, 3 dual screen monitors) (0.50)	1	ls		$0		$0	200,000	$200,000	$200,000	$200,000
Control System Software (License)	1	ls		$0		$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning) (.50)	1	ls		$0		$0	1,020,000	$1,020,000	$1,020,000	$1,020,000
Balance of Plant Instrumentation (0.50)	1	ls		$0		$0	253,000	$253,000	$253,000	$253,000
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls		$0		$0	244,256.24	$244,256	$244,256.24	$244,256
Electrical - 48,750 GSF										
26-05-13.10 Cable Terminations,										
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	48,750	sf		$0		$0	0.65	$31,688	$0.65	$31,688
26-05-19.35 Cable Terminations										
Termination 2-way connectors, copper or alum, 600 volt, #600 - (800A) 6 ckt x 2 set x 3w x 2 plcs, 970 T Chiller Ckt	72	ea		$0		$0	225.00	$16,200	$225.00	$16,200
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	-	ea		$0		$0	245.00	$0	$245.00	$0
26-05-19.90 Wire										
Wire, copper, for Light Fixtures (Sqft Basis)	48,750	sf		$0		$0	1.60	$78,000	$1.60	$78,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	48,750	sf		$0		$0	1.05	$51,188	$1.05	$51,188
26-05-26.80 Grounding										
Building Ground Ring	950	lf		$0		$0	26.00	$24,700	$26.00	$24,700
Grounding New Panels & Switchboards	16	ea		$0		$0	300.00	$4,800	$300.00	$4,800
Ground New Substation (Dbl Ended)	2	ea		$0		$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea		$0		$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea		$0		$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea		$0		$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
26-05-29.20 Hangers										
Seismic or Special Bracing of Conduit & equipment	48,750	sf		$0		$0	0.60	$29,250	$0.60	$29,250
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	23	ea		$0		$0	475.00	$10,925	$475.00	$10,925
26-05-33.05 Conduit										
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	48,750	sf		$0		$0	3	$146,250	$3.00	$146,250
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	48,750	sf		$0		$0	2.25	$109,688	$2.25	$109,688
Conduit for Light Fixtures (Sqft Basis) -	48,750	sf		$0		$0	3.80	$185,250	$3.80	$185,250
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	48,750	sf		$0		$0	1.10	$53,625	$1.10	$53,625
20A Feeder Ckt. - FCU Term Unit x 80' ave (15 allw)	1,200	lf		$0		$0	13.30	$15,960	$13.30	$15,960
100A Feeder Ckt - Cool Tower Fans., 6 each x 140' each ave	840	lf		$0		$0	33.00	$27,720	$33.00	$27,720
100A Feeder Ckt - AHU Circuits, 3 each x 160' ave	480	lf		$0		$0	33.00	$15,840	$33.00	$15,840
100A Feeder Ckt - Boiler FD Fans, 4 each x 120' ave	-	lf		$0		$0	33.00	$0	$33.00	$0
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 120' ave	-	lf		$0		$0	33.00	$0	$33.00	$0
150A Elect Ckt - CHW Primary Pumps, 6 each x 140' ave allw	840	lf		$0		$0	37.00	$31,080	$37.00	$31,080
225A Elect Ckt - Boiler Feedwater Pumps, 4 each x 120' ave allw	-	lf		$0		$0	53.00	$0	$53.00	$0
225A Elect Ckt - Btm Discharge FD Boiler Fan, 4 each x 100' ave allw	-	lf		$0		$0	53.00	$0	$53.00	$0
400A Elect Ckt - CHW Secondary Pumps - 6 each x 120' ea ave	720	lf		$0		$0	121.00	$87,120	$121.00	$87,120
600A Elect Ckt - Cool Tower Pumps, 4 ea x 260' each ave	1,040	lf		$0		$0	183.00	$190,320	$183.00	$190,320
1000A Elect Ckt - 970 Ton Chillers, 6 each x 140' each ave	840	lf		$0		$0	344.00	$288,960	$344.00	$288,960
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel										
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea		$0		$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes										
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 144 GSF	338	ea		$0		$0	57.00	$19,266	$57.00	$19,266
Outlet boxes, pressed steel, 4" square - Card Readers - CR	10	ea		$0		$0	57.00	$570	$57.00	$570
Outlet boxes, pressed steel, 4" square - CCTV locations	10	ea		$0		$0	57.00	$570	$57.00	$570
26-05-33.65 Pull Boxes										
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	7	ea		$0		$0	350.00	$2,450	$350.00	$2,450
26-05-33.95 Cutting And Drilling										
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	48,750	sf		$0		$0	0.50	$24,375	$0.50	$24,375
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea		$0		$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type										
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	48,750	sf		$0		$0	0.95	$46,313	$0.95	$46,313
26-05-80.10 Motor Connections										
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	48,750	sf		$0		$0	0.95	$46,313	$0.95	$46,313
26-13-00.00 Medium Voltage Switchgear/ Substations										
7000A Double Ended Substation #1 CUP Size allw	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2	1	ea		$0		$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
1200A Switchgear, 5 KV - CUP Size allw	1	ea		$0		$0	110,000.00	$110,000	$110,000.00	$110,000

University of Houston
UH Alternate 5
CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following
Conceptual Design Estimates
8/5/2022

Alternate 5	48,750 UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses	2 ea		$0		$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1 ls		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type									
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	6 ea		$0		$0	9,500.00	$57,000	$9,500.00	$57,000
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	- ea		$0		$0	35,000.00	$0	$35,000.00	$0
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility	2 ea		$0		$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	6 ea		$0		$0	725.00	$4,350	$725.00	$4,350
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	- ea		$0		$0	1,170.00	$0	$1,170.00	$0
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - CUP size allw	2 ea		$0		$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1 ls		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards									
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 1000 ton Chillers (1 per)	6 ea		$0		$0	22,700.00	$136,200	$22,700.00	$136,200
26-24-16.30 Panelboards Commercial Applications									
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	48,750 sf		$0		$0	3.01	$146,738	$3.01	$146,738
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	48,750 sf		$0		$0	1.05	$51,188	$1.05	$51,188
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	48,750 sf		$0		$0	0.75	$36,563	$0.75	$36,563
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	48,750 sf		$0		$0	0.26	$12,675	$0.26	$12,675
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1 ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2 ea		$0		$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12 ea		$0		$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center									
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1 ea		$0		$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements									
Duplex & Special Receptacle Devices CUP (SF Basis)	48,750 sf		$0		$0	0.85	$41,438	$0.85	$41,438
26-28-16.10 Circuit Breakers									
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	48,750 sf		$0		$0	1.12	$54,600	$1.12	$54,600
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	6 ea		$0		$0	8,500.00	$51,000	$8,500.00	$51,000
26-28-16.20 Safety Switches									
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	48,750 sf		$0		$0	0.60	$29,250	$0.60	$29,250
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives									
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	7 ea		$0		$0	5,900.00	$41,300	$5,900.00	$41,300
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	- ea		$0		$0	6,500.00	$0	$6,500.00	$0
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	- ea		$0		$0	6,500.00	$0	$6,500.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	5 ea		$0		$0	7,300.00	$36,500	$7,300.00	$36,500
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	- ea		$0		$0	8,100.00	$0	$8,100.00	$0
Variable frequency drives, custom-engineered, 460 volt, 300 HP - labor only, CHW Sec Pumps	5 ea		$0		$0	9,800.00	$49,000	$9,800.00	$49,000
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4 ea		$0		$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators									
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly Tank	- ea		$0		$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2)	- ea		$0		$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel	- gal		$0		$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection									
Building Lightning Protection CUP (SF Basis)	48,750 sf		$0		$0	0.70	$34,125	$0.70	$34,125
26-51-13.50 Interior Lighting Fixtures									
Interior Networked EMCS Light Control Points, Conduit & wire	48,750 sf		$0		$0	0.50	$24,375	$0.50	$24,375
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	48,750 sf		$0		$0	11.00	$536,250	$11.00	$536,250
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 144 GSF	50 ea		$0		$0	170.00	$8,500	$170.00	$8,500
26-52-13.10 Emergency Lighting And Battery Units									
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8 ea		$0		$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures									
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	6 ea		$0		$0	435.00	$2,610	$435.00	$2,610
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1 ea		$0		$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices									
Lighting Controls, Conduit and wire - Office area - 30% of Plant	14,625 sf		$0		$0	2.00	$29,250	$2.00	$29,250
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8 ea		$0		$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips									
Fixture Whips (SF Basis) -	48,750 sf		$0		$0	0.45	$21,938	$0.45	$21,938
						$0			
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1 ls		$0		$0	194,665.08	$194,665	$194,665.08	$194,665
27-00-00.00 COMMUNICATIONS									
27-11-19.10 Termination Blocks And Patch Panels									
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1 ea		$0		$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber									
Tel/ Data System CUP Conduit & Cable (SF Basis)	48,750 sf		$0		$0	3.00	$146,250	$3.00	$146,250
Tel/ Data System, Engineer & Program (SF Basis)	48,750 sf		$0		$0	0.21	$10,238	$0.21	$10,238
Tel/ Data System, Backbone allw (SF Basis)	48,750 sf		$0		$0	0.30	$14,625	$0.30	$14,625
Tel/ Data Devices CUP (SF Basis)	48,750 sf		$0		$0	0.65	$31,688	$0.65	$31,688
Tel./ Data Equipment Rack complete allw	2 ea		$0		$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	16 ea		$0		$0	280.00	$4,480	$280.00	$4,480
Wire Management, Vertical & Horiz per Rack	2 ea		$0		$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	32 lf		$0		$0	78.00	$2,496	$78.00	$2,496
			$0		$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System									
Sound & Public Address System Conduit & cable - CUP (SF Basis)	48,750 sf		$0		$0	1.00	$48,750	$1.00	$48,750
Sound & PA Speaker 1 per 800 sf, qty allw	60 ea		$0		$0	250.00	$15,000	$250.00	$15,000
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	48,750 sf		$0		$0	0.50	$24,375	$0.50	$24,375
WAP - Wireless Access Paging Device - 1 per 2400 sf	40 ea		$0		$0	270.00	$10,800	$270.00	$10,800
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	48,750 sf		$0		$0	0.40	$19,500	$0.40	$19,500
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1 ls		$0		$0	17,277.80	$17,278	$17,277.80	$17,278
28-05-00.00 ELECTRONIC SAFETY & SECURITY									
28-23-13.10 CCTV Security & Door Egress System									
CCTV Security Monitoring System Conduit & Cable (SF Basis)	48,750 sf		$0		$0	0.80	$39,000	$0.80	$39,000
CCTV Camera Dome Fixed (7 ea) - interior qty allw	7 ea		$0		$0	2,030.00	$14,210	$2,030.00	$14,210
CCTV Camera P-T-Z 180 Degree w support, 8 megapixel, Exterior allw	3 ea		$0		$0	2,570.00	$7,710	$2,570.00	$7,710
Security Door Egress System Conduit and Cable (SF Basis)	48,750 sf		$0		$0	0.75	$36,563	$0.75	$36,563
Door Card Reader Control/ Alarm Panel	1 ea		$0		$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - qty allw	10 ea		$0		$0	1,150.00	$11,500	$1,150.00	$11,500
Door Duress Pushbutton - PB , qty allw	5 ea		$0		$0	145.00	$725	$145.00	$725
Door Strike/ Contact	10 ea		$0		$0	220.00	$2,200	$220.00	$2,200
Door Position Switch	10 ea		$0		$0	200.00	$2,000	$200.00	$2,000
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	10 ea		$0		$0	680.00	$6,800	$680.00	$6,800
Door Electrified Lever Set & Transfer Hinge - qty allw	5 ea		$0		$0	960.00	$4,800	$960.00	$4,800
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	5 ea		$0		$0	550.00	$2,750	$550.00	$2,750
Door Deep J- Box 4"x4" x 2-1'8"	10 ea		$0		$0	55.00	$550	$55.00	$550
Door Large Pull Box/ J- Box 12"x12" x 4"	10 ea		$0		$0	190.00	$1,900	$190.00	$1,900
28-31-23.50 Alarm Panels And Devices									
Fire Alarm System Core & Shell (SF Basis)	48,750 sf		$0		$0	3.52	$171,600	$3.52	$171,600
Fire Alarm System Programming (SF Basis)	48,750 sf		$0		$0	0.32	$15,600	$0.32	$15,600
Fire Alarm System Test & Check Out	48,750 sf		$0		$0	0.15	$7,313	$0.15	$7,313
Fire Alarm Master Control Panel, Office > 28,000 SF	1 ea		$0		$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	60 ea		$0		$0	340.00	$20,400	$340.00	$20,400
Fire Alarm Pull Station (addressable), qty allw	5 ea		$0		$0	255.00	$1,275	$255.00	$1,275
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1 ls		$0		$0	18,774.75	$18,775	$18,774.75	$18,775
			$0		$0		$0		$0
Cost of Work Subtotal			$3,131,430		$49,498,600		$30,993,070		$83,623,100

	Premium Time	
Direct Construction Costs		$83,623,100
General Conditions	10.00%	$8,362,310
Sub-Total Construction Costs		$91,985,410
P&P bonds	2.5%	$2,299,635
Building Permit	0.45%	$413,934
Sub-Total Construction Costs		$94,698,979
GL & Umbrella	1.50%	$1,420,485
Professional liability	1.00%	$946,990
Builder Risk	0.10%	$94,699
Design Completion Uncertainty Factor	25.00%	$24,290,288
Sub-Total Construction Costs		$121,451,441

University of Houston
UH Alternate 5
CHP: Reciprocating Engine Generator, 44 MW with Absorption Chillers, Load Following
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Alternate 5	48,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
							GC Fee		6.00%	$7,287,086
							Design fee		8.00%	$9,716,115
Alternate 5							**Total Construction Costs**			**$138,454,643**
										$138,455,000
							AACE Class 5 ROM Budget Range:	High	50%	$207,681,964
								Low	-30%	$96,918,250

University of Houston
UH Alternate 6
CHP: Combustion Turbine, 44 MW with Absorption Chillers, Load Following
Conceptual Design Estimates
8/5/2022

Alternate 6	96,125	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement										
Misc Hoisting	200	hr		$0		$0	$125	$25,000	$125.00	$25,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavatior										
Demolition minor	96,125	sf		$0		$0	$ 1.00	$96,125	$1.00	$96,125
Dump fee	890	cy		$0		$0	$ 25.00	$22,251	$25.00	$22,251
Haul off 12 cy/ld x 2 hr rt	223	hr		$0		$0	$ 68.00	$15,131	$68.00	$15,131
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	10,681	cy		$0		$0	$ 18.00	$192,250	$18.00	$192,250
Import fill	10,681	cy	$ 6.00	$64,083	$ 9.00	$96,125	$ 10.00	$106,806	$25.00	$267,014
Fdn Struct exc	7,481	cy		$0		$0	$ 25.00	$187,015	$25.00	$187,015
Dump fee	18,161	cy		$0		$0	$ 25.00	$454,029	$25.00	$454,029
Hal off 12 cy/ld x 3 hr rt	4,540	hr		$0		$0	$ 68.00	$308,740	$68.00	$308,740
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	7,120	cy		$0		$0	650.00	$4,628,241	$650.00	$4,628,241
Misc concrete	200	cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	160	cy		$0		$0	1000.00	$160,222	$1,000.00	$160,222
Slab on grade 12in	96,125	sf		$0		$0	14.00	$1,345,750	$14.00	$1,345,750
Tilt up skin 30 hi	43,260	sf		$0		$0	55.00	$2,379,300	$55.00	$2,379,300
Mechanical pads	96,125	sf		$0		$0	0.50	$48,063	$0.50	$48,063
				$0		$0		$0	$0.00	$0
Div 34										
CMU misc	14,910	sf		$0		$0	28.00	$417,480	$28.00	$417,480
									$0.00	
Metals										
Steel framing #15lb/sf	721	tn		$0		$0	$ 8,000.00	$5,767,500	$8,000.00	$5,767,500
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	96,125	sf		$0		$0	$ 5.00	$480,625	$5.00	$480,625
skin back u framing 4#/sf	87	tn		$0		$0	$ 8,000.00	$692,160	$8,000.00	$692,160
Misc metals	96,125	sf		$0		$0	$ 1.00	$96,125	$1.00	$96,125
Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	96,125	sf	$ 1.00	$96,125	$ 1.00	$96,125		$0	$2.00	$192,250
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	46	lf		$0		$0	$ 350.00	$16,100	$350.00	$16,100
Counter top	115	sf		$0		$0	$ 58.00	$6,670	$58.00	$6,670
Wall cabinets	46	lf		$0		$0	$ 375.00	$17,250	$375.00	$17,250
									$0.00	
Div 7										
Caulking	96,125	sf		$0		$0	$ 0.40	$38,450	$0.40	$38,450
Fire stopping	96,125	sf		$0		$0	$ 0.50	$48,063	$0.50	$48,063
Waterproofing slab	96,125	sf		$0		$0	$ 8.00	$769,000	$8.00	$769,000
Waterproofing walls	4,326	sf		$0		$0	$ 9.00	$38,934	$9.00	$38,934
Roofing	96,125	sf		$0		$0	$ 18.00	$1,730,250	$18.00	$1,730,250
Sheet metal	96,125	sf		$0		$0	$ 4.75	$456,594	$4.75	$456,594
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	96,125	sf		$0		$0	$ 4.50	$432,563	$4.50	$432,563
									$0.00	
Div 8										
HM Frame	19	ea	$150	$2,850	650	$12,350		$0	$800.00	$15,200
Hm Door	19	ea	$150	$2,850	700	$13,300		$0	$850.00	$16,150
Hardware	19	ea	$150	$2,850	1,000	$19,000		$0	$1,150.00	$21,850
Glass dr	4	ea		$0		$0	$3,800	$15,200	$3,800.00	$15,200
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	4,326	sf		$0		$0	$125	$540,750	$125.00	$540,750
Int glazing	800	sf		$0		$0	$125	$100,000	$125.00	$100,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	12	ea		$0		$0	$20,000	$240,000	$20,000.00	$240,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	5,210	sf		$0		$0	18.00	$93,780	$18.00	$93,780
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	160	hr		$0		$0	125.00	$20,000	$125.00	$20,000
Firestopping at top of wall	521	lf		$0		$0	6.00	$3,126	$6.00	$3,126
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	6,500	sf		$0		$0	$ 10.00	$65,000	$10.00	$65,000
Open ceiling painted	89,625	sf		$0		$0	$ 1.50	$134,438	$1.50	$134,438
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	96,125	sf		$0		$0	$ 2.00	$192,250	$2.00	$192,250
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	96,125	sf		$0		$0	$ 1.50	$144,188	$1.50	$144,188
Carpet,		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	6,500	sf		$0		$0	$ 8.00	$52,000	$8.00	$52,000
Epoxy sealer	89,625	sf		$0		$0	15.00	$1,344,375	$15.00	$1,344,375
Epoxy sealer mezzanine	-	sf		$0		$0	15.00	$0	$15.00	$0
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	10,420	sf		$0		$0	1.00	$10,420	$1.00	$10,420
Paint drs	19	ea		$0		$0	100.00	$1,900	$100.00	$1,900
Paint steel	96,125	sf		$0		$0	1.00	$96,125	$1.00	$96,125
Hoisting	32	hr		$0		$0	125.00	$4,000	$125.00	$4,000
Paint mezzanine	-	sf		$0		$0	1.00	$0	$1.00	$0
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	96,125	sf		$0		$0	2.00	$192,250	$2.00	$192,250
Signage	96,125	sf		$0		$0	0.50	$48,063	$0.50	$48,063
Toilet accessories	2	ea		$0		$0	$ 1,200.00	$2,400	$1,200.00	$2,400
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings				$0		$0		$0	$0.00	$0
Misc items	96,125	sf		$0		$0	1.00	$96,125	$1.00	$96,125
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1	ls		$0		$0	150,000	$150,000	$150,000.00	$150,000
				$0		$0		$0	$0.00	$0
Option-6 Major Equipment (96,125 SF)										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
Absorption Chiller, 1000 Ton	6	EA	$ 82,000	$492,000	$ 615,000	$3,690,000		$0	$697,000	$4,182,000

Combustion Turbine Generator 4.6 MW per Data Base, includes freight	11	EA	$ 164,220	########	$ 3,282,000	$36,102,000		$0	$3,446,220	$37,908,420
Includes Inlet Filter Silencer, Controls/Instrumentation, Gas Fuel Pkg, Lube Oil Pkg, water was										
Heat Recovery Steam Generator (54 kpph)	3	EA	$ 405,000	########	$ 3,035,000	$9,105,000		$0	$3,440,000	$10,320,000
Fuel Gas Compressor	11	EA	$ -	$0	$ 908,700	$9,995,700		$0	$908,700.00	$9,995,700
Continuous Emissions Monitoring Equipment	2	LS	$ 80,000	$160,000	$350,000	$700,000		$0	$430,000	$860,000
Pumps										
includes feedwater, inlet air chiller, oil pumps	4	LS	$ -	$0	$482,290	$1,929,160		$0	$482,290	$1,929,160
Service & Instrument Air Compressor Package	1	LS	$ 20,000.00	$20,000	$ 70,000	$70,000		$0	$90,000.00	$90,000
Boiler Makeup Water Treatment System	1	LS	##########	$750,000	$ 1,000,000	$1,000,000		$0	##########	$1,750,000
Air handler - boiler area	1	EA	$ 26,250	$26,250	$ 105,000	$105,000		$0	$131,250.00	$131,250
Air handler - ops area	1	EA	$ 22,050	$22,050	$ 88,200	$88,200		$0	$110,250.00	$110,250
Air handler - chiller area	1	EA	$ 12,250	$12,250	$ 64,000	$64,000		$0	$76,250	$76,250
Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Condensate Tank, (Surge tank 9,000 - 10,000 gallons)	1	EA	$ 30,000	$30,000	$130,000	$130,000		$0	$160,000	$160,000
Condensate Pumps	3	EA	$ 10,000	$30,000	$20,000	$60,000		$0	$30,000	$90,000
Cooling Towers - 1000 Ton Nominal	6	EA	$ 100,000	$600,000	$187,500	$1,125,000		$0	$287,500	$1,725,000
Primary CHW Pumps	6	EA	$ 15,000	$90,000	$60,000	$360,000		$0	$75,000	$450,000
Secondary CHW Pumps	6	EA	$ 25,000	$150,000	$125,000	$750,000		$0	$150,000	$900,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$100,000	$400,000		$0	$125,000	$500,000
MEP General Conditions - 96,125 GSF										
Temp Power & Lighting - mods area	96,125	sf		$0		$0	$0.90	$86,513	$0.90	$86,513
MEP Hoisting - Crane Rental, HVAC Equipment	60	day		$0		$0	$ 1,800.00	$108,000	$1,800.00	$108,000
MEP Hoisting - Crane Rental, Elect Equipment	16	day		$0		$0	$ 1,800.00	$28,800	$1,800	$28,800
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	96,125	sf		$0		$0	5.10	$490,238	$5.10	$490,238
Fire Protection Pipe Sleeves & Fire Seal Penetrations	96,125	sf		$0		$0	0.10	$9,613	$0.10	$9,613
Fire Protection Seismic Restraints per NFPA 13	96,125	sf		$0		$0	0.15	$14,419	$0.15	$14,419
8" Entry Assy w valves & meters	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	2	ea		$0		$0	850.00	$1,700	$850.00	$1,700
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	40	lf		$0		$0	145.00	$5,800	$145.00	$5,800
Sprinkler System Flow Switch - qty allw	6	ea		$0		$0	185.00	$1,110	$185.00	$1,110
Sprinkler System Tamper Switch - qty allw	6	ea		$0		$0	180.00	$1,080	$180.00	$1,080
Test new System Internally and w AHJ or Fire Marshall (32 MH	64	mh		$0		$0	115.00	$7,360	$115.00	$7,360
Fire Pump 100 HP, 1500 gpm - allw	1	ls		$0		$0	78,700.00	$78,700	$78,700.00	$78,700
Jockey Pump 3-5 HP - allw	1	ls		$0		$0	5,000.00	$5,000	$5,000.00	$5,000
Sprinkler Foreman @ 10% (50/50 Lab/Matl split allw)	1	ls		$0		$0	31,610.94	$31,611	$31,610.94	$31,611
Plumbing - 96,125 SF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	8	fix		$0		$0	137.00	$1,096	$137.00	$1,096
Sterilization, Chlorination, Domestic Water System	8	fix		$0		$0	45.00	$360	$45.00	$360
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,500.00	$2,500	$2,500.00	$2,500
22-05-29.10 Hangers And Supports For Plumb'g/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	3	ea		$0		$0	2,200.00	$6,600	$2,200.00	$6,600
HVAC Equip Vib Isolators per - FCU's/ VAV's (28 ea x 4)	112	ea		$0		$0	100.00	$11,200	$100.00	$11,200
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	96,125	sf		$0		$0	0.80	$76,900	$0.80	$76,900
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis	96,125	sf		$0		$0	0.10	$9,613	$0.10	$9,613
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	96,125	sf		$0		$0	1.00	$96,125	$1.00	$96,125
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	8	ea		$0		$0	2,950.00	$23,600	$2,950.00	$23,600
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Industrial Water IW system Piping	1	lsum		$0		$0	20,000.00	$20,000	$20,000.00	$20,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (3)	90	lf		$0		$0	41.00	$3,690	$41.00	$3,690
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	28,838	sf		$0		$0	3.70	$106,701	$3.70	$106,701
Building Nat Gas Pipe Distribution	96,125	sf		$0		$0	0.50	$48,063	$0.50	$48,063
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	10	lsum		$0		$0	8,000.00	$80,000	$8,000.00	$80,000
Natural Gas to HRSG Units	2	lsum		$0		$0	8,000.00	$16,000	$8,000.00	$16,000
22-11-13.48 Equipment Connections										
AHU 2 1/2" Coil Connection Assy - Htg HW	3	ea		$0		$0	9,100.00	$27,300	$9,100.00	$27,300
AHU 3" Coil Connection Assy - Chill Wtr	3	ea		$0		$0	9,900.00	$29,700	$9,900.00	$29,700
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	96,125	sf		$0		$0	0.50	$48,063	$0.50	$48,063
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	96,125	sf		$0		$0	0.30	$28,838	$0.30	$28,838
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters (2 ea)	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	8	ea		$0		$0	3,200.00	$25,600	$3,200.00	$25,600
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary Cl No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	12	ea		$0		$0	450.00	$5,400	$450.00	$5,400
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis	96,125	sf		$0		$0	0.30	$28,838	$0.30	$28,838
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	12	ea		$0		$0	575.00	$6,900	$575.00	$6,900
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	225	lf		$0		$0	210.00	$47,250	$210.00	$47,250
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insu	96,125	sf		$0		$0	2.20	$211,475	$2.20	$211,475
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	1	ea		$0		$0	840.00	$840	$840.00	$840
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium ad	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium ad	2	ea		$0		$0	260.00	$520	$260.00	$520

22-47-16.10 Electric Water Coolers								
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea	$0	$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw	1	ls	$0	$0	51,623.76	$51,624	$51,623.76	$51,624
			$0	$0		$0	$0.00	$0
HVAC - 96,125 SF								
23-05-00.00 Common Work Results For HVAC								
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	96,125	sf	$0	$0	0.75	$72,094	$0.75	$72,094
23-05-23.30 Valves, Iron Body								
HVAC Chill & Condenser Water Valves	6,000	ton	$0	$0	38.00	$228,000	$38.00	$228,000
23-05-93.10 Balancing, Air								
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	96,125	sf	$0	$0	0.33	$31,721	$0.33	$31,721
Mech Contractor Assist 3rd Party - Cx Commissioning Support (4 men 1 week)	160	mh	$0	$0	130.00	$20,800	$130.00	$20,800
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	96,125	sf	$0	$0	1.00	$96,125	$1.00	$96,125
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	96,125	sf	$0	$0	4.00	$384,500	$4.00	$384,500
23-05-93.50 Piping, Testing								
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	57,675	lb	$0	$0	0.15	$8,651	$0.15	$8,651
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr wate	48	mh	$0	$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr wate	48	mh	$0	$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dr	48	mh	$0	$0	130.00	$6,240	$130.00	$6,240
Chill Wtr & Condsr Water Special Hangers & Supports	6,000	ton	$0	$0	88.00	$528,000	$88.00	$528,000
Plant HVAC Chilled Water Pipe Insulation	6,000	ton	$0	$0	110.00	$660,000	$110.00	$660,000
Cooling Tower Cell Overflow Drain Piping	7	ea	$0	$0	3,000.00	$21,000	$3,000.00	$21,000
Cooling Tower Equalizer & By-pass piping	6,000	ton	$0	$0	162.00	$972,000	$162.00	$972,000
Cooling Tower Chill & Condenser Water Plant Piping	6,000	ton	$0	$0	294.00	$1,764,000	$294.00	$1,764,000
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	3	lsum	$0	$0	600,000.00	$1,800,000	$600,000.00	$1,800,000
Boiler Install - Loose Piping from Vendor	3	ea	$0	$0	7,000.00	$21,000	$7,000.00	$21,000
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacke	96,125	sf	$0	$0	11.00	$1,057,375	$11.00	$1,057,375
Boiler Feedwater Piping	96,125	sf	$0	$0	14.00	$1,345,750	$14.00	$1,345,750
23-07-13.10 Duct Thermal Insulation								
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfc	34,605	sf	$0	$0	5.40	$186,867	$5.40	$186,867
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	6,000	ton	$0	$0	10.00	$60,000	$10.00	$60,000
23-09-23.10 Control Components/DDC Systems								
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (3 ea)	48	pt	$0	$0	2,000.00	$96,000	$2,000.00	$96,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (28 ea) allw	56	pt	$0	$0	2,000.00	$112,000	$2,000.00	$112,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt	$0	$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	3	pt	$0	$0	2,000.00	$6,000	$2,000.00	$6,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt	$0	$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	3	ea	$0	$0	3,600.00	$10,800	$3,600.00	$10,800
Control Components/BACnet Systems, front end costs, Programming & Engineering	96,125	sf	$0	$0	2.00	$192,250	$2.00	$192,250
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	96,125	sf	$0	$0	0.50	$48,063	$0.50	$48,063
23-09-53.10 Control Components								
Control Components, Chill & Condsr Control Valves & Specialties	6,000	ton	$0	$0	64.00	$384,000	$64.00	$384,000
Control Components, Steam & Stm Condensate Control Valves & Specialties	3	ls	$0	$0	200,000.00	$600,000	$200,000.00	$600,000
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	28	ea	$0	$0	170.00	$4,760	$170.00	$4,760
23-23-16.10 Refrigerant Piping Component Specialties								
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 6,000 Ton	15,000	lb	$0	$0	14.00	$210,000	$14.00	$210,000
23-31-13.13 Rectangular Metal Ducts								
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.60 lbs/ sf allw (96,125 sf	57,675	lb	$0	$0	14.40	$830,520	$14.40	$830,520
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 2 ea	100	lf	$0	$0	280.00	$28,000	$280.00	$28,000
23-31-13.19 Duct Accessories								
Balance Dampers & Turning Vanes (SF Basis) at 50%	96,125	sf	$0	$0	0.25	$24,031	$0.25	$24,031
Flex Duct (SF Basis) at 50% - SA Only	96,125	sf	$0	$0	0.14	$13,458	$0.14	$13,458
Fire/ Smoke Dampers (SF Basis)	96,125	sf	$0	$0	0.60	$57,675	$0.60	$57,675
Duct Access Door, insulated, (SF Basis)	96,125	sf	$0	$0	0.13	$12,496	$0.13	$12,496
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	6	ea	$0	$0	1,300.00	$7,800	$1,300.00	$7,800
23-34-16.10 Centrifugal Type HVAC Fans								
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	96,125	sf	$0	$0	2.00	$192,250	$2.00	$192,250
23-36-13.10 Constant Volume Mixing Boxes								
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty all	28	ea	$0	$0	1480.00	$41,440	$1,480.00	$41,440
23-37-13.10 Diffusers								
Grilles, Registers & Diffusers (SF Basis	96,125	sf	$0	$0	0.70	$67,288	$0.70	$67,288
25-10-10.10 Integrated Automation - Instrumentation & Controls								
Controllers (Redundant PLC, Panel & Remote I/O Panels) - **included in CTG unit cost**	1	ls	$0	$0	515,905	$515,905	$515,905	$515,905
Control System Hardware (2 Work Sta, 5 Server, Server Racks Redundant Switches Firewal	1	ls	$0	$0	120,000	$120,000	$120,000	$120,000
Control Room Furniture (Console, 8 dual screen monitors)	1	ls	$0	$0	200,000	$200,000	$200,000	$200,000
Control System Software (License)	1	ls	$0	$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning	1	ls	$0	$0	1,936,527	$1,936,527	$1,936,527	$1,936,527
Balance of Plant Instrumentation	1	ls	$0	$0	431649	$431,649	$431,649	$431,649
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	465,292.45	$465,292	$465,292.45	$465,292
Electrical - 96,125 SF								
26-05-13.10 Cable Terminations,								
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	96,125	sf	$0	$0	0.65	$62,481	$0.65	$62,481
26-05-19.35 Cable Terminations								
Termination 2-way connectors, copper or alum, 600 volt, #500 - (2000A) 6 ckt x 4 set x 3w x 2 plcs, 2	144	ea	$0	$0	200.00	$28,800	$200.00	$28,800
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeder	-	ea	$0	$0	245.00	$0	$245.00	$0
26-05-19.90 Wire								
Wire, copper, for Light Fixtures (Sqft Basis)	96,125	sf	$0	$0	1.60	$153,800	$1.60	$153,800
Wire, copper, for Duplex Receptacles (Sqft Basis)	96,125	sf	$0	$0	1.05	$100,931	$1.05	$100,931
26-05-26.80 Grounding								
Building Ground Ring	1,400	lf	$0	$0	26.00	$36,400	$26.00	$36,400
Grounding New Panels & Switchboards	16	ea	$0	$0	300.00	$4,800	$300.00	$4,800
Ground New Substation (Dbl Ended) - CUP allw	4	ea	$0	$0	680.00	$2,720	$680.00	$2,720
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea	$0	$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea	$0	$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr	4	ea	$0	$0	600.00	$2,400	$600.00	$2,400
Grounding & Bonding System, SF Basis, CUP	96,125	sf	$0	$0	0.50	$48,063	$0.50	$48,063
26-05-29.20 Hangers								
Seismic or Special Bracing of Conduit & equipment	96,125	sf	$0	$0	0.60	$57,675	$0.60	$57,675
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	23	ea	$0	$0	475.00	$10,925	$475.00	$10,925
26-05-33.05 Conduit								
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	96,125	sf	$0	$0	3	$288,375	$3.00	$288,375
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	96,125	sf	$0	$0	2.25	$216,281	$2.25	$216,281
Conduit for Light Fixtures (Sqft Basis) -	96,125	sf	$0	$0	3.80	$365,275	$3.80	$365,275
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	96,125	sf	$0	$0	1.10	$105,738	$1.10	$105,738
20A Feeder Ckt. - FCU Term Unit x 80' ave (28 allw)	2,240	lf	$0	$0	13.30	$29,792	$13.30	$29,792
100A Feeder Ckt - Cool Tower Fans., 6 each x 200' each ave	1,200	lf	$0	$0	33.00	$39,600	$33.00	$39,600
100A Feeder Ckt - AHU Circuits, 3 each x 160' ave	480	lf	$0	$0	33.00	$15,840	$33.00	$15,840
100A Feeder Ckt - Boiler FD Fans, 3 each x 340' ave	1,020	lf	$0	$0	33.00	$33,660	$33.00	$33,660
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 160' ave	480	lf	$0	$0	33.00	$15,840	$33.00	$15,840
150A Elect Ckt - CHW Primary Pumps, 6 each x 140' ave allw	840	lf	$0	$0	37.00	$31,080	$37.00	$31,080
225A Elect Ckt - Boiler Feedwater Pumps, 3 each x 340' ave allw	1,020	lf	$0	$0	53.00	$54,060	$53.00	$54,060
225A Elect Ckt - Btm Discharge FD Boiler Fan, 3 each x 340' ave allw	1,020	lf	$0	$0	53.00	$54,060	$53.00	$54,060
650A Elect Ckt - CHW Secondary Pumps - 6 each x 120' ea ave	720	lf	$0	$0	205.00	$147,600	$205.00	$147,600
600A Elect Ckt - Cool Tower Pumps, 4 ea x 220' each ave	880	lf	$0	$0	183.00	$161,040	$183.00	$161,040
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel								
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea	$0	$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes								
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 144 GSF	668	ea	$0	$0	57.00	$38,076	$57.00	$38,076
Outlet boxes, pressed steel, 4" square - Card Readers - CP	10	ea	$0	$0	57.00	$570	$57.00	$570
Outlet boxes, pressed steel, 4" square - CCTV locations	11	ea	$0	$0	57.00	$627	$57.00	$627
26-05-33.65 Pull Boxes								
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ck	6	ea	$0	$0	350.00	$2,100	$350.00	$2,100
26-05-33.95 Cutting And Drilling								
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis)	96,125	sf	$0	$0	0.50	$48,063	$0.50	$48,063
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeder	-	ea	$0	$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type								
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	96,125	sf	$0	$0	0.95	$91,319	$0.95	$91,319
26-05-80.10 Motor Connections								
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis	96,125	sf	$0	$0	0.95	$91,319	$0.95	$91,319
26-13-00.00 Medium Voltage Switchgear/ Substations								
7000A Double Ended Substation #1 CUP size allw	1	ea	$0	$0	1,380,000.00	$1,380,000	##########	$1,380,000
7000A Double Ended Substation #2 CUP size allw	1	ea	$0	$0	1,380,000.00	$1,380,000	##########	$1,380,000
1200A Switchgear, 15 KV - CUP size allw	1	ea	$0	$0	120,000.00	$120,000	$120,000.00	$120,000
2000A Switchgear, 15 KV - CUP size allw	1	ea	$0	$0	210,000.00	$210,000	$210,000.00	$210,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses - CUP allw	4	ea	$0	$0	29,400.00	$117,600	$29,400.00	$117,600
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls	$0	$0	20,000.00	$20,000	$20,000.00	$20,000

26-22-13.10 Transformer, Dry-Type								
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	5	ea	$0	$0	9,500.00	$47,500	$9,500.00	$47,500
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	3	ea	$0	$0	35,000.00	$105,000	$35,000.00	$105,000
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, Utility - CUP allw	4	ea	$0	$0	140,000.00	$560,000	$140,000.00	$560,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	5	ea	$0	$0	725.00	$3,625	$725.00	$3,625
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	3	ea	$0	$0	1,170.00	$3,510	$1,170.00	$3,510
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA - CUP allw	4	ea	$0	$0	1,500.00	$6,000	$1,500.00	$6,000
Utility Xfmr Short Ckt & arc flash study	1	ls	$0	$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards								
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 970 ton Chillers (1 per	6	ea	$0	$0	22,700.00	$136,200	$22,700.00	$136,200
26-24-16.30 Panelboards Commercial Applications								
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	96,125	sf	$0	$0	3.01	$289,336	$3.01	$289,336
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	96,125	sf	$0	$0	1.05	$100,931	$1.05	$100,931
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	96,125	sf	$0	$0	0.75	$72,094	$0.75	$72,094
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	96,125	sf	$0	$0	0.26	$24,993	$0.26	$24,993
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floc	1	ea	$0	$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	4	ea	$0	$0	3,000.00	$12,000	$3,000.00	$12,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	16	ea	$0	$0	450.00	$7,200	$450.00	$7,200
26-24-19.30 Motor Control Center								
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea	$0	$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements								
Duplex & Special Receptacle Devices CUP (SF Basis	96,125	sf	$0	$0	0.85	$81,706	$0.85	$81,706
26-28-16.10 Circuit Breakers								
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	96,125	sf	$0	$0	1.12	$107,660	$1.12	$107,660
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds Chillers	5	ea	$0	$0	8,500.00	$42,500	$8,500.00	$42,500
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds Boilers	3	ea	$0	$0	8,500.00	$25,500	$8,500.00	$25,500
26-28-16.20 Safety Switches								
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUI	96,125	sf	$0	$0	0.60	$57,675	$0.60	$57,675
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives								
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	6	ea	$0	$0	5,900.00	$35,400	$5,900.00	$35,400
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Far	3	ea	$0	$0	6,500.00	$19,500	$6,500.00	$19,500
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	3	ea	$0	$0	6,500.00	$19,500	$6,500.00	$19,500
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	6	ea	$0	$0	7,300.00	$43,800	$7,300.00	$43,800
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	3	ea	$0	$0	8,100.00	$24,300	$8,100.00	$24,300
Variable frequency drives, custom-engineered, 460 volt, 450 HP - labor only, CHW Sec Pumps	6	ea	$0	$0	12,200.00	$73,200	$12,200.00	$73,200
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4	ea	$0	$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators								
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly tank - see equip abov	-	ea	$0	$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2)	-	ea	$0	$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel	-	gal	$0	$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection								
Building Lightning Protection CUP (SF Basis)	96,125	sf	$0	$0	0.70	$67,288	$0.70	$67,288
26-51-13.50 Interior Lighting Fixtures								
Interior Networked EMCS Light Control Points, Conduit & wire	96,125	sf	$0	$0	0.50	$48,063	$0.50	$48,063
Interior Lighting 100% LED Fixtures (SF Basis) - CUF	96,125	sf	$0	$0	11.00	$1,057,375	$11.00	$1,057,375
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 144 GS	100	ea	$0	$0	170.00	$17,000	$170.00	$17,000
26-52-13.10 Emergency Lighting And Battery Units								
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8	ea	$0	$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures								
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	6	ea	$0	$0	435.00	$2,610	$435.00	$2,610
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall	2	ea	$0	$0	475.00	$950	$475.00	$950
26-61-13.10 Energy Saving Lighting Devices								
Lighting Controls, Conduit and wire - Office area - 30% of Plan	28,838	sf	$0	$0	2.00	$57,676	$2.00	$57,676
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8	ea	$0	$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips								
Fixture Whips (SF Basis) -	96,125	sf	$0	$0	0.45	$43,256	$0.45	$43,256
						$0		
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw	1	ls	$0	$0	270,948.48	$270,948	$270,948.48	$270,948
27-00-00.00 COMMUNICATIONS								
27-11-19.10 Termination Blocks And Patch Panels								
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea	$0	$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber								
Tel/ Data System CUP Conduit & Cable (SF Basis)	96,125	sf	$0	$0	3.00	$288,375	$3.00	$288,375
Tel/ Data System, Engineer & Program (SF Basis	96,125	sf	$0	$0	0.21	$20,186	$0.21	$20,186
Tel/ Data System, Backbone allw (SF Basis	96,125	sf	$0	$0	0.30	$28,838	$0.30	$28,838
Tel/ Data Devices CUP (SF Basis	96,125	sf	$0	$0	0.65	$62,481	$0.65	$62,481
Tel./ Data Equipment Rack complete allw	2	ea	$0	$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	16	ea	$0	$0	280.00	$4,480	$280.00	$4,480
Wire Management, Vertical & Horiz per Rack	2	ea	$0	$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	32	lf	$0	$0	78.00	$2,496	$78.00	$2,496
			$0	$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System								
Sound & Public Address System Conduit & cable - CUP (SF Basis)	96,125	sf	$0	$0	1.00	$96,125	$1.00	$96,125
Sound & PA Speaker 1 per 800 sf, qty allw	120	ea	$0	$0	250.00	$30,000	$250.00	$30,000
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	96,125	sf	$0	$0	0.50	$48,063	$0.50	$48,063
WAP - Wireless Access Paging Device - 1 per 2400 sf	40	ea	$0	$0	270.00	$10,800	$270.00	$10,800
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	96,125	sf	$0	$0	0.40	$38,450	$0.40	$38,450
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls	$0	$0	32,382.43	$32,382	$32,382.43	$32,382
28-05-00.00 ELECTRONIC SAFETY & SECURITY								
28-23-13.10 CCTV Security & Door Egress System								
CCTV Security Monitoring System Conduit & Cable (SF Basis)	96,125	sf	$0	$0	0.80	$76,900	$0.80	$76,900
CCTV Camera Dome Fixed (7 ea) - interior qty allw	7	ea	$0	$0	2,030.00	$14,210	$2,030.00	$14,210
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	4	ea	$0	$0	2,570.00	$10,280	$2,570.00	$10,280
Security Door Egress System Conduit and Cable (SF Basis)	96,125	sf	$0	$0	0.75	$72,094	$0.75	$72,094
Door Card Reader Control/ Alarm Panel	1	ea	$0	$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - per scheduled tk-off Qty Allw	10	ea	$0	$0	1,150.00	$11,500	$1,150.00	$11,500
Door Duress Pushbutton - PB , qty allw	5	ea	$0	$0	145.00	$725	$145.00	$725
Door Strike/ Contact	10	ea	$0	$0	220.00	$2,200	$220.00	$2,200
Door Position Switch	10	ea	$0	$0	200.00	$2,000	$200.00	$2,000
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	10	ea	$0	$0	680.00	$6,800	$680.00	$6,800
Door Electrified Lever Set & Transfer Hinge - qty allw	5	ea	$0	$0	960.00	$4,800	$960.00	$4,800
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	5	ea	$0	$0	550.00	$2,750	$550.00	$2,750
Door Deep J- Box 4"x4" x 2-1'8"	10	ea	$0	$0	55.00	$550	$55.00	$550
Door Large Pull Box/ J- Box 12"x12" x 4'	10	ea	$0	$0	190.00	$1,900	$190.00	$1,900
28-31-23.50 Alarm Panels And Devices								
Fire Alarm System Core & Shell (SF Basis	96,125	sf	$0	$0	3.52	$338,360	$3.52	$338,360
Fire Alarm System Programming (SF Basis	96,125	sf	$0	$0	0.32	$30,760	$0.32	$30,760
Fire Alarm System Test & Check Out	96,125	sf	$0	$0	0.15	$14,419	$0.15	$14,419
Fire Alarm Master Control Panel, Office > 28,000 SF	1	ea	$0	$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	120	ea	$0	$0	340.00	$40,800	$340.00	$40,800
Fire Alarm Pull Station (addressable), qty allw	6	ea	$0	$0	255.00	$1,530	$255.00	$1,530
Security Foreman at 10% (50/50 Lab/ Mat'l split allw	1	ls	$0	$0	33,058.88	$33,059	$33,058.88	$33,059
			$0	$0		$0		$0
Cost of Work Subtotal			########	$66,714,550		$53,671,686		$126,177,764

	Premium Time		
	Direct Construction Costs		$126,177,764
	General Conditions	10.00%	$12,617,776
	Sub-Total Construction Costs		$138,795,541
	P&P bonds	2.5%	$3,469,889
	Building Permit	0.45%	$624,580
	Sub-Total Construction Costs		$142,890,009
	GL & Umbrella	1.00%	$1,428,900
	Professional liability	1.00%	$1,428,900
	Builder Risk	0.10%	$142,890
	Design Completion Uncertainty Factor	25.00%	$36,472,675
	Sub-Total Construction Costs		$182,363,374
	GC Fee	6.00%	$10,941,802
	Design fee	8.00%	$14,589,070
Alternate 6	**Total Construction Costs**		**$207,894,246**
			$207,894,000

AACE Class 5 ROM Budget Range:	High	50%	$311,841,369
	Low	-30%	$145,525,972

University of Houston
UH Satellite Chilled Water Plant
3000 Ton Satellite Chilled Water Plant
Conceptual Design Estimates
8/5/2022

3000 Ton Satellite Chilled Water Plant	18,750	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement										
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	18,750	sf		$0		$0	$ 1.00	$18,750	$1.00	$18,750
Dump fee	174	cy		$0		$0	$ 25.00	$4,340	$25.00	$4,340
Haul off 12 cy/ld x 2 hr rt	43	hr		$0		$0	$ 68.00	$2,951	$68.00	$2,951
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	2,083	cy		$0		$0	$ 18.00	$37,500	$18.00	$37,500
Import fill	2,083	cy	$ 6.00	$12,500	$ 9.00	$18,750	$ 10.00	$20,833	$25.00	$52,083
Fdn Struct exc	1,650	cy		$0		$0	$ 25.00	$41,250	$25.00	$41,250
Dump fee	3,733	cy		$0		$0	$ 25.00	$93,333	$25.00	$93,333
Hal off 12 cy/ld x 3 hr rt	933	hr		$0		$0	$ 68.00	$63,467	$68.00	$63,467
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	1,389	cy		$0		$0	650.00	$902,778	$650.00	$902,778
Misc concrete	200	cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	61	cy		$0		$0	1000.00	$61,111	$1,000.00	$61,111
Slab on grade 12in	18,750	sf		$0		$0	14.00	$262,500	$14.00	$262,500
Tilt skin 30 hi	16,500	sf		$0		$0	55.00	$907,500	$55.00	$907,500
Mechanical pads	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
				$0		$0		$0	$0.00	$0
Div 34										
CMU misc	3,420	sf		$0		$0	28.00	$95,760	$28.00	$95,760
									$0.00	
Metals										
Steel framing #15lb/sf	141	tn		$0		$0	$ 8,000.00	$1,125,000	$8,000.00	$1,125,000
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	18,750	sf		$0		$0	$ 5.00	$93,750	$5.00	$93,750
skin back u framing 4#/sf	33	tn		$0		$0	$ 8,000.00	$264,000	$8,000.00	$264,000
Misc metals	18,750	sf		$0		$0	$ 1.00	$18,750	$1.00	$18,750
Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	18,750	sf	$ 1.00	$18,750	$ 1.00	$18,750		$0	$2.00	$37,500
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	16	lf		$0		$0	$ 350.00	$5,600	$350.00	$5,600
Counter top	40	sf		$0		$0	$ 58.00	$2,320	$58.00	$2,320
Wall cabinets	16	lf		$0		$0	$ 375.00	$6,000	$375.00	$6,000
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	18,750	sf		$0		$0	$ 0.40	$7,500	$0.40	$7,500
Fire stopping	18,750	sf		$0		$0	$ 0.50	$9,375	$0.50	$9,375
Waterproofing slab	18,750	sf		$0		$0	$ 8.00	$150,000	$8.00	$150,000
Waterproofing walls	1,650	sf		$0		$0	$ 9.00	$14,850	$9.00	$14,850
Roofing	18,750	sf		$0		$0	$ 18.00	$337,500	$18.00	$337,500
Sheet metal	18,750	sf		$0		$0	$ 4.75	$89,063	$4.75	$89,063
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	18,750	sf		$0		$0	$ 4.50	$84,375	$4.50	$84,375
				$0		$0		$0	$0.00	$0
Div 8										
HM Frame	11	ea	$150	$1,650	650	$7,150		$0	$800.00	$8,800
Hm Door	11	ea	$150	$1,650	700	$7,700		$0	$850.00	$9,350
Hardware	11	ea	$150	$1,650	1,000	$11,000		$0	$1,150.00	$12,650
Glass dr	1	ea		$0		$0	$3,800	$3,800	$3,800.00	$3,800
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	1,650	sf		$0		$0	$125	$206,250	$125.00	$206,250
Int glazing	800	sf		$0		$0	$125	$100,000	$125.00	$100,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	1	ea		$0		$0	$20,000	$20,000	$20,000.00	$20,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall (interor of exteror wall) x 30-0		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,900	sf		$0		$0	18.00	$34,200	$18.00	$34,200
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	80	hr		$0		$0	125.00	$10,000	$125.00	$10,000
Firestopping at top of wall	190	lf		$0		$0	6.00	$1,140	$6.00	$1,140
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	1,750	sf		$0		$0	$ 10.00	$17,500	$10.00	$17,500
Open ceiling painted	17,000	sf		$0		$0	$ 1.50	$25,500	$1.50	$25,500
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	18,750	sf		$0		$0	$ 2.00	$37,500	$2.00	$37,500
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	18,750	sf		$0		$0	$ 1.50	$28,125	$1.50	$28,125
Carpet,		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	1,750	sf		$0		$0	$ 8.00	$14,000	$8.00	$14,000
Epoxy sealer	17,000	sf		$0		$0	15.00	$255,000	$15.00	$255,000
Epoxy sealer mezzanine	-	sf		$0		$0	15.00	$0	$15.00	$0
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	3,800	sf		$0		$0	1.00	$3,800	$1.00	$3,800
Paint drs	11	ea		$0		$0	150.00	$1,650	$150.00	$1,650
Paint steel	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Hoisting	24	hr		$0		$0	125.00	$3,000	$125.00	$3,000
Paint mezzanine	-	sf		$0		$0	1.00	$0	$1.00	$0
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	18,750	sf		$0		$0	2.00	$37,500	$2.00	$37,500
Signage	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1	ls		$0		$0	60,000	$60,000	$60,000.00	$60,000
				$0		$0		$0	$0.00	$0
Option-7 Satellite Major Equipment 18,750 GSF										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
1000 Ton Magnetic Bearing Chiller	3	EA	$ 75,000	$225,000	$448,000	$1,344,000		$0	$523,000	$1,569,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250

Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	4	EA	$ 100,000	$400,000	$196,000	$784,000		$0	$296,000	$1,184,000
Primary CHW Pumps	4	EA	$ 15,000	$60,000	$60,000	$240,000		$0	$75,000	$300,000
Secondary CHW Pumps	4	EA	$ 25,000	$100,000	$150,000	$600,000		$0	$175,000	$700,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$150,000	$600,000		$0	$175,000	$700,000
MEP General Conditions - 18,750 GSF										
Temp Power & Lighting - mods area	18,750	sf		$0		$0	$1.00	$18,750	$1.00	$18,750
MEP Hoisting - Crane Rental, HVAC Equipment	26	day		$0		$0	$ 1,800.00	$46,800	$1,800.00	$46,800
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	18,750	sf		$0		$0	5.10	$95,625	$5.10	$95,625
Fire Protection Pipe Sleeves & Fire Seal Penetrations	18,750	sf		$0		$0	0.10	$1,875	$0.10	$1,875
Fire Protection Seismic Restraints per NFPA 13	18,750	sf		$0		$0	0.15	$2,813	$0.15	$2,813
8" Entry Assy w valves & meters -	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	20	lf		$0		$0	145.00	$2,900	$145.00	$2,900
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	32	mh		$0		$0	115.00	$3,680	$115.00	$3,680
Fire Pump 100 HP, 1500 gpm - allw - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	6,283.63	$6,284	$6,283.63	$6,284
Plumbing - 18,750 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	7	fix		$0		$0	137.00	$959	$137.00	$959
Sterilization, Chlorination, Domestic Water System	7	fix		$0		$0	45.00	$315	$45.00	$315
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,000.00	$2,000	$2,000.00	$2,000
22-05-29.10 Hangers And Supports For Plumbing/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (8 ea x 4)	32	ea		$0		$0	100.00	$3,200	$100.00	$3,200
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	18,750	sf		$0		$0	0.80	$15,000	$0.80	$15,000
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	18,750	sf		$0		$0	0.10	$1,875	$0.10	$1,875
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	7	ea		$0		$0	2,950.00	$20,650	$2,950.00	$20,650
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	5,625	sf		$0		$0	3.70	$20,813	$3.70	$20,813
Building Nat Gas Pipe Distribution - none required	-	sf		$0		$0	0.70	$0	$0.70	$0
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	1	ea		$0		$0	9,900.00	$9,900	$9,900.00	$9,900
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	18,750	sf		$0		$0	0.50	$9,375	$0.50	$9,375
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	18,750	sf		$0		$0	0.30	$5,625	$0.30	$5,625
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters (2 ea)	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	7	ea		$0		$0	3,200.00	$22,400	$3,200.00	$22,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	6	ea		$0		$0	450.00	$2,700	$450.00	$2,700
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	18,750	sf		$0		$0	0.30	$5,625	$0.30	$5,625
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	4	ea		$0		$0	575.00	$2,300	$575.00	$2,300
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	140	lf		$0		$0	210.00	$29,400	$210.00	$29,400
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	18,750	sf		$0		$0	2.20	$41,250	$2.20	$41,250
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	14,529.63	$14,530	$14,529.63	$14,530
				$0		$0		$0	$0.00	$0
HVAC - 18,750 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	18,750	sf		$0		$0	0.75	$14,063	$0.75	$14,063
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	4,000	ton		$0		$0	38.00	$152,000	$38.00	$152,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	18,750	sf		$0		$0	0.33	$6,188	$0.33	$6,188
Mech Contractor Assist 3rd Party - Cx Commissioning Support (4 men 1 week)	160	mh		$0		$0	130.00	$20,800	$130.00	$20,800
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	18,750	sf		$0		$0	1.00	$18,750	$1.00	$18,750
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	18,750	sf		$0		$0	3.00	$56,250	$3.00	$56,250
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	12,188	lb		$0		$0	0.15	$1,828	$0.15	$1,828
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	4,000	ton		$0		$0	88.00	$352,000	$88.00	$352,000
Plant HVAC Chilled Water Pipe Insulation	4,000	ton		$0		$0	110.00	$440,000	$110.00	$440,000
Cooling Tower Cell Overflow Drain Piping	5	ea		$0		$0	3,000.00	$15,000	$3,000.00	$15,000
Cooling Tower Equalizer & By-pass piping	4,000	ton		$0		$0	162.00	$648,000	$162.00	$648,000
Cooling Tower Chill & Condenser Water Plant Piping	4,000	ton		$0		$0	294.00	$1,176,000	$294.00	$1,176,000
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	-	lsum		$0		$0	500,000.00	$0	$500,000.00	$0
Boiler Install - Loose Piping from Vendor	-	ea		$0		$0	7,000.00	$0	$7,000.00	$0
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	-	sf		$0		$0	11.00	$0	$11.00	$0
Boiler Feedwater Piping & Insulation	-	sf		$0		$0	14.00	$0	$14.00	$0

23-07-13.10 Duct Thermal Insulation								
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	7,313	sf	$0	$0	5.40	$39,490	$5.40	$39,490
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	4,000	ton	$0	$0	10.00	$40,000	$10.00	$40,000
23-09-23.10 Control Components/DDC Systems								
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (8 ea) allw	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt	$0	$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	2	pt	$0	$0	2,000.00	$4,000	$2,000.00	$4,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt	$0	$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea	$0	$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	18,750	sf	$0	$0	2.00	$37,500	$2.00	$37,500
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
23-09-53.10 Control Components								
Control Components, Chill & Condsr Control Valves & Specialties	4,000	ton	$0	$0	60.00	$240,000	$60.00	$240,000
Control Components, Steam & Stm Condensate Control Valves & Specialties	-	ls	$0	$0	200,000.00	$0	$200,000.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	8	ea	$0	$0	170.00	$1,360	$170.00	$1,360
23-23-16.10 Refrigerant Piping Component Specialties								
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 4,000 Ton)	10,000	lb	$0	$0	14.00	$140,000	$14.00	$140,000
23-31-13.13 Rectangular Metal Ducts								
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (18,750 sf)	12,188	lb	$0	$0	14.40	$175,507	$14.40	$175,507
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 4 ea	-	lf	$0	$0	280.00	$0	$280.00	$0
23-31-13.19 Duct Accessories								
Balance Dampers & Turning Vanes (SF Basis) at 50%	18,750	sf	$0	$0	0.25	$4,688	$0.25	$4,688
Flex Duct (SF Basis) at 50% - SA Only	18,750	sf	$0	$0	0.14	$2,625	$0.14	$2,625
Fire/ Smoke Dampers (SF Basis)	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
Duct Access Door, insulated, (SF Basis)	18,750	sf	$0	$0	0.13	$2,438	$0.13	$2,438
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea	$0	$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans								
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	18,750	sf	$0	$0	2.00	$37,500	$2.00	$37,500
23-36-13.10 Constant Volume Mixing Boxes								
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	8	ea		$0	1480	$11,840	$1,480.00	$11,840
23-37-13.10 Diffusers								
Grilles, Registers & Diffusers (SF Basis)	18,750	sf	$0	$0	0.70	$13,125	$0.70	$13,125
25-10-10.10 Integrated Automation - Instrumentation & Controls								
Controllers (Redundant PLC, Panel & Remote I/O Panels) (0.25)	1	ls	$0	$0	126,480	$126,480	$126,480	$126,480
Control System Hardware (2 Work Sta, 2 Server, Server Racks Redundant Switches Firewall (0.50)	1	ls	$0	$0	60,000	$60,000	$60,000	$60,000
Control Room Furniture (Console, 4 dual screen monitors) (0.50)	1	ls	$0	$0	100,000	$100,000	$100,000	$100,000
Control System Software (License)	1	ls	$0	$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning) (0.25)	1	ls	$0	$0	510,000	$510,000	$510,000	$510,000
Balance of Plant Instrumentation (0.25)	1	ls	$0	$0	127,000	$127,000	$127,000	$127,000
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	143,147.09	$143,147	$143,147.09	$143,147
Electrical - 18,750 GSF								
26-05-13.10 Cable Terminations,								
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	18,750	sf	$0	$0	0.65	$12,188	$0.65	$12,188
26-05-19.35 Cable Terminations								
Termination 2-way connectors, copper or alum, 600 volt, #600 - (800A) 4 ckt x 2 set x 3w x 2 plcs, 970 T Chiller Ckt	48	ea	$0	$0	225.00	$10,800	$225.00	$10,800
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	24	ea	$0	$0	245.00	$5,880	$245.00	$5,880
26-05-19.90 Wire								
Wire, copper, for Light Fixtures (Sqft Basis)	18,750	sf	$0	$0	1.60	$30,000	$1.60	$30,000
Wire, copper, for Duplex Receptacles (Sqft Basis)	18,750	sf	$0	$0	1.05	$19,688	$1.05	$19,688
26-05-26.80 Grounding								
Building Ground Ring	550	lf	$0	$0	26.00	$14,300	$26.00	$14,300
Grounding New Panels & Switchboards	12	ea	$0	$0	300.00	$3,600	$300.00	$3,600
Ground New Substation (Dbl Ended)	2	ea	$0	$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea	$0	$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea	$0	$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea	$0	$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
26-05-29.20 Hangers								
Seismic or Special Bracing of Conduit & equipment	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	14	ea	$0	$0	475.00	$6,650	$475.00	$6,650
26-05-33.05 Conduit								
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	18,750	sf	$0	$0	3	$56,250	$3.00	$56,250
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	18,750	sf	$0	$0	2.25	$42,188	$2.25	$42,188
Conduit for Light Fixtures (Sqft Basis) -	18,750	sf	$0	$0	3.80	$71,250	$3.80	$71,250
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	18,750	sf	$0	$0	1.10	$20,625	$1.10	$20,625
20A Feeder Ckt. - FCU Term Unit x 80' ave (8 allw)	640	lf	$0	$0	13.30	$8,512	$13.30	$8,512
100A Feeder Ckt - Cool Tower Fans., 5 each x 220' each ave	1,100	lf	$0	$0	33.00	$36,300	$33.00	$36,300
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf	$0	$0	33.00	$5,280	$33.00	$5,280
100A Feeder Ckt - Boiler FD Fans, 4 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
150A Elect Ckt - CHW Primary Pumps, 5 each x 100' ave allw	500	lf	$0	$0	37.00	$18,500	$37.00	$18,500
225A Elect Ckt - Boiler Feedwater Pumps, 4 each x 120' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
225A Elect Ckt - Btm Discharge FD Boiler Fan, 4 each x 100' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
650A Elect Ckt - CHW Secondary Pumps - 5 each x 70' ea ave	350	lf	$0	$0	205.00	$71,750	$205.00	$71,750
600A Elect Ckt - Cool Tower Pumps, 4 ea x 120' each ave	480	lf	$0	$0	183.00	$87,840	$183.00	$87,840
1000A Elect Ckt - 1000 Ton Chillers, 4 each x 140' each ave	560	lf	$0	$0	344.00	$192,640	$344.00	$192,640
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel								
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea	$0	$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes								
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	223	ea	$0	$0	57.00	$12,711	$57.00	$12,711
Outlet boxes, pressed steel, 4" square - Card Readers - CR	4	ea	$0	$0	57.00	$228	$57.00	$228
Outlet boxes, pressed steel, 4" square - CCTV locations	6	ea	$0	$0	57.00	$342	$57.00	$342
26-05-33.65 Pull Boxes								
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	4	ea	$0	$0	350.00	$1,400	$350.00	$1,400
26-05-33.95 Cutting And Drilling								
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea	$0	$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type								
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	18,750	sf	$0	$0	0.95	$17,813	$0.95	$17,813
26-05-80.10 Motor Connections								
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	18,750	sf	$0	$0	0.95	$17,813	$0.95	$17,813
26-13-00.00 Medium Voltage Switchgear/ Substations								
7000A Double Ended Substation #1, CUP size allw	1	ea	$0	$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2	-	ea	$0	$0	1,380,000.00	$0	$1,380,000.00	$0
1200A Switchgear, 15 KV - CUP size allw	1	ea	$0	$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP allw	2	ea	$0	$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls	$0	$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type								
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	5	ea	$0	$0	9,500.00	$47,500	$9,500.00	$47,500
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	-	ea	$0	$0	35,000.00	$0	$35,000.00	$0
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, CUP Utility allw	2	ea	$0	$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	5	ea	$0	$0	725.00	$3,625	$725.00	$3,625
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	-	ea	$0	$0	1,170.00	$0	$1,170.00	$0
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA CUP Utility allw	2	ea	$0	$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls	$0	$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards								
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 970 ton Chillers (1 per)	4	ea	$0	$0	22,700.00	$90,800	$22,700.00	$90,800
26-24-16.30 Panelboards Commercial Applications								
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	18,750	sf	$0	$0	3.01	$56,438	$3.01	$56,438
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	18,750	sf	$0	$0	1.05	$19,688	$1.05	$19,688
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	18,750	sf	$0	$0	0.75	$14,063	$0.75	$14,063
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	18,750	sf	$0	$0	0.26	$4,875	$0.26	$4,875
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea	$0	$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea	$0	$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12	ea	$0	$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center								
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea	$0	$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements								
Duplex & Special Receptacle Devices CUP (SF Basis)	18,750	sf	$0	$0	0.85	$15,938	$0.85	$15,938
26-28-16.10 Circuit Breakers								
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	18,750	sf	$0	$0	1.12	$21,000	$1.12	$21,000
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	4	ea	$0	$0	8,500.00	$34,000	$8,500.00	$34,000
26-28-16.20 Safety Switches								
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	18,750	sf	$0	$0	0.60	$11,250	$0.60	$11,250
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives								
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	4	ea	$0	$0	5,900.00	$23,600	$5,900.00	$23,600
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0

Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	4	ea	$0	$0	7,300.00	$29,200	$7,300.00	$29,200
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	-	ea	$0	$0	8,100.00	$0	$8,100.00	$0
Variable frequency drives, custom-engineered, 460 volt, 450 HP - labor only, CHW Sec Pumps	4	ea	$0	$0	12,200.00	$48,800	$12,200.00	$48,800
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	4	ea	$0	$0	10,800.00	$43,200	$10,800.00	$43,200
26-32-13.13 Diesel Generators								
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly Tank was 1 ea	-	ea	$0	$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2) was 2 ea	-	ea	$0	$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel was 750 gal	-	gal	$0	$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection								
Building Lightning Protection CUP (SF Basis)	18,750	sf	$0	$0	0.70	$13,125	$0.70	$13,125
26-51-13.50 Interior Lighting Fixtures								
Interior Networked EMCS Light Control Points, Conduit & wire	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	18,750	sf	$0	$0	11.00	$206,250	$11.00	$206,250
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	33	ea	$0	$0	170.00	$5,610	$170.00	$5,610
26-52-13.10 Emergency Lighting And Battery Units								
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8	ea	$0	$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures								
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	3	ea	$0	$0	435.00	$1,305	$435.00	$1,305
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea	$0	$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices								
Lighting Controls, Conduit and wire - Office area - 30% of Plant	5,625	sf	$0	$0	2.00	$11,250	$2.00	$11,250
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8	ea	$0	$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips								
Fixture Whips (SF Basis) -	18,750	sf	$0	$0	0.45	$8,438	$0.45	$8,438
					$0			
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	108,656.04	$108,656	$108,656.04	$108,656
27-00-00.00 COMMUNICATIONS								
27-11-19.10 Termination Blocks And Patch Panels								
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea	$0	$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber								
Tel/ Data System CUP Conduit & Cable (SF Basis)	18,750	sf	$0	$0	3.00	$56,250	$3.00	$56,250
Tel/ Data System, Engineer & Program (SF Basis)	18,750	sf	$0	$0	0.21	$3,938	$0.21	$3,938
Tel/ Data System, Backbone allw (SF Basis)	18,750	sf	$0	$0	0.30	$5,625	$0.30	$5,625
Tel/ Data Devices CUP (SF Basis)	18,750	sf	$0	$0	0.65	$12,188	$0.65	$12,188
Tel./ Data Equipment Rack complete allw	2	ea	$0	$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	10	ea	$0	$0	280.00	$2,800	$280.00	$2,800
Wire Management, Vertical & Horiz per Rack	2	ea	$0	$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	22	lf	$0	$0	78.00	$1,716	$78.00	$1,716
			$0	$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System								
Sound & Public Address System Conduit & cable - CUP (SF Basis)	18,750	sf	$0	$0	1.00	$18,750	$1.00	$18,750
Sound & PA Speaker 1 per 800 sf, qty allw	23	ea	$0	$0	250.00	$5,750	$250.00	$5,750
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	18,750	sf	$0	$0	0.50	$9,375	$0.50	$9,375
WAP - Wireless Access Paging Device - 1 per 2400 sf	8	ea	$0	$0	270.00	$2,160	$270.00	$2,160
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	18,750	sf	$0	$0	0.40	$7,500	$0.40	$7,500
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls	$0	$0	7,170.30	$7,170	$7,170.30	$7,170
28-05-00.00 ELECTRONIC SAFETY & SECURITY								
28-23-13.10 CCTV Security & Door Egress System								
CCTV Security Monitoring System Conduit & Cable (SF Basis)	18,750	sf	$0	$0	0.80	$15,000	$0.80	$15,000
CCTV Camera Dome Fixed (7 ea) - interior qty allw	4	ea	$0	$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	2	ea	$0	$0	2,570.00	$5,140	$2,570.00	$5,140
Security Door Egress System Conduit and Cable (SF Basis)	18,750	sf	$0	$0	0.75	$14,063	$0.75	$14,063
Door Card Reader Control/ Alarm Panel	1	ea	$0	$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - qty allw	4	ea	$0	$0	1,150.00	$4,600	$1,150.00	$4,600
Door Duress Pushbutton - PB , qty allw	4	ea	$0	$0	145.00	$580	$145.00	$580
Door Strike/ Contact	4	ea	$0	$0	220.00	$880	$220.00	$880
Door Position Switch	4	ea	$0	$0	200.00	$800	$200.00	$800
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	4	ea	$0	$0	680.00	$2,720	$680.00	$2,720
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea	$0	$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea	$0	$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	4	ea	$0	$0	55.00	$220	$55.00	$220
Door Large Pull Box/ J- Box 12"x12" x 4"	4	ea	$0	$0	190.00	$760	$190.00	$760
28-31-23.50 Alarm Panels And Devices								
Fire Alarm System Core & Shell (SF Basis)	18,750	sf	$0	$0	3.52	$66,000	$3.52	$66,000
Fire Alarm System Programming (SF Basis)	18,750	sf	$0	$0	0.32	$6,000	$0.32	$6,000
Fire Alarm System Test & Check Out	18,750	sf	$0	$0	0.15	$2,813	$0.15	$2,813
Fire Alarm Master Control Panel, Office > 28,000 SF	1	ea	$0	$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	23	ea	$0	$0	340.00	$7,820	$340.00	$7,820
Fire Alarm Pull Station (addressable), qty allw	2	ea	$0	$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls	$0	$0	8,306.75	$8,307	$8,306.75	$8,307
			$0	$0		$0		$0
Cost of Work Subtotal			$1,102,250	$4,739,940		$15,663,158		$21,505,348

	Premium Time		
	Direct Construction Costs		$21,505,348
	General Conditions	10.00%	$2,150,535
	Sub-Total Construction Costs		$23,655,883
	P&P bonds	2.5%	$591,397
	Building Permit	0.45%	$106,451
	Sub-Total Construction Costs		$24,353,732
	GL & Umbrella	1.50%	$365,306
	Professional liability	1.00%	$243,537
	Builder Risk	0.10%	$24,354
	Design Completion Uncertainty Factor	25.00%	$6,246,732
	Sub-Total Construction Costs		$31,233,661
	GC Fee	6.00%	$1,874,020
	Design fee	8.00%	$2,498,693
3000 Ton Satellite Chilled Water Plant	**Total Construction Costs**		**$35,606,374**
			$35,606,000

AACE Class 5 ROM Budget Range:	High	50%	$53,409,560
	Low	-30%	$24,924,462

University of Houston
UH Satellite Chilled Water Plant
7000 Ton Satellite Chilled Water Plant
Conceptual Design Estimates
8/5/2022

7000 Ton Satellite Chilled Water Plant	22,550	UT	UPL	LABOR	UPM	MATL	UPS	SUBCTR	Total UP	TOTAL
				$0		$0		$0		$0
Div 1 General Requirement										
Misc Hoisting	120	hr		$0		$0	$125	$15,000	$125.00	$15,000
				$0		$0		$0	$0.00	$0
Div 2 Demolition /excavation										
Demolition minor	22,550	sf		$0		$0	$ 1.00	$22,550	$1.00	$22,550
Dump fee	209	cy		$0		$0	$ 25.00	$5,220	$25.00	$5,220
Haul off 12 cy/ld x 2 hr rt	52	hr		$0		$0	$ 68.00	$3,550	$68.00	$3,550
Traffic control	40	hr	$ 55.00	$2,200	$ 6.00	$240		$0	$61.00	$2,440
				$0		$0		$0	$0.00	$0
Excavation 3-0	2,506	cy		$0		$0	$ 18.00	$45,100	$18.00	$45,100
Import fill	2,506	cy	$ 6.00	$15,033	$ 9.00	$22,550	$ 10.00	$25,056	$25.00	$62,639
Fdn Struct exc	1,940	cy		$0		$0	$ 25.00	$48,509	$25.00	$48,509
Dump fee	4,446	cy		$0		$0	$ 25.00	$111,148	$25.00	$111,148
Hal off 12 cy/ld x 3 hr rt	1,111	hr		$0		$0	$ 68.00	$75,581	$68.00	$75,581
				$0		$0		$0	$0.00	$0
Div 3										
				$0		$0		$0	$0.00	$0
Concrete drilled Piers		cy		$0		$0	600.00	$0	$600.00	$0
Concrete fdn Mat fdn 24in	1,670	cy		$0		$0	650.00	$1,085,741	$650.00	$1,085,741
Misc concrete	200	cy		$0		$0	800.00	$160,000	$800.00	$160,000
Grade beam	70	cy		$0		$0	1000.00	$70,000	$1,000.00	$70,000
Slab on grade 12in	22,550	sf		$0		$0	14.00	$315,700	$14.00	$315,700
Tilt skin 30 hi	18,900	sf		$0		$0	55.00	$1,039,500	$55.00	$1,039,500
Mechanical pads	22,550	sf		$0		$0	0.50	$11,275	$0.50	$11,275
				$0		$0		$0	$0.00	$0
Div 34										
CMU misc	3,420	sf		$0		$0	28.00	$95,760	$28.00	$95,760
									$0.00	
Metals										
Steel framing #15lb/sf	169	tn		$0		$0	$ 8,000.00	$1,353,000	$8,000.00	$1,353,000
Cooling tower framing 35#/sf	19	tn		$0		$0	$ 8,000.00	$154,000	$8,000.00	$154,000
Galv grating	1,100	sf		$0		$0	$ 55.00	$60,500	$55.00	$60,500
Stairs to mezzanine		ea		$0		$0	$ 50,000	$0	$50,000.00	$0
Metal roof deck	22,550	sf		$0		$0	$ 5.00	$112,750	$5.00	$112,750
skin back u framing 4#/sf	38	tn		$0		$0	$ 8,000.00	$302,400	$8,000.00	$302,400
Misc metals	22,550	sf		$0		$0	$ 1.00	$22,550	$1.00	$22,550
Handrail	200	lf		$0		$0	$ 300.00	$60,000	$300.00	$60,000
Steel framing #15lb/sf Mezzanine	-	tn		$0		$0	$ 8,000.00	$0	$8,000.00	$0
Composite deck Mezzanine	-	sf		$0		$0	$ 9.00	$0	$9.00	$0
									$0.00	
Div 6 Carpenter										
Blocking and backing	22,550	sf	$ 1.00	$22,550	$ 1.00	$22,550		$0	$2.00	$45,100
Plywood elect and tel data	1,000	sf	$ 1.00	$1,000	$ 1.00	$1,000		$0	$2.00	$2,000
Base cabinets	16	lf		$0		$0	$ 350.00	$5,600	$350.00	$5,600
Counter top	40	sf		$0		$0	$ 58.00	$2,320	$58.00	$2,320
Wall cabinets	16	lf		$0		$0	$ 375.00	$6,000	$375.00	$6,000
				$0		$0		$0	$0.00	$0
Div 7										
Caulking	22,550	sf		$0		$0	$ 0.40	$9,020	$0.40	$9,020
Fire stopping	22,550	sf		$0		$0	$ 0.50	$11,275	$0.50	$11,275
Waterproofing slab	22,550	sf		$0		$0	$ 8.00	$180,400	$8.00	$180,400
Waterproofing walls	1,890	sf		$0		$0	$ 9.00	$17,010	$9.00	$17,010
Roofing	22,550	sf		$0		$0	$ 18.00	$405,900	$18.00	$405,900
Sheet metal	22,550	sf		$0		$0	$ 4.75	$107,113	$4.75	$107,113
Canopys		sf		$0		$0	$ 90.00	$0	$90.00	$0
Fireproofing	22,550	sf		$0		$0	$ 4.50	$101,475	$4.50	$101,475
				$0		$0		$0	$0.00	$0
Div 8										
HM Frame	11	ea	$150	$1,650	650	$7,150		$0	$800.00	$8,800
Hm Door	11	ea	$150	$1,650	700	$7,700		$0	$850.00	$9,350
Hardware	11	ea	$150	$1,650	1,000	$11,000		$0	$1,150.00	$12,650
Glass dr	1	ea		$0		$0	$3,800	$3,800	$3,800.00	$3,800
Card key system	8	ea		$0		$0	$2,500	$20,000	$2,500.00	$20,000
Ext Glazing 10% of wall	1,890	sf		$0		$0	$125	$236,250	$125.00	$236,250
Int glazing	800	sf		$0		$0	$125	$100,000	$125.00	$100,000
Skylight	600	sf		$0		$0	$75	$45,000	$75.00	$45,000
Ohd dr	1	ea		$0		$0	$20,000	$20,000	$20,000.00	$20,000
				$0		$0		$0	$0.00	$0
Div 9 Partitions										
Furred wall (interor of exteror wall) x 30-0		sf		$0		$0	9.00	$0	$9.00	$0
Int walls	1,900	sf		$0		$0	18.00	$34,200	$18.00	$34,200
Column covers	600	sf		$0		$0	20.00	$12,000	$20.00	$12,000
Drywall soffit	500	sf		$0		$0	8.00	$4,000	$8.00	$4,000
Hoisting	80	hr		$0		$0	125.00	$10,000	$125.00	$10,000
Firestopping at top of wall	190	lf		$0		$0	6.00	$1,140	$6.00	$1,140
				$0		$0		$0	$0.00	$0
Div 9 Ceiling										
Acoustical ceiling	1,750	sf		$0		$0	$ 10.00	$17,500	$10.00	$17,500
Open ceiling painted	17,000	sf		$0		$0	$ 1.50	$25,500	$1.50	$25,500
Drywall ceiling		sf		$0		$0	$ 10.00	$0	$10.00	$0
Acoustical sound panels (allow)	22,550	sf		$0		$0	$ 2.00	$45,100	$2.00	$45,100
Mezzanine paint decking		sf		$0		$0	$1.50	$0	$1.50	$0
									$0.00	$0
Div 9 Flooring										
Flr prep minor	22,550	sf		$0		$0	$ 1.50	$33,825	$1.50	$33,825
Carpet,		sf		$0		$0	$ 5.00	$0	$5.00	$0
LVT ,tile	1,750	sf		$0		$0	$ 8.00	$14,000	$8.00	$14,000
Epoxy sealer	20,800	sf		$0		$0	15.00	$312,000	$15.00	$312,000
Epoxy sealer mezzanine	-	sf		$0		$0	15.00	$0	$15.00	$0
				$0		$0		$0	$0.00	$0
Div 9 Painting										
Furred wall	-	sf		$0		$0	0.60	$0	$0.60	$0
Int walls	3,800	sf		$0		$0	1.00	$3,800	$1.00	$3,800
Paint drs	11	ea		$0		$0	150.00	$1,650	$150.00	$1,650
Paint steel	22,550	sf		$0		$0	1.00	$22,550	$1.00	$22,550
Hoisting	24	hr		$0		$0	125.00	$3,000	$125.00	$3,000
Paint mezzanine	-	sf		$0		$0	1.00	$0	$1.00	$0
				$0		$0		$0	$0.00	$0
Div 10										
Misc items	22,550	sf		$0		$0	2.00	$45,100	$2.00	$45,100
Signage	22,550	sf		$0		$0	0.50	$11,275	$0.50	$11,275
				$0		$0		$0	$0.00	$0
Div 11 Equipment										
Refrigerator	1	ea	500.00	$500	2000.00	$2,000		$0	$2,500.00	$2,500
Microwave	1	ea	100.00	$100	350.00	$350		$0	$450.00	$450
				$0		$0		$0	$0.00	$0
Div 12 Furnishings										
Misc items	22,550	sf		$0		$0	1.00	$22,550	$1.00	$22,550
Lab equipment	1	ls		$0		$0	10000.00	$10,000	$10,000.00	$10,000
				$0		$0		$0	$0.00	$0
Div 14 Elevator Protection										
Elevator 2stp		stp		$0		$0	65,000	$0	$65,000.00	$0
Crane allow	1	ls		$0		$0	60,000	$60,000	$60,000.00	$60,000
				$0		$0		$0	$0.00	$0
Option-7 Satellite Major Equipment 18,750 GSF										
		EA	$ -	$0	$ -	$0		$0	$0.00	$0
1000 Ton Magnetic Bearing Chiller	7	EA	$ 75,000	$525,000	$448,000	$3,136,000		$0	$523,000	$3,661,000
Service & Instrument Air Compressor Package	1	LS	$ 20,000	$20,000	$70,000	$70,000		$0	$90,000	$90,000
Chiller Water Treatment System/ Equipment	2	LS	$ 15,000	$30,000	$60,000	$120,000		$0	$75,000	$150,000
Air handler - chiller area	1	EA	$ 12,250	$12,250	$115,000	$115,000		$0	$127,250	$127,250

Purge system	1	EA	$ 5,000	$5,000	$20,000	$20,000		$0	$25,000	$25,000
Cooling Towers - 1000 Ton Nominal	7	EA	$ 100,000	$700,000	$196,000	$1,372,000		$0	$296,000	$2,072,000
Primary CHW Pumps	7	EA	$ 15,000	$105,000	$60,000	$420,000		$0	$75,000	$525,000
Secondary CHW Pumps	7	EA	$ 25,000	$175,000	$150,000	$1,050,000		$0	$175,000	$1,225,000
Chilled Water Expansion Tank	2	EA	$ 5,000	$10,000	$40,000	$80,000		$0	$45,000	$90,000
Sidestream Filtration	2	EA	$ 50,000	$100,000	$350,000	$700,000		$0	$400,000	$800,000
Cooling Tower Pumps	4	EA	$ 25,000	$100,000	$150,000	$600,000		$0	$175,000	$700,000
MEP General Conditions - 18,750 GSF										
Temp Power & Lighting - mods area	22,550	sf		$0		$0	$1.00	$22,550	$1.00	$22,550
MEP Hoisting - Crane Rental, HVAC Equipment	26	day		$0		$0	$ 1,800.00	$46,800	$1,800.00	$46,800
MEP Hoisting - Crane Rental, Elect Equipment	8	day		$0		$0	$ 1,800.00	$14,400	$1,800	$14,400
Fire Sprinkler										
21-00-00.00 FIRE SUPPRESSION						$0		$0	$0.00	$0
Fire Protection Wet System, Branch Pipe & Heads	22,550	sf		$0		$0	5.10	$115,005	$5.10	$115,005
Fire Protection Pipe Sleeves & Fire Seal Penetrations	22,550	sf		$0		$0	0.10	$2,255	$0.10	$2,255
Fire Protection Seismic Restraints per NFPA 13	22,550	sf		$0		$0	0.15	$3,383	$0.15	$3,383
8" Entry Assy w valves & meters -	1	ea		$0		$0	10,800.00	$10,800	$10,800.00	$10,800
8" Red Press Backflow Preventer, Dbl Check	1	ea		$0		$0	6,400.00	$6,400	$6,400.00	$6,400
Fire Inspector Test Drain & Flow Switch Assy	1	ea		$0		$0	850.00	$850	$850.00	$850
Pipe Groove Joint w Vic Ftgs & Hangers - 8" Entry assy	20	lf		$0		$0	145.00	$2,900	$145.00	$2,900
Sprinkler System Flow Switch - qty allw	2	ea		$0		$0	185.00	$370	$185.00	$370
Sprinkler System Tamper Switch - qty allw	2	ea		$0		$0	180.00	$360	$180.00	$360
Test new System Internally and w AHJ or Fire Marshall (32 MH)	32	mh		$0		$0	115.00	$3,680	$115.00	$3,680
Fire Pump 100 HP, 1500 gpm - allw - not expected	-	ls		$0		$0	78,700.00	$0	$78,700.00	$0
Jockey Pump 3-5 HP - allw - not expected	-	ls		$0		$0	5,000.00	$0	$5,000.00	$0
Sprinkler Foreman @ 10% (50/50 Lab/Mat'l split allw)	1	ls		$0		$0	7,300.13	$7,300	$7,300.13	$7,300
Plumbing - 18,750 GSF										
22-05-00.00 Common Work Results For Plumbing										$0
Testing Dom. Water, Waste & Vent System	7	fix		$0		$0	137.00	$959	$137.00	$959
Sterilization, Chlorination, Domestic Water System	7	fix		$0		$0	45.00	$315	$45.00	$315
22-05-23.20 Valves, Bronze										
Plumbing Valves, bronze, Gate/Ball, soldered, 125 psi, 3/4" to 4 Dom Wtr	1	lsum		$0		$0	2,000.00	$2,000	$2,000.00	$2,000
22-05-29.10 Hangers And Supports For Plumbing/HVAC Pipe/Equip.										
HVAC Equip Vib Isolators/ Supports - AHU's	1	ea		$0		$0	2,200.00	$2,200	$2,200.00	$2,200
HVAC Equip Vib Isolators per - FCU's/ VAV's (8 ea x 4)	32	ea		$0		$0	100.00	$3,200	$100.00	$3,200
22-05-53.10 Piping System Identification Labels										
HVAC Piping & Duct ID & Valve Tag CUP Allw. (SF Basis)	22,550	sf		$0		$0	0.80	$18,040	$0.80	$18,040
Plumbing System Pipe ID & Valve Tag CUP Allw. (SF Basis)	22,550	sf		$0		$0	0.10	$2,255	$0.10	$2,255
22-05-76.20 Cleanout Tees										
IBCO Cleanout tee, cast iron, plug, brass, no hub, 3", with 1 coupling - qty allw	2	ea		$0		$0	120.00	$240	$120.00	$240
22-07-19.10 Piping Insulation										
Insulation, P-Trap (ADA), under sinks or lavatories, 1-1/4" or 1-1/2" - RestRm	2	ea		$0		$0	57.00	$114	$57.00	$114
Domestic Water Plumbing Pipe Insulation	22,550	sf		$0		$0	1.00	$22,550	$1.00	$22,550
22-11-13.23 Pipe/Tube, Copper										
Domestic Water Piping per Fixture Count	7	ea		$0		$0	2,950.00	$20,650	$2,950.00	$20,650
Domestic Water Piping Horiz Floor Distribution	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Industrial Water IW system Piping	1	lsum		$0		$0	15,000.00	$15,000	$15,000.00	$15,000
Pipe, copper, tubing, solder, Type M, w cplg & hgrs, 2" - COND Drain - AHU's (1)	30	lf		$0		$0	41.00	$1,230	$41.00	$1,230
22-11-13.44 Pipe, Steel										
Cooling Tower Plumbing Mk-Up Water	1	lsum		$0		$0	10,000.00	$10,000	$10,000.00	$10,000
Heating HW VAV/ FCU Pipe Distrib (30% GSF of Plant)	5,625	sf		$0		$0	3.70	$20,813	$3.70	$20,813
Building Nat Gas Pipe Distribution - none required	-	sf		$0		$0	0.70	$0	$0.70	$0
Natural Gas to Gen Sets	-	lsum		$0		$0	5,000.00	$0	$5,000.00	$0
Natural Gas to Gas Turbine Generators	-	lsum		$0		$0	8,000.00	$0	$8,000.00	$0
22-11-13.48 Equipment Connections										
AHU 3" Coil Connection Assy - Chill Wtr	1	ea		$0		$0	9,900.00	$9,900	$9,900.00	$9,900
22-11-19.34 Sleeves & Escutcheons										
Dom. Wtr + Waste & Vent, Fire Safe & Seal Pipe Penetrations (SF Basis)	22,550	sf		$0		$0	0.50	$11,275	$0.50	$11,275
HVAC Piping & Duct, Fire Safe & Seal Pipe Penetrations	22,550	sf		$0		$0	0.30	$6,765	$0.30	$6,765
22-11-19.38 Water Supply Meters										
Chilled Water Insertion Flow Meter	2	ea		$0		$0	2,400.00	$4,800	$2,400.00	$4,800
HPS & LPC Flow Meters (2 ea)	-	ea		$0		$0	2,400.00	$0	$2,400.00	$0
22-11-19.38 Backflow Preventors										
Dom Water Backflow Preventer - 4"	1	ea		$0		$0	2,600.00	$2,600	$2,600.00	$2,600
22-11-19.54 Water Hammer Arresters/Shock Absorbers										
Water Hammer Arrester/Shock absorber, 12 to 32 FU, 3/4"-1" male I.P.S. qty allw	2	ea		$0		$0	145.00	$290	$145.00	$290
22-11-23.10 General Utility Pumps										
Water Heater Circ Pump w Pipe Hk-up	1	ea		$0		$0	3,960.00	$3,960	$3,960.00	$3,960
22-13-16.20 Pipe, Cast Iron										
San Waste & Vent Piping per Fixture Count	7	ea		$0		$0	3,200.00	$22,400	$3,200.00	$22,400
San Waste & Vent Piping, Floor Horiz Piping	1	lsum		$0		$0	7,000.00	$7,000	$7,000.00	$7,000
Sanitary CI No Hub VTR Assy, 2"-3"	2	ea		$0		$0	400.00	$800	$400.00	$800
Sanitary Waste & Vent FD/ FS Hook-up, 2"-4"	6	ea		$0		$0	450.00	$2,700	$450.00	$2,700
22-13-16.60 Trap Primers										
Trap Primer Assy w 10' Tube, Ftgs, Trap Primer & Distrib Unit CUP (SF Basis)	22,550	sf		$0		$0	0.30	$6,765	$0.30	$6,765
22-13-19.13 Sanitary Drains										
Floor Drain, cast iron, 2" & 3" - Tag FD-1 (Restrooms)	2	ea		$0		$0	340.00	$680	$340.00	$680
Floor Sink, Mech Equip area, qty allw	4	ea		$0		$0	575.00	$2,300	$575.00	$2,300
Floor C.O., 3" & 4" qty allw	2	ea		$0		$0	410.00	$820	$410.00	$820
Grade CO, 6" to 8" size	2	ea		$0		$0	750.00	$1,500	$750.00	$1,500
Trench Drain, 12" wide w grate, E-W Run	140	lf		$0		$0	210.00	$29,400	$210.00	$29,400
22-14-26.13 Storm Drain System										
Building Storm Drain System w Insul	22,550	sf		$0		$0	2.20	$49,610	$2.20	$49,610
22-33-33.10 Commercial Electric Water Heaters										
Electric Water Heater 80- 100 gallon, 20 KW	1	ea		$0		$0	8,900.00	$8,900	$8,900.00	$8,900
22-41-13.40 Water Closets										
Water Closet, vit china, Wall hung, seat, supply w stop and Carrier	2	ea		$0		$0	1,095.00	$2,190	$1,095.00	$2,190
22-41-16.10 Lavatories										
Lavatory, Wall Mtd, porcelain, white, oval, 20" x 18", incl trim	2	ea		$0		$0	770.00	$1,540	$770.00	$1,540
22-41-16.30 Sinks										
Sink, SStl Kitch/ Lounge w Garb Disposal unit	-	ea		$0		$0	840.00	$0	$840.00	$0
Sink, Lab Sink at Water Lab	1	ea		$0		$0	877.00	$877	$877.00	$877
Mop Service Basin	1	ea		$0		$0	855.00	$855	$855.00	$855
22-42-39.10 Faucets And Fittings										
Faucets/fittings, automatic flush sensor & operator for Waterclosets & Urinals, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
Faucets/fittings, automatic flush sensor & operator for Sinks & Lavs, Premium add	2	ea		$0		$0	260.00	$520	$260.00	$520
22-47-16.10 Electric Water Coolers										
Electric Water Cooler, wall mtd, non-recess, dual height, 8.2 GPH w Bottle Filler	1	ea		$0		$0	1,820.00	$1,820	$1,820.00	$1,820
Plumbing & HVAC Foreman at 10% JM Hours, CSI above (50/50 Lab/ Mat'l split allw)	1	ls		$0		$0	15,517.63	$15,518	$15,517.63	$15,518
				$0		$0		$0	$0.00	$0
HVAC - 18,750 GSF										
23-05-00.00 Common Work Results For HVAC										
HVAC Duct AutoCadd Coordination Dwg Allw. (2 men.)	22,550	sf		$0		$0	0.75	$16,913	$0.75	$16,913
23-05-23.30 Valves, Iron Body										
HVAC Chill & Condenser Water Valves	4,000	ton		$0		$0	38.00	$152,000	$38.00	$152,000
23-05-93.10 Balancing, Air										
Mech Contractor Assist 3rd Party - HVAC Balancing Air & Water	22,550	sf		$0		$0	0.33	$7,442	$0.33	$7,442
Mech Contractor Assist 3rd Party - Cx Commissioning Support (4 men 1 week)	160	mh		$0		$0	130.00	$20,800	$130.00	$20,800
Test & Balance HVAC Air & Water, AABC or NEBB 3rd Party	22,550	sf		$0		$0	1.00	$22,550	$1.00	$22,550
Commissioning Cx of HVAC systems - Chillers, Pumps, Systems	22,550	sf		$0		$0	3.00	$67,650	$3.00	$67,650
23-05-93.50 Piping, Testing										
HVAC Duct Leakage Testing, both SA & RA Duct, (lb Basis) - Base Cost	12,188	lb		$0		$0	0.15	$1,828	$0.15	$1,828
Pipe Flushing & Chemical Cleaning (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Chill & Condsr water	48	mh		$0		$0	130.00	$6,240	$130.00	$6,240
Pipe Pressure Testing (2 men 3 days) - Steam & Condensate, Boiler Blow Dn	-	mh		$0		$0	130.00	$0	$130.00	$0
Chill Wtr & Condsr Water Special Hangers & Supports	7,000	ton		$0		$0	88.00	$616,000	$88.00	$616,000
Plant HVAC Chilled Water Pipe Insulation	7,000	ton		$0		$0	110.00	$770,000	$110.00	$770,000
Cooling Tower Cell Overflow Drain Piping	5	ea		$0		$0	3,000.00	$15,000	$3,000.00	$15,000
Cooling Tower Equalizer & By-pass piping	7,000	ton		$0		$0	162.00	$1,134,000	$162.00	$1,134,000
Cooling Tower Chill & Condenser Water Plant Piping	7,000	ton		$0		$0	294.00	$2,058,000	$294.00	$2,058,000
HPS/ MPS Piping System w Hgrs & Supports (per HRSG)	-	lsum		$0		$0	500,000.00	$0	$500,000.00	$0
Boiler Install - Loose Piping from Vendor	-	ea		$0		$0	7,000.00	$0	$7,000.00	$0
HPS/ MPS/ LPC Pipe Insulation - Cal Sil w all Svc Jacket	-	sf		$0		$0	11.00	$0	$11.00	$0
Boiler Feedwater Piping & Insulation	-	sf		$0		$0	14.00	$0	$14.00	$0

23-07-13.10 Duct Thermal Insulation								
Insulation, Ductwork, blanket fbrgls, flexible, 1 lb. density, 1" thk - at 0.60 sfca	7,313	sf	$0	$0	5.40	$39,490	$5.40	$39,490
Insulation, HVAC Equipment - Chillers, Pumps, HX, Boilers, Tanks	7,000	ton	$0	$0	10.00	$70,000	$10.00	$70,000
23-09-23.10 Control Components/DDC Systems								
Control DDC BACnet System, Pt. Count w Conduit/wire, AHU's @ 16 pt ea (1 ea)	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, VAV's/ FPB's @ 2 pt ea (8 ea) allw	16	pt	$0	$0	2,000.00	$32,000	$2,000.00	$32,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Exh Fans Units @ 2 pt ea (3) Qty allw	6	pt	$0	$0	2,000.00	$12,000	$2,000.00	$12,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Compressed Air System allw	2	pt	$0	$0	2,000.00	$4,000	$2,000.00	$4,000
Control DDC BACnet System, Pt. Count w Conduit/wire, Electrical Gear Meters / Misc	8	pt	$0	$0	2,000.00	$16,000	$2,000.00	$16,000
Control Components/BACnet Systems, PLC Panel (1 per 2 AHU + Flr Cover) qty allw	2	ea	$0	$0	3,600.00	$7,200	$3,600.00	$7,200
Control Components/BACnet Systems, front end costs, Programming & Engineering	22,550	sf	$0	$0	2.00	$45,100	$2.00	$45,100
Control Components/BACnet Systems, Controls Testing w Balancer/Commissioning	22,550	sf	$0	$0	0.50	$11,275	$0.50	$11,275
23-09-53.10 Control Components								
Control Components, Chill & Condsr Control Valves & Specialties	7,000	ton	$0	$0	60.00	$420,000	$60.00	$420,000
Control Components, Steam & Stm Condensate Control Valves & Specialties	-	ls	$0	$0	200,000.00	$0	$200,000.00	$0
Control Components, sensor, electric operated, temperature - T Stat, VAV/ FCU Units	8	ea	$0	$0	170.00	$1,360	$170.00	$1,360
23-23-16.10 Refrigerant Piping Component Specialties								
Refrigerant Fill Charge 2.50 lbs/ ton (Chillers, 4,000 Ton)	10,000	lb	$0	$0	14.00	$140,000	$14.00	$140,000
23-31-13.13 Rectangular Metal Ducts								
New HVAC Galv Stl Duct, incl ftgs & supt - at 0.65 lbs/ sf allw (18,750 sf)	12,188	lb	$0	$0	14.40	$175,507	$14.40	$175,507
New HVAC Galv Stl Duct,Boiler Flue - Double Duct Breeching, 50 LF each x 4 ea	-	lf	$0	$0	280.00	$0	$280.00	$0
23-31-13.19 Duct Accessories								
Balance Dampers & Turning Vanes (SF Basis) at 50%	22,550	sf	$0	$0	0.25	$5,638	$0.25	$5,638
Flex Duct (SF Basis) at 50% - SA Only	22,550	sf	$0	$0	0.14	$3,157	$0.14	$3,157
Fire/ Smoke Dampers (SF Basis)	22,550	sf	$0	$0	0.60	$13,530	$0.60	$13,530
Duct Access Door, insulated, (SF Basis)	22,550	sf	$0	$0	0.13	$2,932	$0.13	$2,932
Motorized Damper Reg. to 36" - 2 per AHU to 16,000 cfm, AHU mods allw	2	ea	$0	$0	1,300.00	$2,600	$1,300.00	$2,600
23-34-16.10 Centrifugal Type HVAC Fans								
Exhaust & Supply Fans, Centrifugal Roof CUP (SF Basis)	22,550	sf	$0	$0	2.00	$45,100	$2.00	$45,100
23-36-13.10 Constant Volume Mixing Boxes								
FPB mixing box, var volume, 1000 to 1600 CFM, includes electric or pneu motor, no pipe conn, qty allw	8	ea		$0	1480	$11,840	$1,480.00	$11,840
23-37-13.10 Diffusers								
Grilles, Registers & Diffusers (SF Basis)	22,550	sf	$0	$0	0.70	$15,785	$0.70	$15,785
25-10-10.10 Integrated Automation - Instrumentation & Controls								
Controllers (Redundant PLC, Panel & Remote I/O Panels) (0.25)	1	ls	$0	$0	126,480	$126,480	$126,480	$126,480
Control System Hardware (2 Work Sta, 2 Server, Server Racks Redundant Switches Firewall (0.50)	1	ls	$0	$0	60,000	$60,000	$60,000	$60,000
Control Room Furniture (Console, 4 dual screen monitors) (0.50)	1	ls	$0	$0	100,000	$100,000	$100,000	$100,000
Control System Software (License)	1	ls	$0	$0	62,234	$62,234	$62,234	$62,234
Control System Integration (Programming, Testing, Start-up, Commissioning) (0.25)	1	ls	$0	$0	510,000	$510,000	$510,000	$510,000
Balance of Plant Instrumentation (0.25)	1	ls	$0	$0	127,000	$127,000	$127,000	$127,000
HVAC Foreman at 10% JM Hour (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	209,606.69	$209,607	$209,606.69	$209,607
Electrical - 18,750 GSF								
26-05-13.10 Cable Terminations,								
Cable terminations - CUP Bldg to 18,000 gsf (Sqft Basis)	22,550	sf	$0	$0	0.65	$14,658	$0.65	$14,658
26-05-19.35 Cable Terminations								
Termination 2-way connectors, copper or alum, 600 volt, #600 - (800A) 4 ckt x 2 set x 3w x 2 plcs, 970 T Chiller Ckt	48	ea	$0	$0	225.00	$10,800	$225.00	$10,800
Termination 2-way connectors, copper or alum, 600 volt, #750 - 4 set x 3w x 2 plcs Chill Util Feeders	24	ea	$0	$0	245.00	$5,880	$245.00	$5,880
26-05-19.90 Wire								
Wire, copper, for Light Fixtures (Sqft Basis)	22,550	sf	$0	$0	1.60	$36,080	$1.60	$36,080
Wire, copper, for Duplex Receptacles (Sqft Basis)	22,550	sf	$0	$0	1.05	$23,678	$1.05	$23,678
26-05-26.80 Grounding								
Building Ground Ring	550	lf	$0	$0	26.00	$14,300	$26.00	$14,300
Grounding New Panels & Switchboards	12	ea	$0	$0	300.00	$3,600	$300.00	$3,600
Ground New Substation (Dbl Ended)	2	ea	$0	$0	680.00	$1,360	$680.00	$1,360
Grounding New Tel/ Data-Comm Racks - per details (2 ea racks) Comm Rooms qty allw	2	ea	$0	$0	280.00	$560	$280.00	$560
Ground Bar, 18" Long Copper - Server/ Comm Room	1	ea	$0	$0	400.00	$400	$400.00	$400
Ground New Transformers (xx Bldg + incoming Public Utility Xfmr)	8	ea	$0	$0	600.00	$4,800	$600.00	$4,800
Grounding & Bonding System, SF Basis, CUP	22,550	sf	$0	$0	0.50	$11,275	$0.50	$11,275
26-05-29.20 Hangers								
Seismic or Special Bracing of Conduit & equipment	22,550	sf	$0	$0	0.60	$13,530	$0.60	$13,530
Slotted U-Strut channel 1 5/8" x 1 5/8" - Disc Switch support - HVAC Equip, Qty Allw	14	ea	$0	$0	475.00	$6,650	$475.00	$6,650
26-05-33.05 Conduit								
Misc Elect Service & Distribution - HVAC Sm Equip Power (not listed below)	22,550	sf	$0	$0	3	$67,650	$3.00	$67,650
Conduit for Duplex & Switch Devices (Sqft Basis) - CUP	22,550	sf	$0	$0	2.25	$50,738	$2.25	$50,738
Conduit for Light Fixtures (Sqft Basis) -	22,550	sf	$0	$0	3.80	$85,690	$3.80	$85,690
Electrical EMCS Distribution, Conduit & Cable (SF Basis)	22,550	sf	$0	$0	1.10	$24,805	$1.10	$24,805
20A Feeder Ckt. - FCU Term Unit x 80' ave (8 allw)	640	lf	$0	$0	13.30	$8,512	$13.30	$8,512
100A Feeder Ckt - Cool Tower Fans., 5 each x 220' each ave	1,100	lf	$0	$0	33.00	$36,300	$33.00	$36,300
100A Feeder Ckt - AHU Circuits, 1 each x 160' ave	160	lf	$0	$0	33.00	$5,280	$33.00	$5,280
100A Feeder Ckt - Boiler FD Fans, 4 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
100A Feeder Ckt - Stm Condensate Pumps, 3 each x 120' ave	-	lf	$0	$0	33.00	$0	$33.00	$0
150A Elect Ckt - CHW Primary Pumps, 5 each x 100' ave allw	500	lf	$0	$0	37.00	$18,500	$37.00	$18,500
225A Elect Ckt - Boiler Feedwater Pumps, 4 each x 120' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
225A Elect Ckt - Btm Discharge FD Boiler Fan, 4 each x 100' ave allw	-	lf	$0	$0	53.00	$0	$53.00	$0
650A Elect Ckt - CHW Secondary Pumps - 5 each x 70' ea ave	350	lf	$0	$0	205.00	$71,750	$205.00	$71,750
600A Elect Ckt - Cool Tower Pumps, 4 ea x 120' each ave	480	lf	$0	$0	183.00	$87,840	$183.00	$87,840
1000A Elect Ckt - 1000 Ton Chillers, 4 each x 140' each ave	560	lf	$0	$0	344.00	$192,640	$344.00	$192,640
26-05-33.25 Conduit Fittings For Rigid Galvanized Steel								
Conduit fittings for RGS, 90 LRad Ell, 4" dia - Utility Feeders up in Bldg,	-	ea	$0	$0	450.00	$0	$450.00	$0
26-05-33.50 Outlet Boxes								
Outlet boxes, pressed steel, 4" square - Lighting Fixtures, 1/ 84 GSF	223	ea	$0	$0	57.00	$12,711	$57.00	$12,711
Outlet boxes, pressed steel, 4" square - Card Readers - CR	4	ea	$0	$0	57.00	$228	$57.00	$228
Outlet boxes, pressed steel, 4" square - CCTV locations	6	ea	$0	$0	57.00	$342	$57.00	$342
26-05-33.65 Pull Boxes								
Pull boxes, sheet metal, 18" W x 18" H x 6" D, NEMA 1 - 1 per Chiller Ckt	4	ea	$0	$0	350.00	$1,400	$350.00	$1,400
26-05-33.95 Cutting And Drilling								
Electrical Fire Safe & Seal Conduit Penetrations (SF Basis) -	22,550	sf	$0	$0	0.50	$11,275	$0.50	$11,275
Hole drilling, concrete wall, 8" thk, 4" C size, to 10' high - Utility Feeders	-	ea	$0	$0	250.00	$0	$250.00	$0
26-05-36.10 Cable Tray Ladder Type								
Cable tray, ladder type, galv steel, 4" deep, 12" rung spacing, 36" wide, CUP	22,550	sf	$0	$0	0.95	$21,423	$0.95	$21,423
26-05-80.10 Motor Connections								
Motor connections, flexible conduit & fittings, 3 ph, 460 volt CUP (SF Basis)	22,550	sf	$0	$0	0.95	$21,423	$0.95	$21,423
26-13-00.00 Medium Voltage Switchgear/ Substations								
7000A Double Ended Substation #1, CUP size allw	1	ea	$0	$0	1,380,000.00	$1,380,000	$1,380,000.00	$1,380,000
7000A Double Ended Substation #2	-	ea	$0	$0	1,380,000.00	$0	$1,380,000.00	$0
1200A Switchgear, 15 KV - CUP size allw	1	ea	$0	$0	120,000.00	$120,000	$120,000.00	$120,000
Load Interrupter Switch, 2 position, 300 KVA 13.8 KV, 600 amp w /CLF Fuses CUP allw	2	ea	$0	$0	29,400.00	$58,800	$29,400.00	$58,800
High/ Med Voltage Local Load study & Utility Co Coordination	1	ls	$0	$0	20,000.00	$20,000	$20,000.00	$20,000
26-22-13.10 Transformer, Dry-Type								
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 75 KVA	5	ea	$0	$0	9,500.00	$47,500	$9,500.00	$47,500
Dry type transformer, 3 ph 480 V primary 120/208 V sec, 300 KVA Boilers	-	ea	$0	$0	35,000.00	$0	$35,000.00	$0
LIQ Filled type transformer, 3 ph 13.8 KV primary 480 V sec, 4 MVA, CUP Utility allw	2	ea	$0	$0	140,000.00	$280,000	$140,000.00	$280,000
Transformer vibration absorber pads (1 pad/ unit) 15 KVA - 112.5 KVA	5	ea	$0	$0	725.00	$3,625	$725.00	$3,625
Transformer vibration absorber pads (1 pad/ unit) 150 KVA - 1500 KVA	-	ea	$0	$0	1,170.00	$0	$1,170.00	$0
Transformer vibration absorber pads (1 pad/ unit) 2000 KVA - 5000 KVA CUP Utility allw	2	ea	$0	$0	1,500.00	$3,000	$1,500.00	$3,000
Utility Xfmr Short Ckt & arc flash study	1	ls	$0	$0	10,000.00	$10,000	$10,000.00	$10,000
26-24-13.20 In Plant Distribution Switchboards								
Switchboards, Distribution, 4 wire, 277/480, 800 A - for 970 ton Chillers (1 per)	4	ea	$0	$0	22,700.00	$90,800	$22,700.00	$90,800
26-24-16.30 Panelboards Commercial Applications								
Panelboards, 3 ph 4w, 100A - 400A,120//208 to 277/480	22,550	sf	$0	$0	3.01	$67,876	$3.01	$67,876
Emergency Panelboards, 3 ph 4w, 100A- 400A, 120/208 to 277/480	22,550	sf	$0	$0	1.05	$23,678	$1.05	$23,678
Panelboards, 3 ph 4w, 600A - 1200A, 277/480	22,550	sf	$0	$0	0.75	$16,913	$0.75	$16,913
Emergency Panelboards, 3 ph 4w, 600A - 1200A, 277/480	22,550	sf	$0	$0	0.26	$5,863	$0.26	$5,863
Panelboards, Lighting Control Panel, incl relays - qty allw 1st floor	1	ea	$0	$0	6,400.00	$6,400	$6,400.00	$6,400
Digital Energy Monitor - 2 per Substation - CUP allw	2	ea	$0	$0	3,000.00	$6,000	$3,000.00	$6,000
Update NEW Panel Schedule w Label/Tag - all New Panels, qty allw	12	ea	$0	$0	450.00	$5,400	$450.00	$5,400
26-24-19.30 Motor Control Center								
Motor Control Center 4000A - Chiller or Comb Chill/ Boiler Plant, size allw	1	ea	$0	$0	205,000.00	$205,000	$205,000.00	$205,000
26-27-26.20 Wiring Devices Elements								
Duplex & Special Receptacle Devices CUP (SF Basis)	22,550	sf	$0	$0	0.85	$19,168	$0.85	$19,168
26-28-16.10 Circuit Breakers								
Circuit breaker, 3 pole, 600 volt, 100-400A Panels, CUP	22,550	sf	$0	$0	1.12	$25,256	$1.12	$25,256
Circuit breaker, 3 pole, 600 volt, 800 amp, enclosed (NEMA 1) Swbds	4	ea	$0	$0	8,500.00	$34,000	$8,500.00	$34,000
26-28-16.20 Safety Switches								
Safety switches, general duty, 3 pole, fusible, 240 volt (SF Basis) CUP	22,550	sf	$0	$0	0.60	$13,530	$0.60	$13,530
26-29-23.10 Variable Frequency Drives/Adj. Frequency Drives								
Variable frequency drives, custom-engineered, 460 volt, 60 HP - labor only, CT Fan	7	ea	$0	$0	5,900.00	$41,300	$5,900.00	$41,300
Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Boiler FD Fan	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0

Variable frequency drives, custom-engineered, 460 volt, 75 HP - labor only, Condensate Pumps	-	ea	$0	$0	6,500.00	$0	$6,500.00	$0
Variable frequency drives, custom-engineered, 460 volt, 100 HP - labor only, CHW Pri Pumps	7	ea	$0	$0	7,300.00	$51,100	$7,300.00	$51,100
Variable frequency drives, custom-engineered, 460 volt, 150 HP - labor only, Boiler Feed Pumps	-	ea	$0	$0	8,100.00	$0	$8,100.00	$0
Variable frequency drives, custom-engineered, 460 volt, 450 HP - labor only, CHW Sec Pumps	7	ea	$0	$0	12,200.00	$85,400	$12,200.00	$85,400
Variable frequency drives, custom-engineered, 460 volt, 350 HP - labor only, Cool Twr Pumps	7	ea	$0	$0	10,800.00	$75,600	$10,800.00	$75,600
26-32-13.13 Diesel Generators								
Diesel Generator Set - for Boiler Plant, 1000 KW Size allw w Belly Tank was 1 ea	-	ea	$0	$0	265,000.00	$0	$265,000.00	$0
Gen Set Auto Transfer Switch w Bypass, Boiler Plant, 1000A (2) was 2 ea	-	ea	$0	$0	55,000.00	$0	$55,000.00	$0
Gen Set Testing Fuel was 750 gal	-	gal	$0	$0	5.50	$0	$5.50	$0
26-41-13.13 Building Lightning Protection								
Building Lightning Protection CUP (SF Basis)	22,550	sf	$0	$0	0.70	$15,785	$0.70	$15,785
26-51-13.50 Interior Lighting Fixtures								
Interior Networked EMCS Light Control Points, Conduit & wire	22,550	sf	$0	$0	0.50	$11,275	$0.50	$11,275
Interior Lighting 100% LED Fixtures (SF Basis) - CUP	22,550	sf	$0	$0	11.00	$248,050	$11.00	$248,050
Emergency ballast, mat'l only, interior, factory install in fixture - 15% 1 fixt/ 84 GSF	33	ea	$0	$0	170.00	$5,610	$170.00	$5,610
26-52-13.10 Emergency Lighting And Battery Units								
Emergency Frog Eye light units, battery operated, twin sealed beam light, 25 W, 6 V each -	8	ea	$0	$0	400.00	$3,200	$400.00	$3,200
26-53-13.10 Exit Lighting Fixtures								
Exit lighting, L.E.D. w/ battery unit, Single Face, ceiling or wall -	3	ea	$0	$0	435.00	$1,305	$435.00	$1,305
Exit lighting, L.E.D. w/ battery unit, Double Face, ceiling or wall -	1	ea	$0	$0	475.00	$475	$475.00	$475
26-61-13.10 Energy Saving Lighting Devices								
Lighting Controls, Conduit and wire - Office area - 30% of Plant	5,625	sf	$0	$0	2.00	$11,250	$2.00	$11,250
Occupancy sensors, Dual Tech w Dimming - Tag OS - qty allw	8	ea	$0	$0	325.00	$2,600	$325.00	$2,600
26-61-13.30 Fixture Whips								
Fixture Whips (SF Basis) -	22,550	sf	$0	$0	0.45	$10,148	$0.45	$10,148
					$0			
Elect Foreman MH's at 10% JM Qty (30/70 Lab/ Mat'l split allw)	1	ls	$0	$0	116,159.40	$116,159	$116,159.40	$116,159
27-00-00.00 COMMUNICATIONS								
27-11-19.10 Termination Blocks And Patch Panels								
EZ-PATH Series 44 Sleeve - at Elect/ Server Room entrances	1	ea	$0	$0	555.00	$555	$555.00	$555
27-13-23.13 Communications Optical Fiber								
Tel/ Data System CUP Conduit & Cable (SF Basis)	22,550	sf	$0	$0	3.00	$67,650	$3.00	$67,650
Tel/ Data System, Engineer & Program (SF Basis)	22,550	sf	$0	$0	0.21	$4,736	$0.21	$4,736
Tel/ Data System, Backbone allw (SF Basis)	22,550	sf	$0	$0	0.30	$6,765	$0.30	$6,765
Tel/ Data Devices CUP (SF Basis)	22,550	sf	$0	$0	0.65	$14,658	$0.65	$14,658
Tel./ Data Equipment Rack complete allw	2	ea	$0	$0	7,500.00	$15,000	$7,500.00	$15,000
Tel/ Comm Treated Plywood Backboard, 4'x8'	10	ea	$0	$0	280.00	$2,800	$280.00	$2,800
Wire Management, Vertical & Horiz per Rack	2	ea	$0	$0	900.00	$1,800	$900.00	$1,800
Cable Tray w Ftgs 18" wide in Comm / Server Rooms per dwgs	22	lf	$0	$0	78.00	$1,716	$78.00	$1,716
			$0	$0	0.00	$0	$0.00	$0
27-51-19.10 Sound & Public Address System								
Sound & Public Address System Conduit & cable - CUP (SF Basis)	22,550	sf	$0	$0	1.00	$22,550	$1.00	$22,550
Sound & PA Speaker 1 per 800 sf, qty allw	23	ea	$0	$0	250.00	$5,750	$250.00	$5,750
WAP - Wireless Access Paging/ Messaging - backbox and conduit only, no devices	22,550	sf	$0	$0	0.50	$11,275	$0.50	$11,275
WAP - Wireless Access Paging Device - 1 per 2400 sf	8	ea	$0	$0	270.00	$2,160	$270.00	$2,160
Audio & Video System - CUP (SF Basis) - NO A/V Equip, just BBox & Conduit only	22,550	sf	$0	$0	0.40	$9,020	$0.40	$9,020
Comm Foreman at 10% Labor (50/50 Lab/Mat'l split allw)	1	ls	$0	$0	8,321.70	$8,322	$8,321.70	$8,322
28-05-00.00 ELECTRONIC SAFETY & SECURITY								
28-23-13.10 CCTV Security & Door Egress System								
CCTV Security Monitoring System Conduit & Cable (SF Basis)	22,550	sf	$0	$0	0.80	$18,040	$0.80	$18,040
CCTV Camera Dome Fixed (7 ea) - interior qty allw	4	ea	$0	$0	2,030.00	$8,120	$2,030.00	$8,120
CCTV Camera P-T-Z 180 Degree w support, 8 megaPixel, Exterior allw	2	ea	$0	$0	2,570.00	$5,140	$2,570.00	$5,140
Security Door Egress System Conduit and Cable (SF Basis)	22,550	sf	$0	$0	0.75	$16,913	$0.75	$16,913
Door Card Reader Control/ Alarm Panel	1	ea	$0	$0	5,900.00	$5,900	$5,900.00	$5,900
Door Card Reader, Swipe Card - qty allw	4	ea	$0	$0	1,150.00	$4,600	$1,150.00	$4,600
Door Duress Pushbutton - PB , qty allw	4	ea	$0	$0	145.00	$580	$145.00	$580
Door Strike/ Contact	4	ea	$0	$0	220.00	$880	$220.00	$880
Door Position Switch	4	ea	$0	$0	200.00	$800	$200.00	$800
Door Card Reader Power Supply - 1 per CR & CR-KP location, allw	4	ea	$0	$0	680.00	$2,720	$680.00	$2,720
Door Electrified Lever Set & Transfer Hinge - qty allw	1	ea	$0	$0	960.00	$960	$960.00	$960
Door Exit Control - Alarm Horn and/or Lock, REX - qty allw	1	ea	$0	$0	550.00	$550	$550.00	$550
Door Deep J- Box 4"x4" x 2-1'8"	4	ea	$0	$0	55.00	$220	$55.00	$220
Door Large Pull Box/ J- Box 12"x12" x 4"	4	ea	$0	$0	190.00	$760	$190.00	$760
28-31-23.50 Alarm Panels And Devices								
Fire Alarm System Core & Shell (SF Basis)	22,550	sf	$0	$0	3.52	$79,376	$3.52	$79,376
Fire Alarm System Programming (SF Basis)	22,550	sf	$0	$0	0.32	$7,216	$0.32	$7,216
Fire Alarm System Test & Check Out	22,550	sf	$0	$0	0.15	$3,383	$0.15	$3,383
Fire Alarm Master Control Panel, Office > 28,000 SF	1	ea	$0	$0	22,700.00	$22,700	$22,700.00	$22,700
Fire Alarm Horn & Strobe (ADA) 1 per 800 sf allw	23	ea	$0	$0	340.00	$7,820	$340.00	$7,820
Fire Alarm Pull Station (addressable), qty allw	2	ea	$0	$0	255.00	$510	$255.00	$510
Security Foreman at 10% (50/50 Lab/ Mat'l split allw)	1	ls	$0	$0	9,359.35	$9,359	$9,359.35	$9,359
			$0	$0		$0		$0
Cost of Work Subtotal			$1,828,583	$7,757,540		$19,274,102		$28,860,225

Premium Time		
Direct Construction Costs		$28,860,225
General Conditions	10.00%	$2,886,023
Sub-Total Construction Costs		$31,746,248
P&P bonds	2.5%	$793,656
Building Permit	0.45%	$142,858
Sub-Total Construction Costs		$32,682,762
GL & Umbrella	1.50%	$490,241
Professional liability	1.00%	$326,828
Builder Risk	0.10%	$32,683
Design Completion Uncertainty Factor	25.00%	$8,383,128
Sub-Total Construction Costs		$41,915,642
GC Fee	6.00%	$2,514,939
Design fee	8.00%	$3,353,251
Total Construction Costs		**$47,783,832**
		$47,784,000

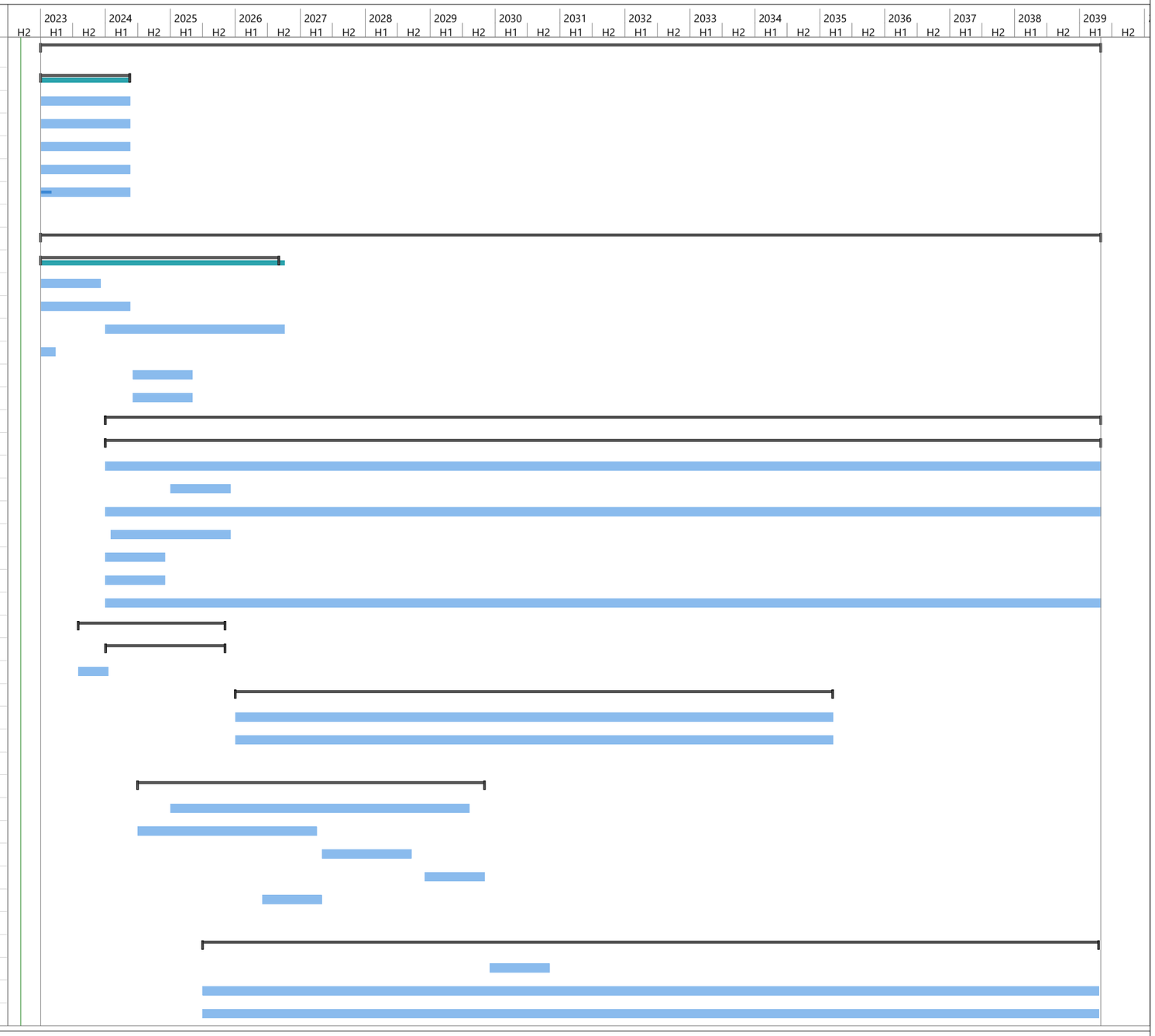
7000 Ton Satellite Chilled Water Plant

AACE Class 5 ROM Budget Range:			
	High	50%	$71,675,748
	Low	-30%	$33,448,683

Appendix J
Proposed Funding Schedule

University of Houston Energy Master Plan 2022

ID	Text1	Task Name	Duration Rounded (Duration2)	Lower Cost	Upper Cost
1		**Proposed Funding Schedule**	**200 mons**	**$362,997,000**	**$544,495,500**
2		**Phase 1 - Improve System Monitoring**	**18 mons**	**$3,431,000**	**$5,146,500**
3	CHW-11	Chilled Water Meters	18 mons	$679,000	$1,018,500
4	STM-04	Steam Meters	18 mons	$652,000	$978,000
5	STM-05	Condensate Meters	18 mons	$595,000	$892,500
6	ELEC-04	Electric Meters	18 mons	$527,000	$790,500
7	MISC-06	SCADA System	18 mons	$978,000	$1,467,000
8					
9		**Phase 2 - Upgrade Systems and Reduce Demand**	**200 mons**	**$101,225,000**	**$151,837,500**
10		**Studies & Inspections**	**48 mons**	**$3,143,000**	**$4,714,500**
11	UT-01	Utility inspection report	12 mons	$84,000	$126,000
12	CHW-01	Chilled water inspection	18 mons	$107,000	$160,500
13	UT-02	Utility tunnel repairs	36 mons	$800,000	$1,200,000
14	STM-01	DA tank inspection	3 mons	$27,000	$40,500
15	ELEC-03	Microgrid study	12 mons	$896,000	$1,344,000
16	MISC-02	HVAC building controls study	12 mons	$1,229,000	$1,843,500
17		**Tunnel Upgrades**	**200 mons**	**$24,739,000**	**$37,108,500**
18		**Upgrade and repairs to CHW Piping**	**200 mons**	**$14,105,000**	**$21,157,500**
19	CHW-07	Replace 500ft of piping - 16 years	200 mons	$10,880,000	$16,320,000
20	CHW-08	Replace Athletics Area piping	12 mons	$3,225,000	$4,837,500
21	STM-02	Replace condensate piping - 16 years	200 mons	$3,904,000	$5,856,000
22	STM-03	Upgrade and repairs to steam traps	24 mons	$214,000	$321,000
23	CHW-09	Replace CHW valves	12 mons	$1,336,000	$2,004,000
24	UT-03	Tunnel sump pump replacements	12 mons	$60,000	$90,000
25	UT-04	Replace pipe supports - 16 years	200 mons	$5,120,000	$7,680,000
26		**CUP Upgrades**	**30 mons**	**$1,364,000**	**$2,046,000**
27		**Replace CHW pumps**	**24 mons**	**$1,226,000**	**$1,839,000**
32	CHW-10	Chilled water filtration	6 mons	$138,000	$207,000
33		**HVAC Upgrades**	**120 mons**	**$71,979,000**	**$107,968,500**
34	MISC-04	Commissioning of buildings - 10 years	120 mons	$21,524,000	$32,286,000
35	MISC-03	Building control upgrades - 10 years	120 mons	$50,455,000	$75,682,500
36					
37		**Phase 3 - Expand System**	**70 mons**	**$165,364,000**	**$248,046,000**
38		New Satellite CHW plant or CHP	60 mons	$120,000,000	$180,000,000
39	ELEC-02	New substation	36 mons	$25,714,000	$38,571,000
40	ELEC-01	New feeders from new substation	18 mons	$14,993,000	$22,489,500
41	MISC-01	Emergency water storage	12 mons	$4,568,000	$6,852,000
42	MISC-06	CUP Booster pump	12 mons	$89,000	$133,500
43					
44		**Phase 4 - Production Efficiency**	**180 mons**	**$92,977,000**	**$139,465,500**
45	CHW-06	Optimize CHW system	12 mons	$76,000	$114,000
46	ELEC-05	PV System - 15 years	180 mons	$85,349,000	$128,023,500
47	ELEC-06	Lighting upgrades - 15 years	180 mons	$7,552,000	$11,328,000



Project: ANL AU2 Schedule
Date: Mon 9/12/22

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress