Analysis and Implementation of a Chilled Water Storage System at the University of Wyoming

Presented By:
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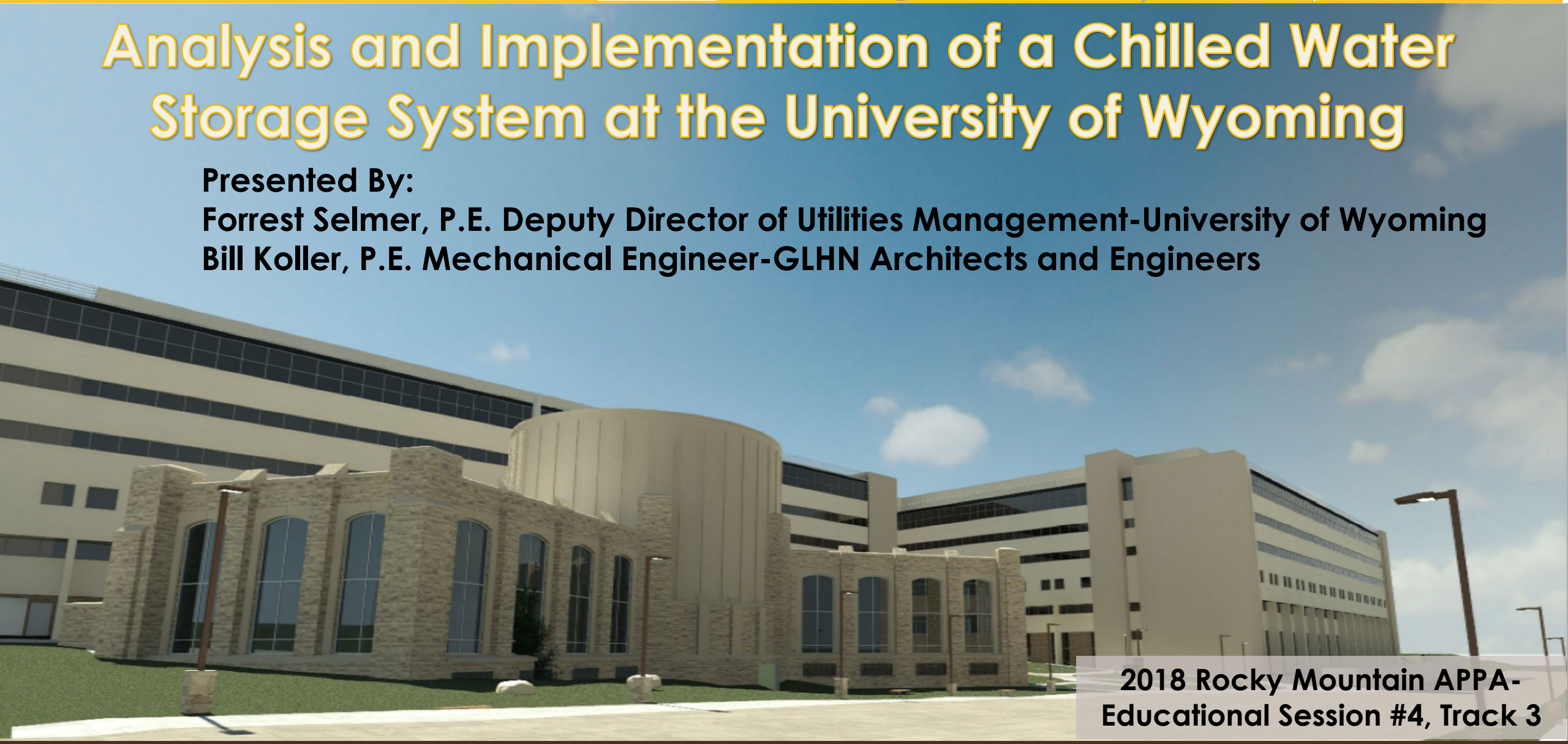


2018 Rocky Mountain APPA-Educational Session #4, Track 3

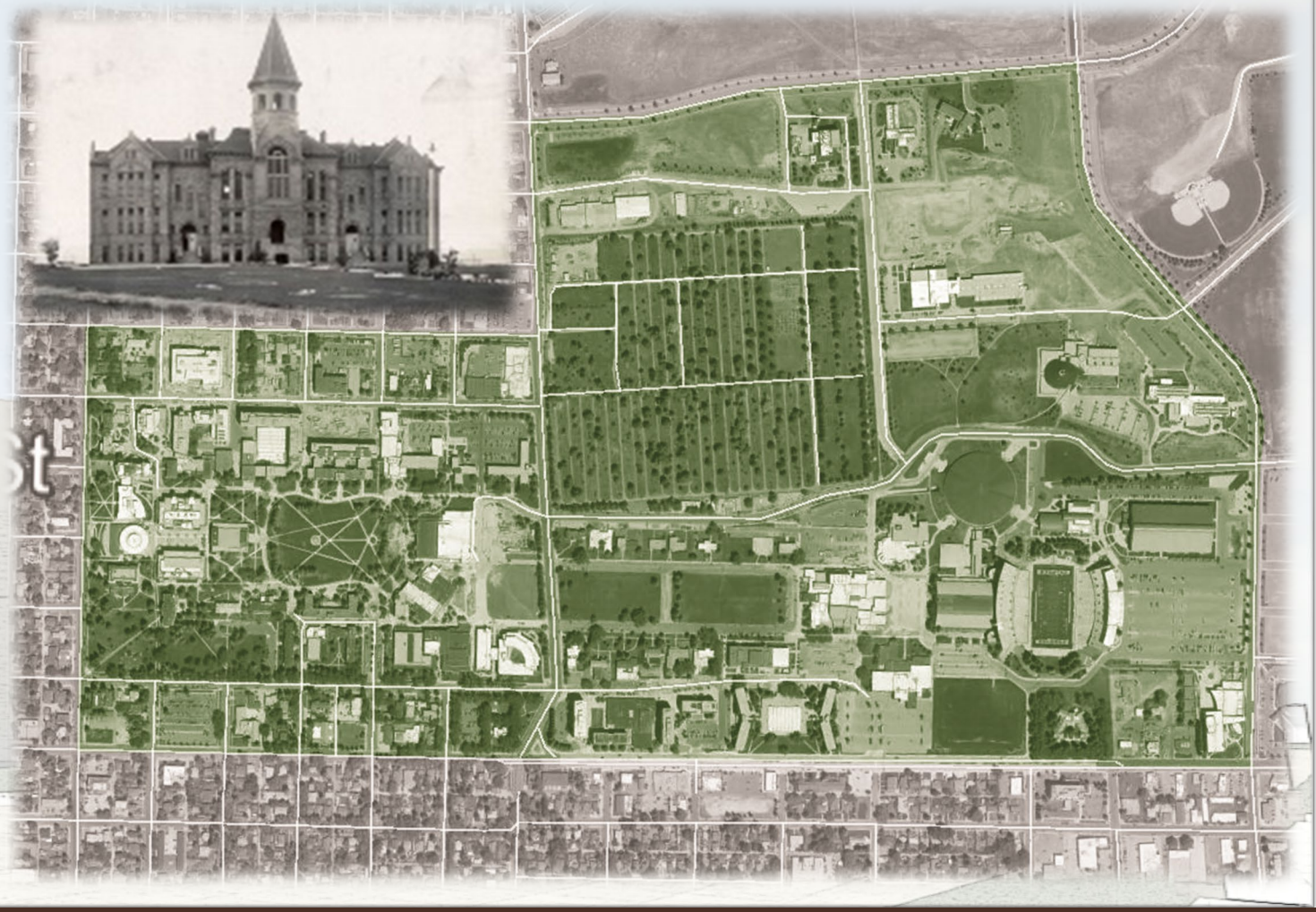
Presentation Objectives

- Case Study-University of Wyoming
  - Project Background
  - Process
  - Analysis
  - Implementation
- Review Technical Aspects of Thermal Energy Storage Systems

University of Wyoming

General Campus Statistics

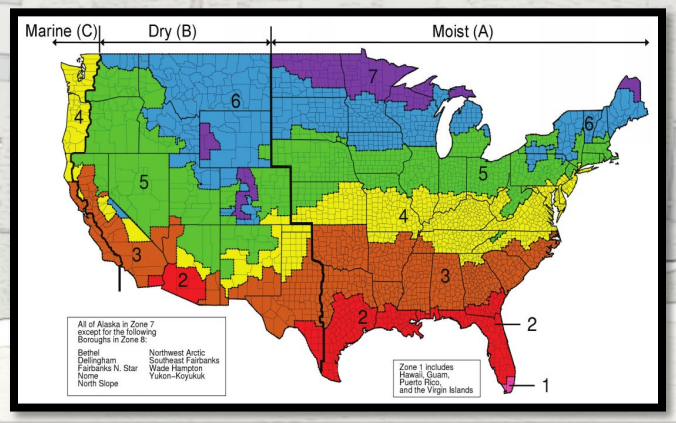
- Founded in 1886
- Located in Laramie Wyoming
- Student Enrollment-9,500 (Laramie) – 14:1 Student/Faculty Ratio
- Buildings on Steam-87 (6.0M sqft)
- Buildings on CHW-29 (1.8M sqft)
- 400 Division 1 Student Athletes



University of Wyoming

Laramie Design Conditions

- 7,200’ Above Sea Level
- Summer 1%
  - 82 DB, 58 WB
  - 80 CDD (65F)
- Winter 1%
  - -3 DB
  - 8,690 HDD (65F)
- Climate Zone 6B



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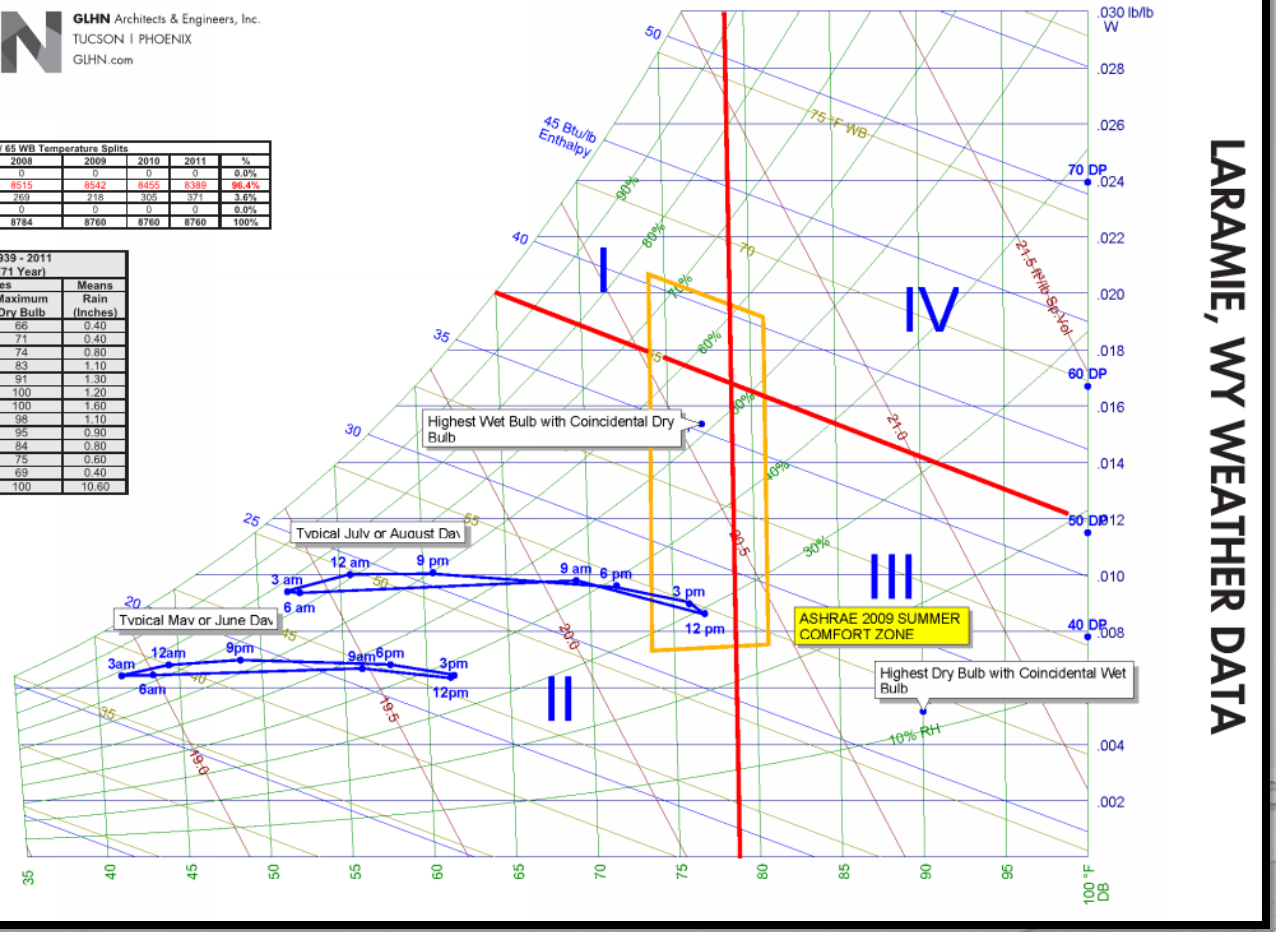
78 DB / 65 WB Temperature Splits

	2007	2008	2009	2010	2011	%
I	0	0	0	0	0	0.0%
II	8361	8515	8542	8455	8389	96.4%
III	399	269	218	305	371	3.6%
IV	0	0	0	0	0	0.0%
Total	8760	8784	8760	8760	8760	100%

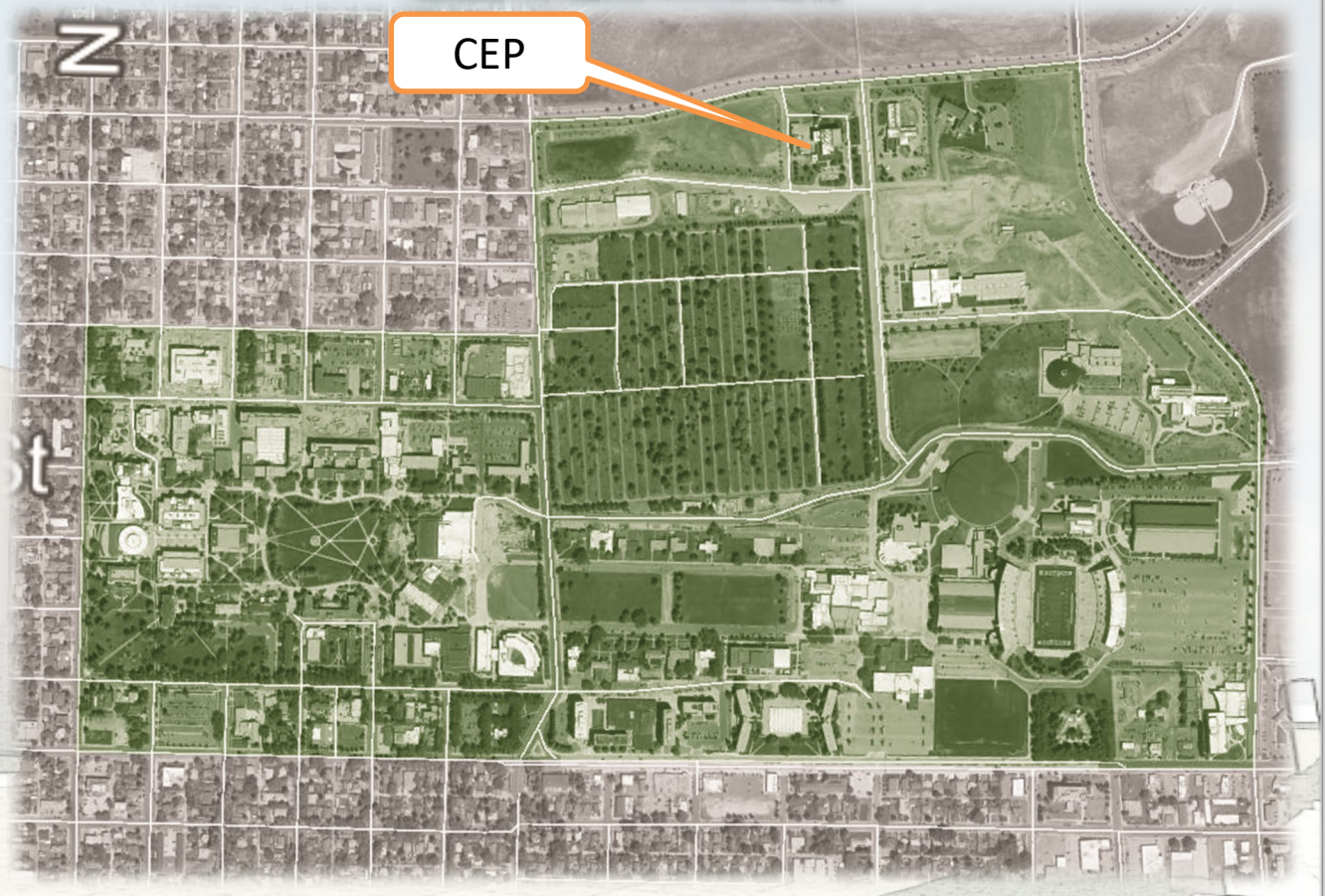
Month	1939 - 2011 (71 Year) Extremes Minimum Dry Bulb	Extremes Maximum Dry Bulb	Means Rain (Inches)
January	-30	66	0.40
February	-34	71	0.40
March	-21	74	0.80
April	-8	83	1.10
May	9	91	1.30
June	25	100	1.20
July	33	100	1.60
August	36	98	1.10
September	8	95	0.90
October	-1	84	0.80
November	-21	75	0.60
December	-28	69	0.40
Yearly	-34	100	10.60



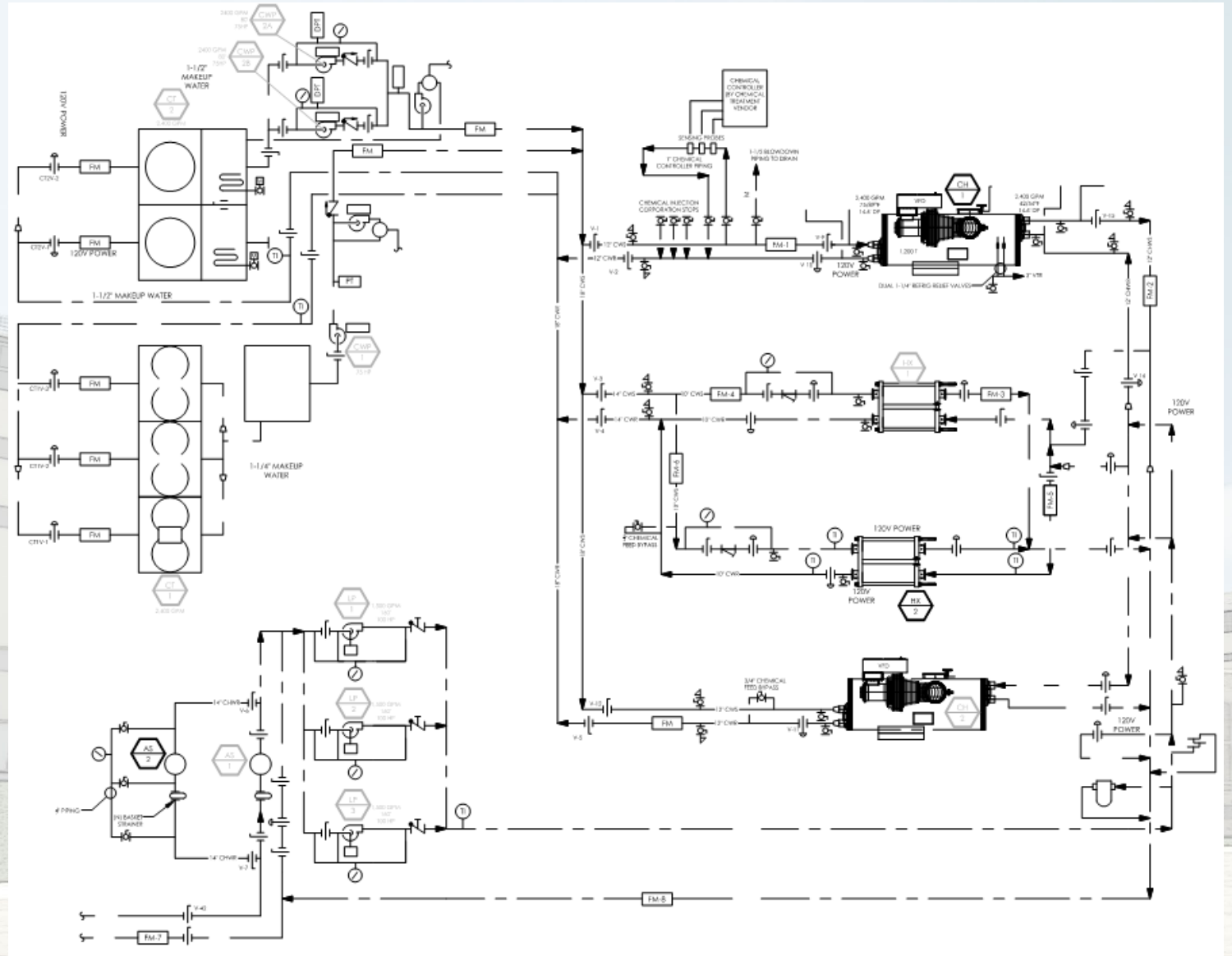
Campus Cooling

Campus Cooling Statistics

- Central Energy Plant (CEP)
  - (2) Water Cooled Chillers
  - 2,400 Tons of Chiller Capacity
  - Variable Primary CHW Pumping
  - Current Peak Load-1,600 Tons
  - (2) Plate and Frame Hydronic Economizers ~ 1,000 T
  - 6 months of “Free Cooling”
  - 525 HP of CHW/CW Pumping Capacity
  - 29 Connected Buildings



Campus Cooling



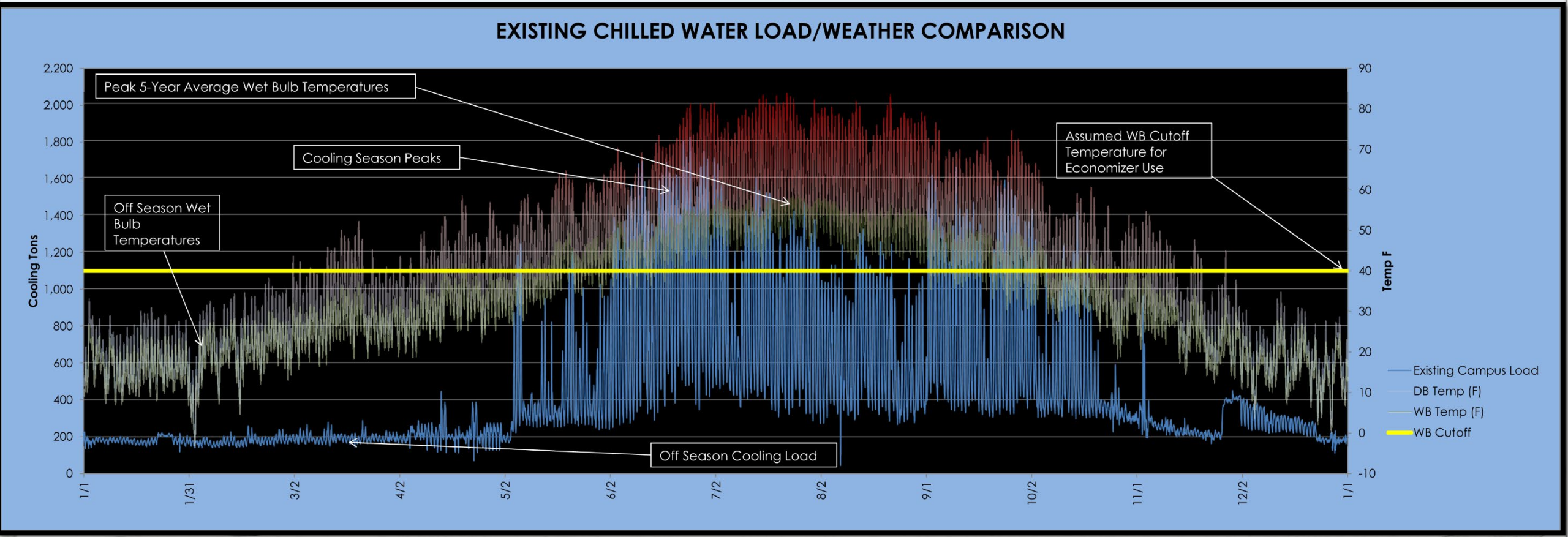
Campus Cooling

Campus Cooling Statistics

- District Cooling System
  - Supplies 1/3 of Campus Area
  - Combination of Direct Buried and Tunnel Piping
  - 14” CHWS/R Mains
  - 17,000’ of CHW Distribution
  - 200,000 gallons

Campus Cooling

Annual Cooling Load Profile



Campus Cooling

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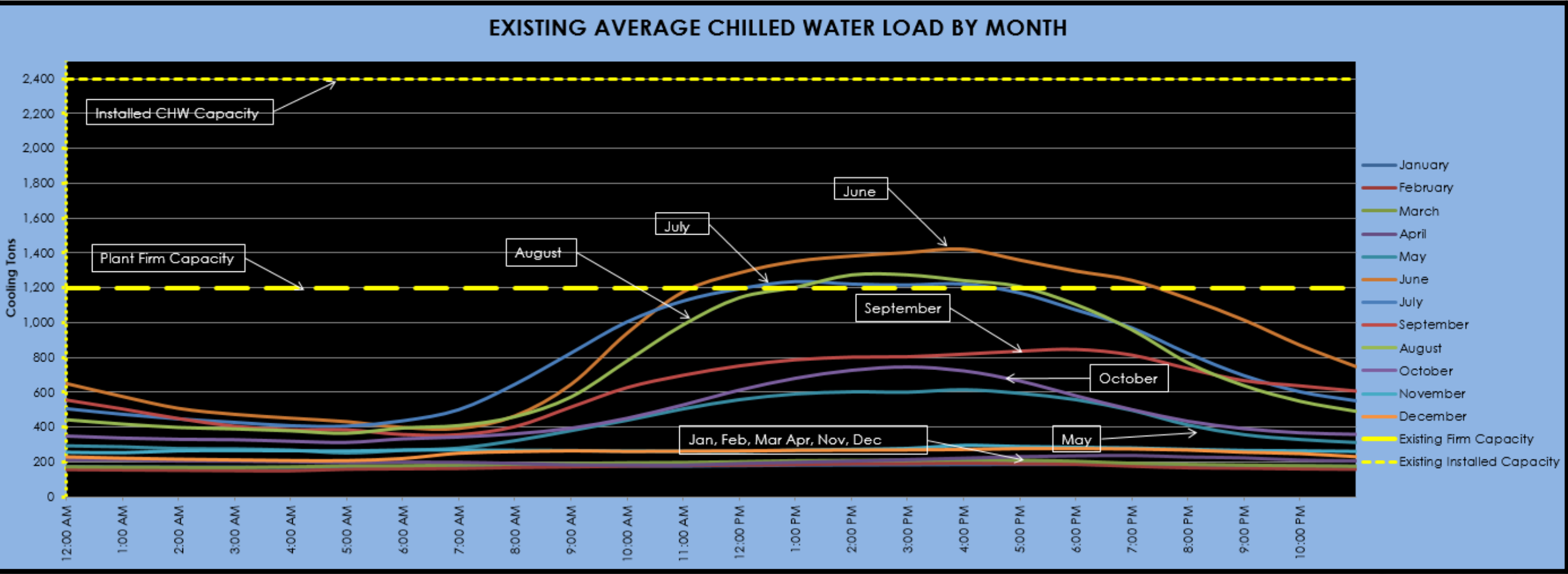
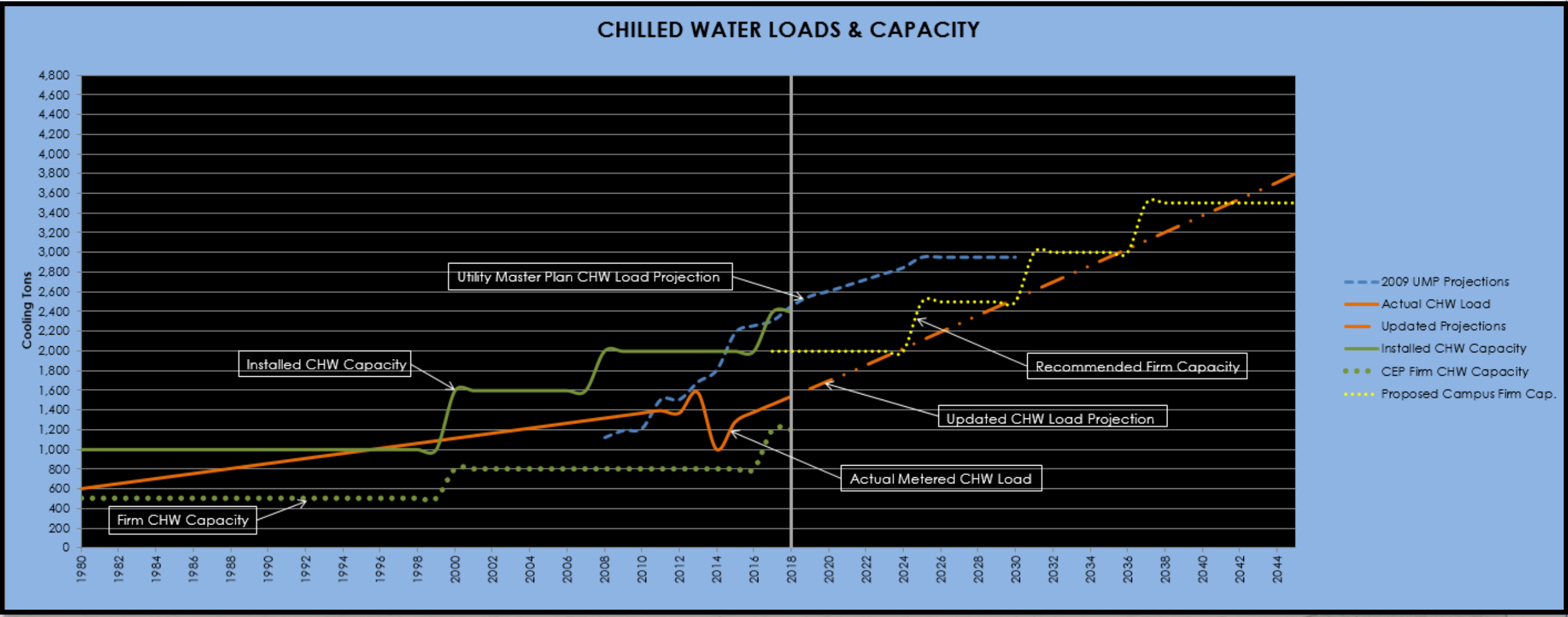
Monthly Cooling Load Profiles



Capacity vs Load Growth

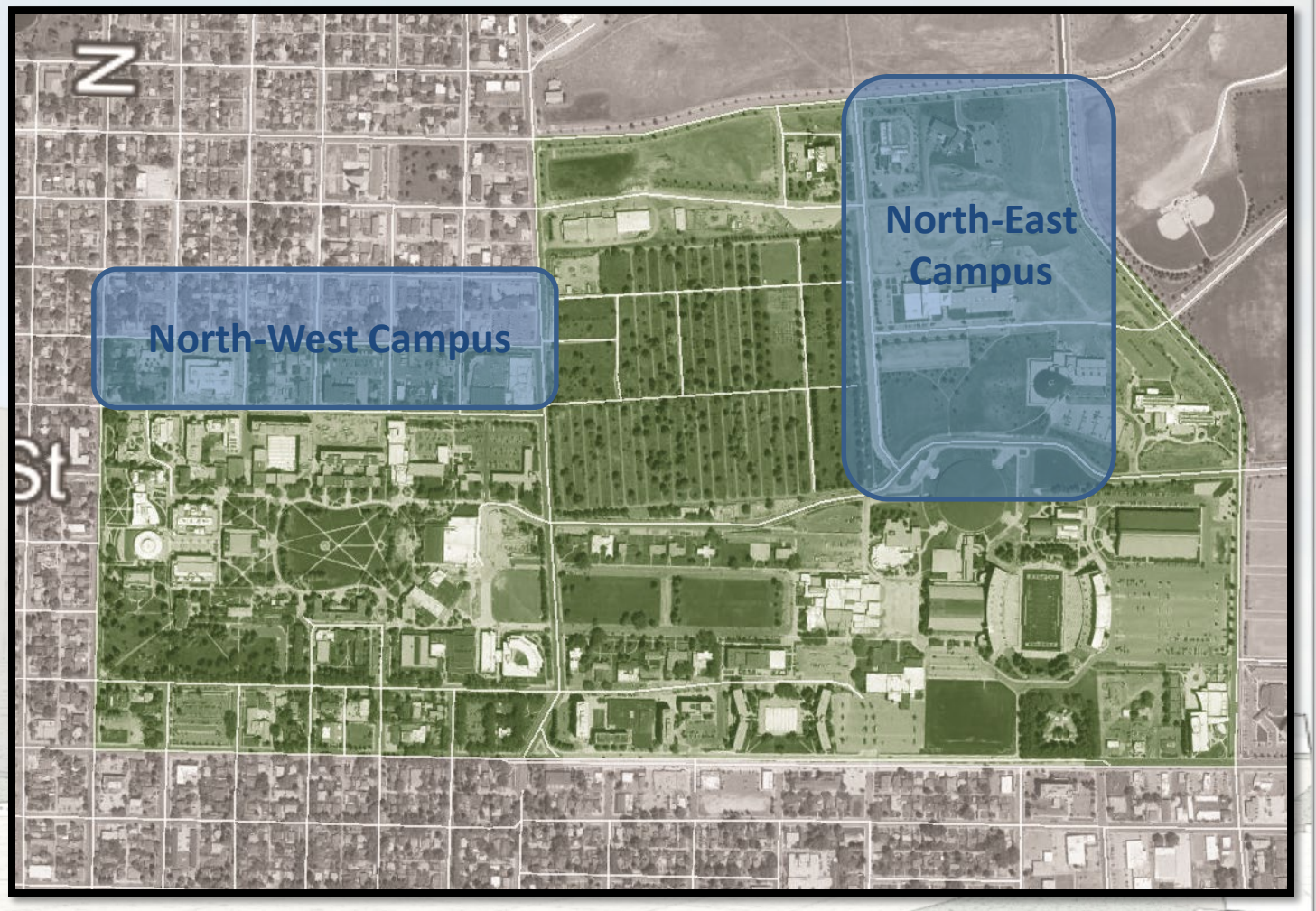
Load Projections



Capacity vs Load Growth

Projected Major Growth Area

- North-West Campus-Project Focus
- North-East Campus



Cooling Options

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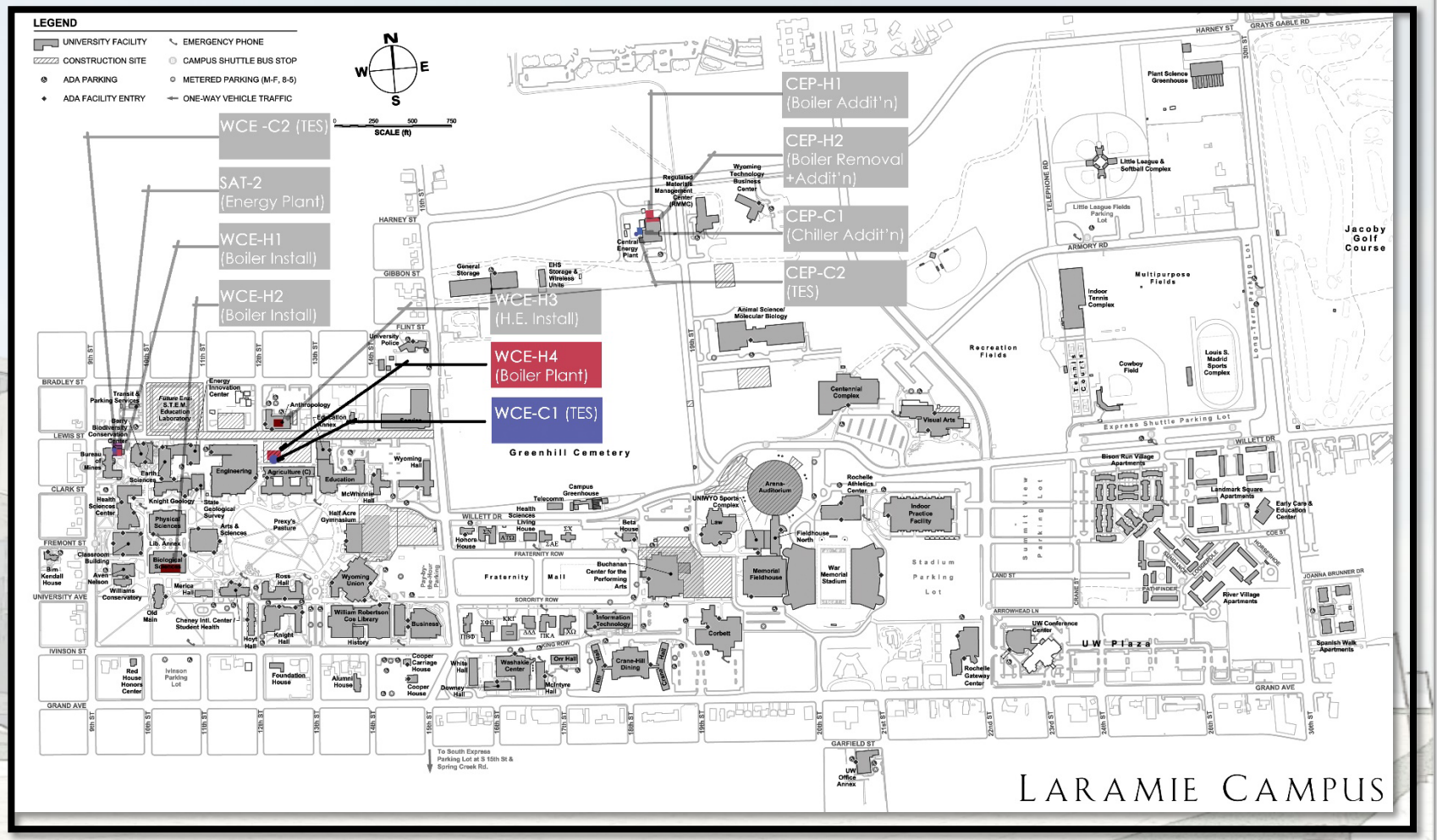
Cooling Options Available

- Evaporative Cooling
- CEP Expansion
- Increased Distribution
- Another Chiller Plant
- Thermal Energy Storage

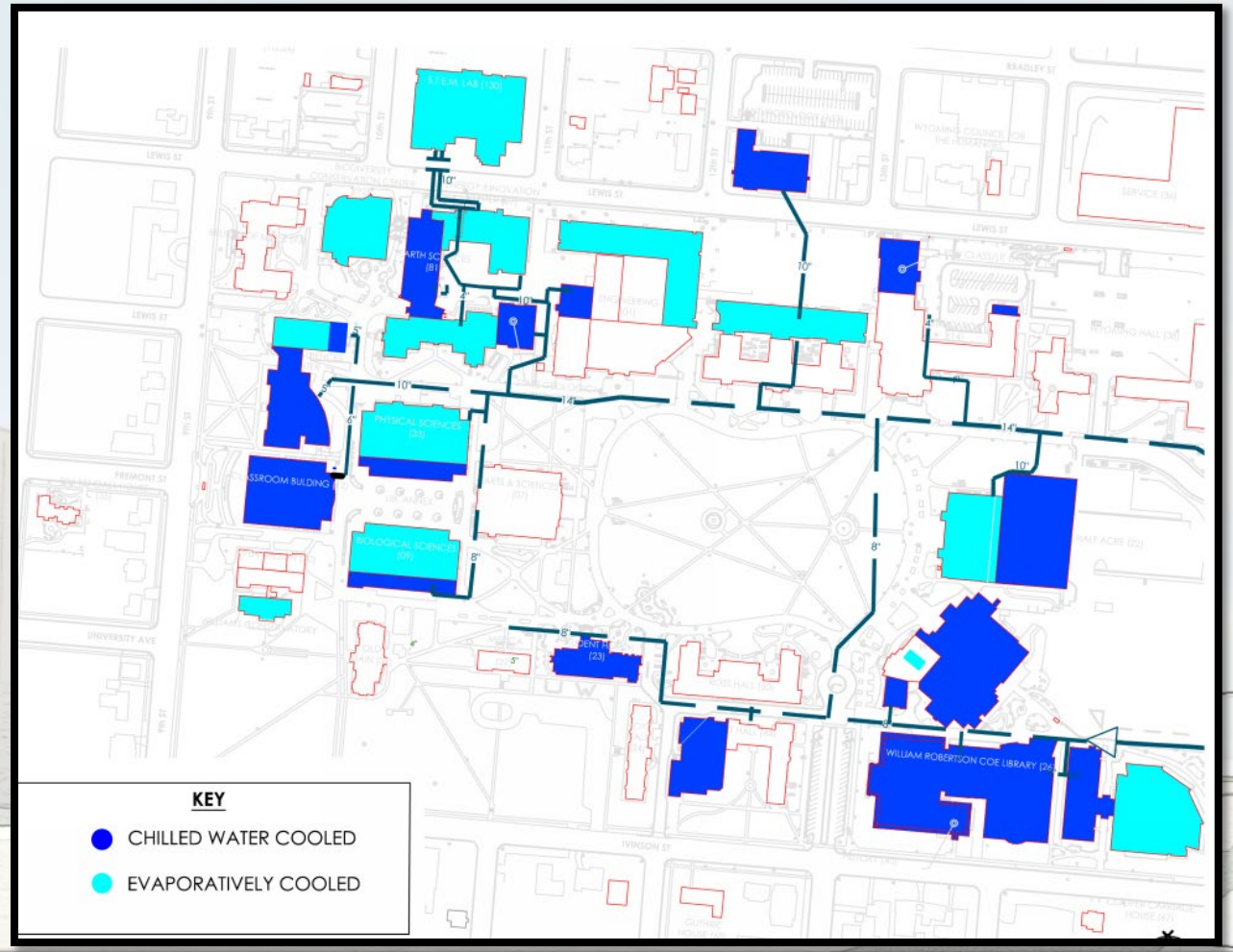
?



Cooling Options

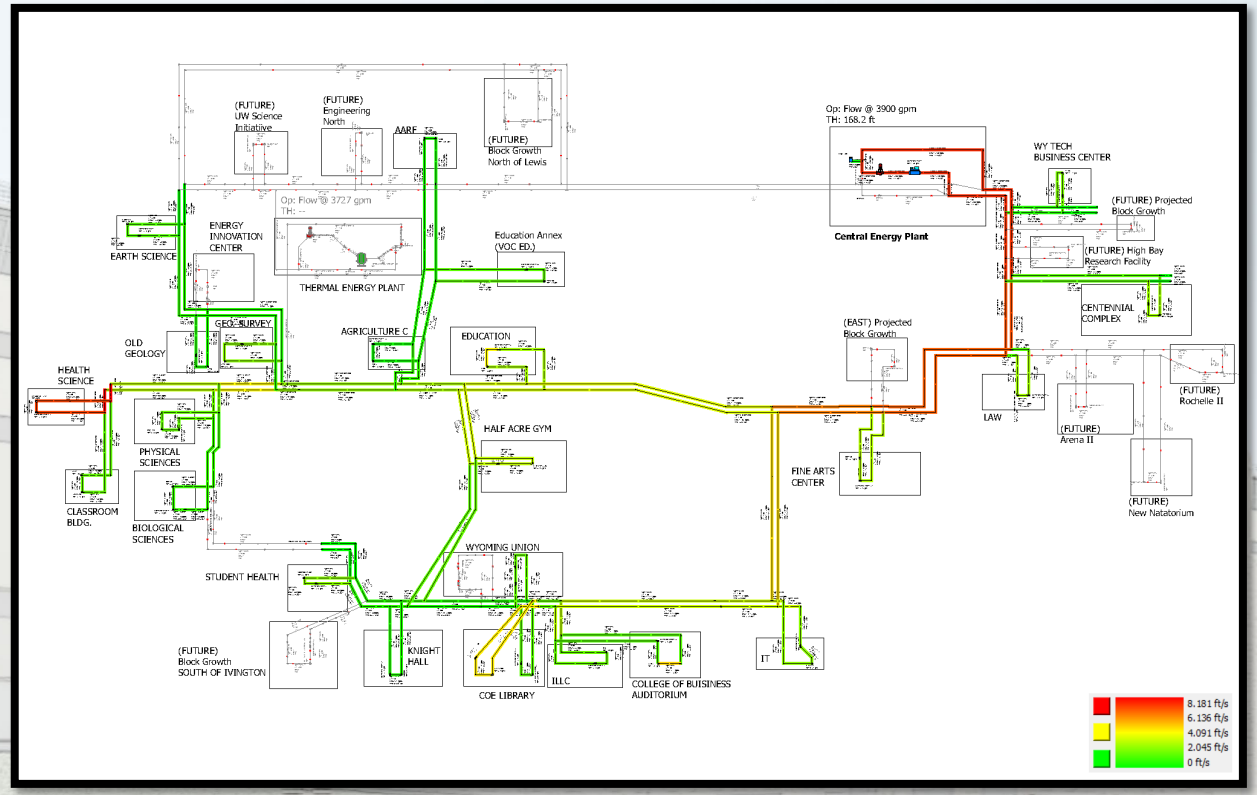
West Campus Evaporative vs Chilled Water Cooled Facilities

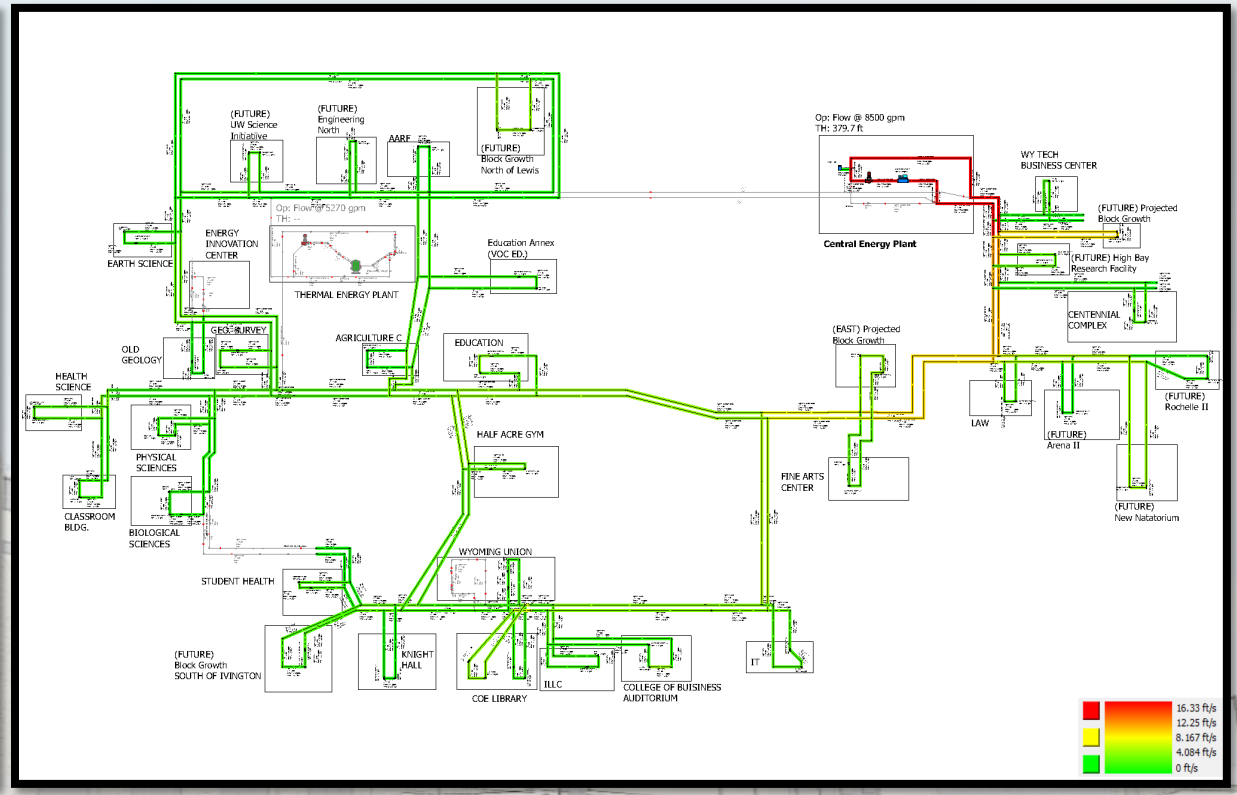
- Large Ductwork
- Tall Floor to Floor Heights
- Difficult with Retrofits
- Humidity
- 58F Discharge Air Temp
- Continuous Maintenance of RO



Cooling Options

CHW Flow Analysis-Existing vs. 30 Year Projected



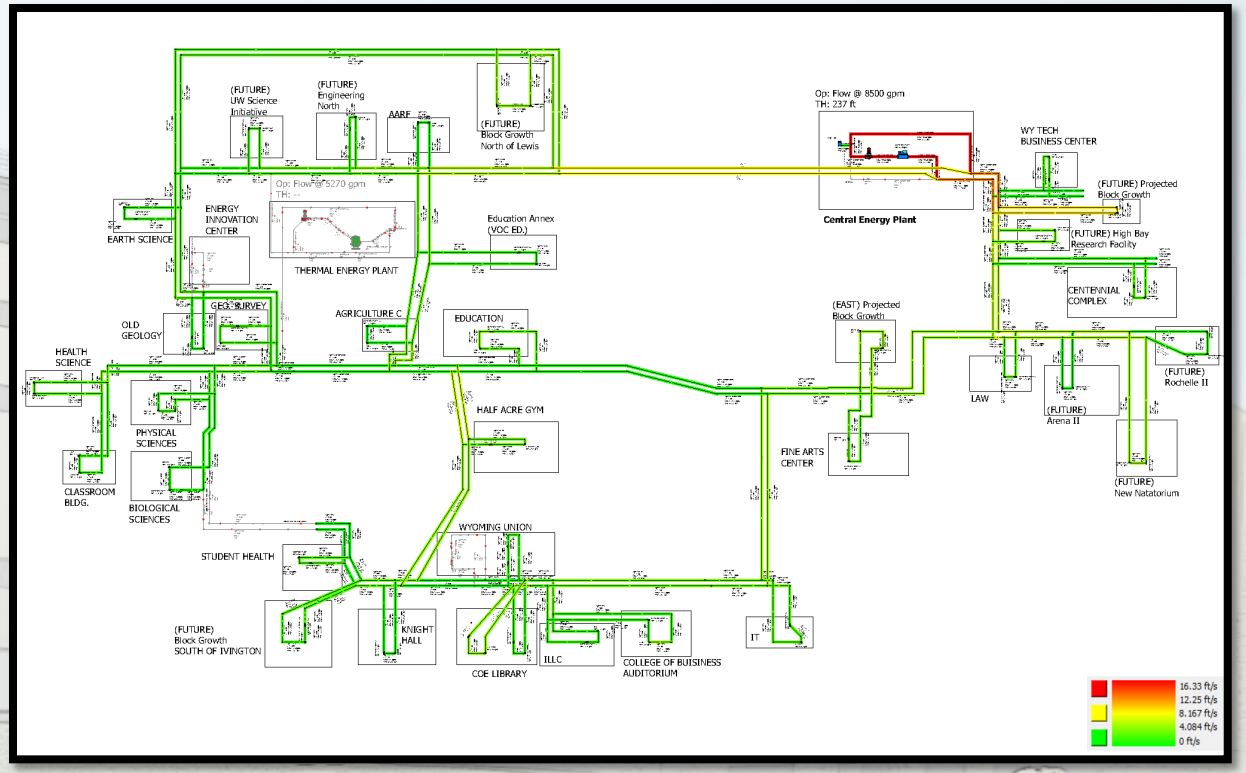


Existing Load/Distribution

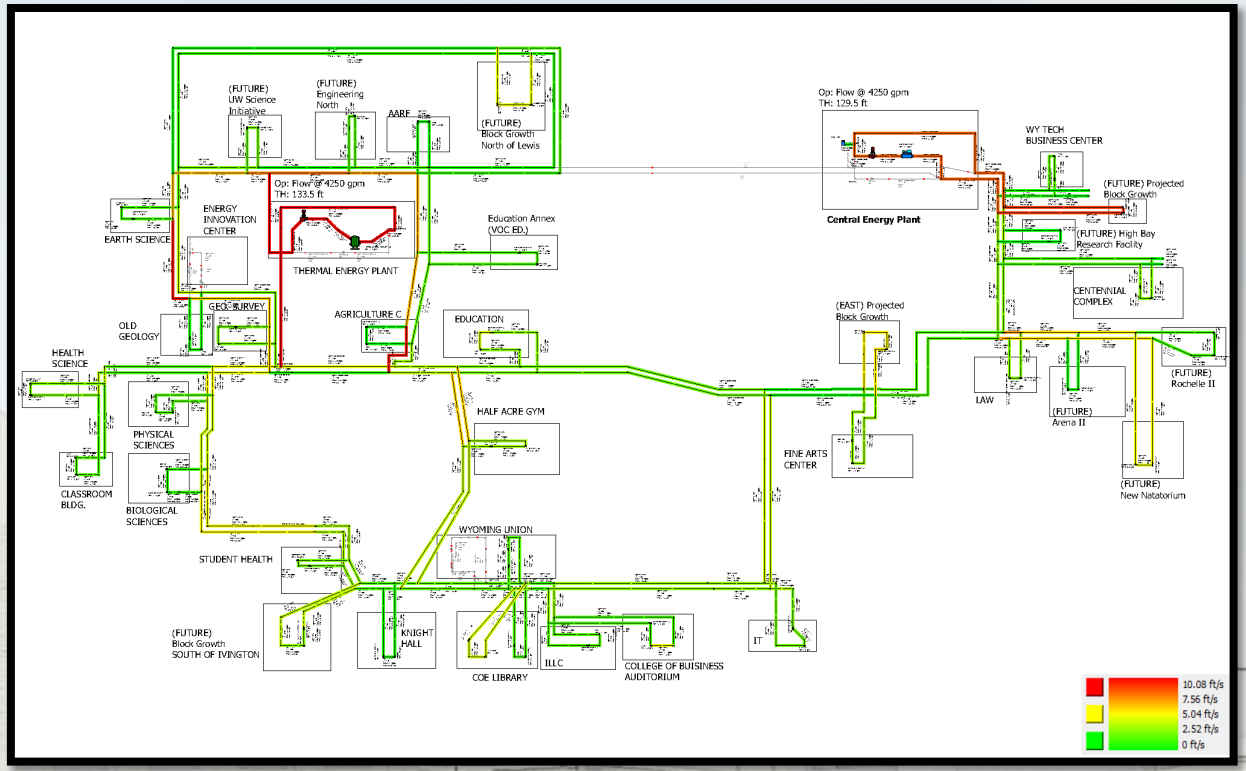
Projected Load w/ no Change to Distribution Network

Cooling Options

CHW Flow Analysis-Various Solutions



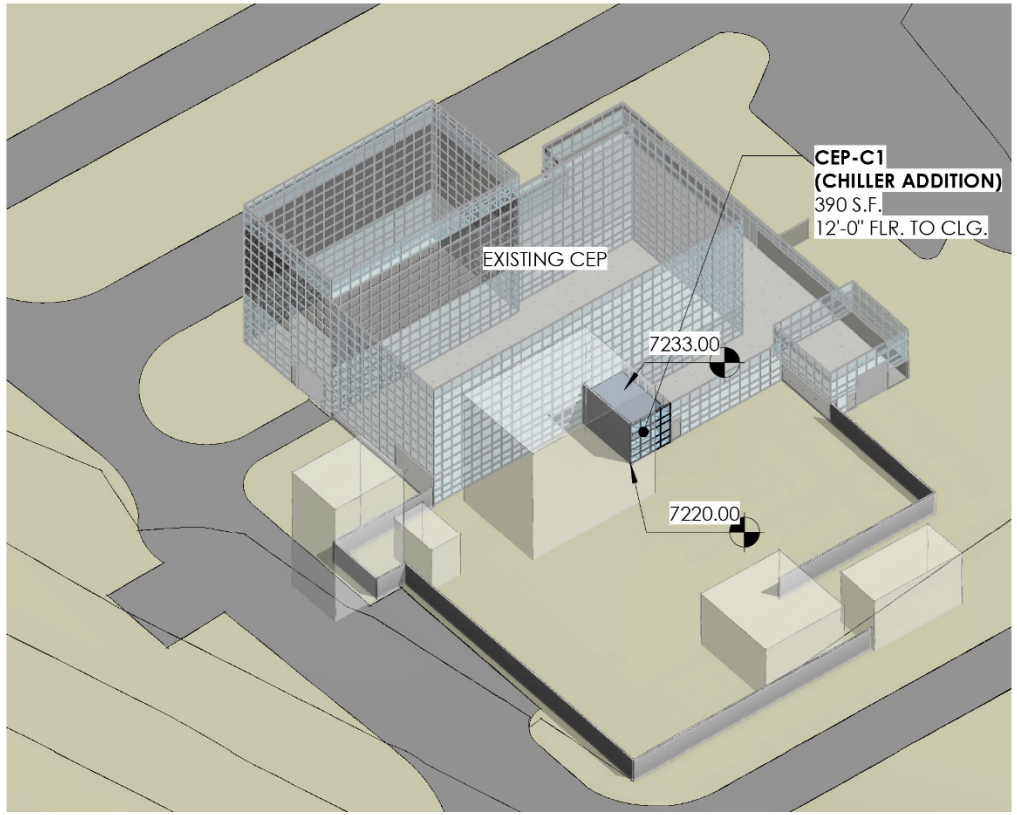
Projected with Campus Interconnect



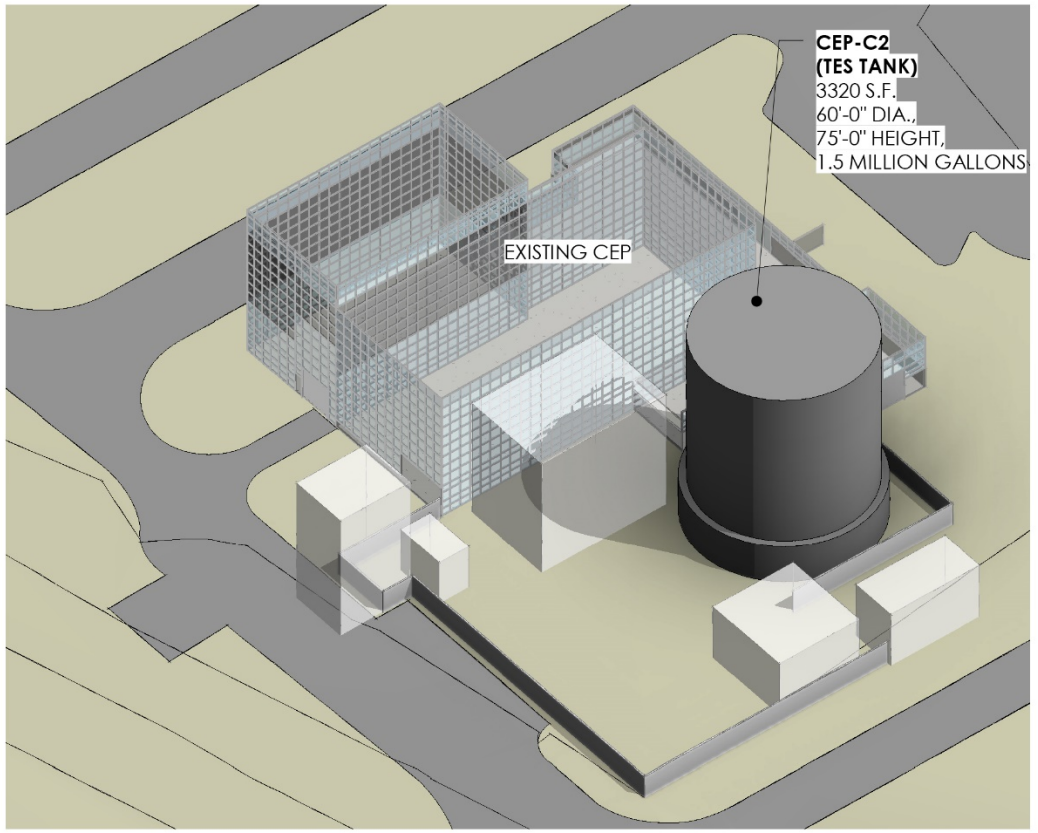
Projected Load West Campus Insertion

Cooling Options

CEP Expansion



2 CEP-C1_ ISOMETRIC VIEW



2 CEP-C2_ ISOMETRIC VIEW

Cooling Options

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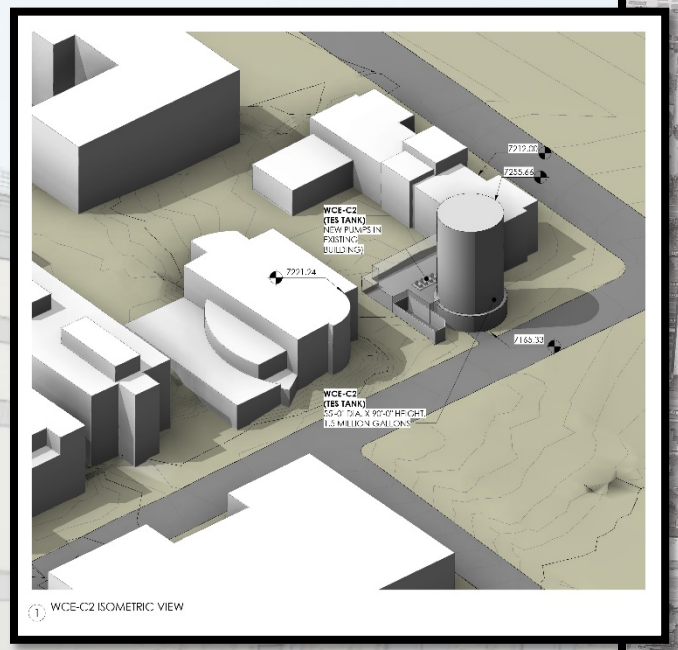
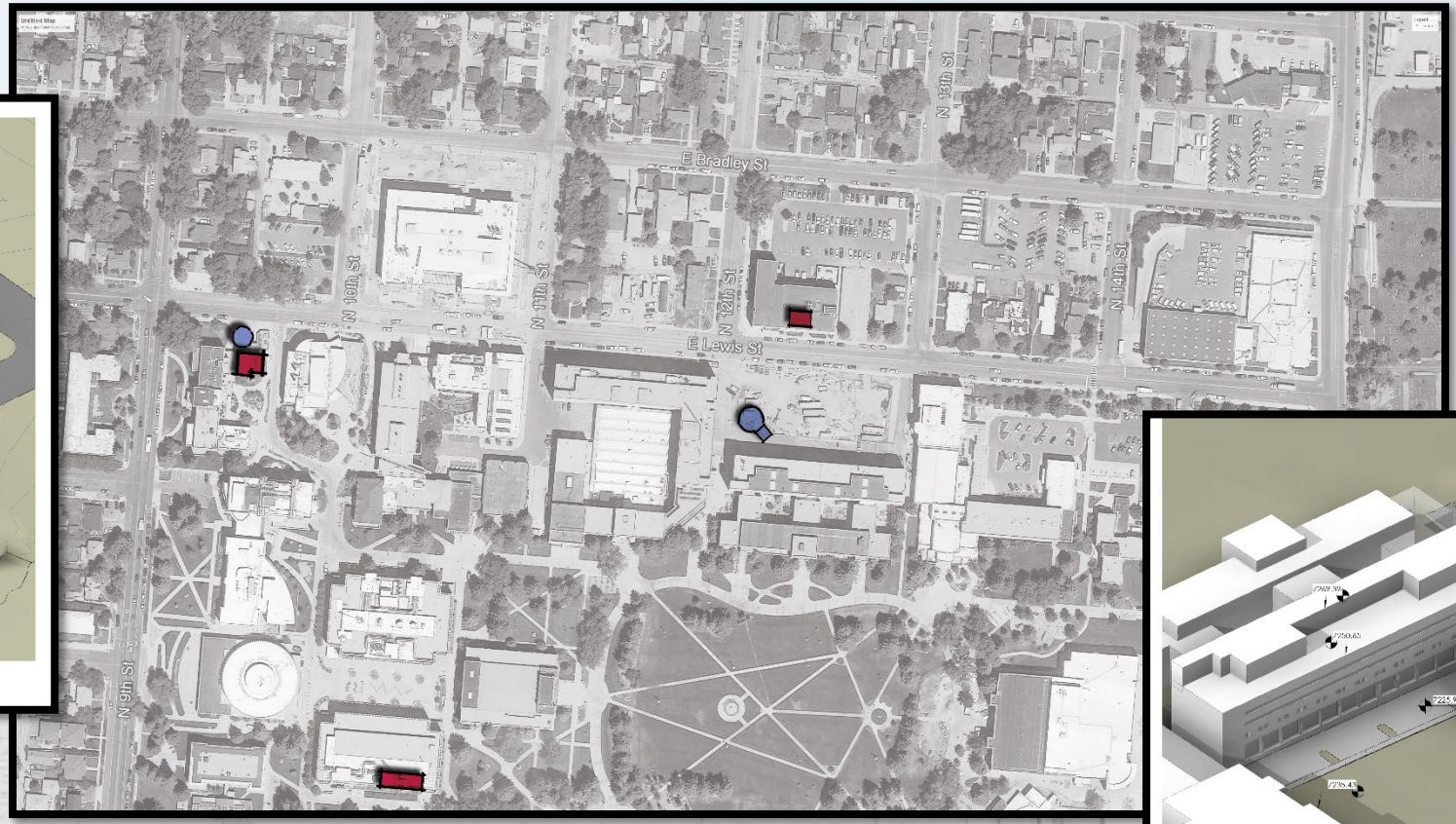
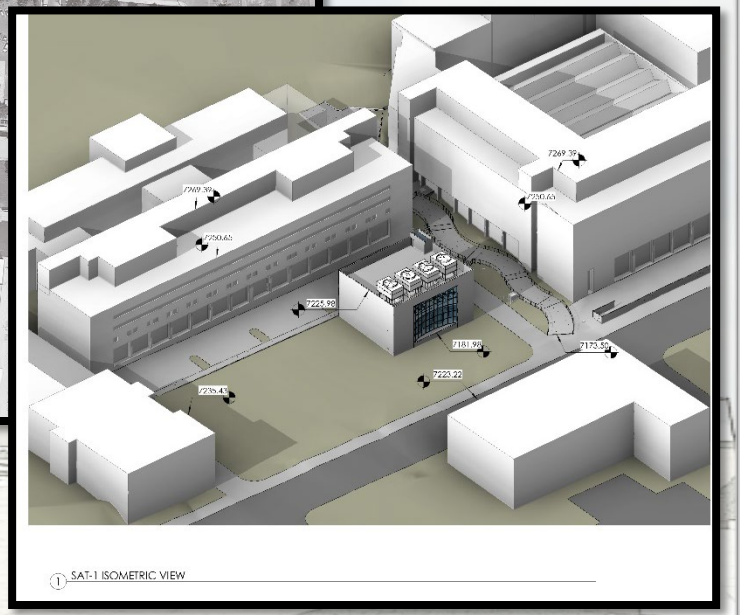
West Campus Plant







Site Comparison

Site Comparison Matrix

COMPARISION		Site Options				
	Item	SAT-1	North of Agriculture	SAT-2	Bureau of Mines
A0	**Site Facts**				
A1	**Area**	2	Site area is flexible at this location	0	Site is limited, plant constructed between existing bldg. and electrical transformers
A2	Adjacent Bldgs	1		0	
A3	Adjacent Hts	-1	Existing bldgs higher than plant	1	Existing bldgs about the same height as plant.
A4	**Open Space**	2	Works with planned open space	1	No adverse impact with planned open space
A5	**Historic context**	0	Existing bldgs adjacent lack architectural context to existing campus. Newly constructed on east and north are compatible with the campus guidelines		Existing bldgs newer and older and fit with architectural context of existing campus.
A6	**Materials**	0	Engineering and Agriculture - Exterior stucco system	1	Bureau of Mines - Sandstone and Brick
A7	**Forms/Visual image**	0	Engineering and Agriculture are monolithic and generic in form	1	Bureau of Mines details reflect the older campus bldgs.
B0	**Site Environment**				
B1	**Drainage / topography**	0	No or minimal impact to existing drainage	0	No or minimal impact to existing drainage
B2	**Wind**				
B3	Cooling tower drift	-1	Toward Lewis St/vehicles, pedestrians, Anthropology	1	Toward Lewis St/vehicles, pedestrians, less impact at this location
B4	Intake	-2	Possible intakes impact on Anthropology	0	None Known
B5	Exhaust				
B6	**Solar access**	-1	Mostly shaded in winter months	1	Solar access throughout the year
B7	**Solar energy production**	0	Two story plant does not allow room for solar panels on roof	0	Two story plant does not allow room for solar panels on roof
B8	**Daylighting**	2	Good potential for daylighting facility	2	Good potential for daylighting facility
B9	**Orientation**	2	No significant orientation issues	2	No significant orientation issues
B10	**Noise internal/external**	0	Separated bldg. minimizes impact to adjacent structures	-1	With bldg. directly adjacent to existing structure sound attenuation will be required.
B11	**Future development**				
B12	Em Generator/Fuel Tank	1	Adequate site area or located on roof	0	Adequate site area or located on roof
B13	CoGen	1	Adequate site area or located on roof	0	

COMPARISION		Site Options			
	Item	SAT-1	North of Agriculture	SAT-2	Bureau of Mines
B14	**Views**	1	Create views to new landscaped areas possible.	1	Create views to existing landscaped areas possible.
C0	**Utilities**				
C1	**Tunnels**	0	Existing to E and S of Bldg	0	Existing to the S of bldg entering BofM
C2	**Electric**	0	Fed from existing west campus substation (1300 ft)	1	Fed from existing west campus substation (500ft)
C3	**Gas**	0	Avail in Lewis	0	Avail in Lewis
C4	**Steam**	1	10" Avail. Close to site	0	10" Avail. 450 ft. to site
C5	**Chilled water lines**		New line required in Lewis		New line required in Lewis
C6	**Sewer**	0	2 - 10" lines avail.	0	8" line avail.
C7	**Storm water**	0	10" line avail.	0	12" lines avail.
C8	**Water**	0	10" line avail.	0	8" line avail.
C9	**Data**	0	Avail.	0	Avail.
D0	**Environmental**				
D1	**Previous uses**	-1	Previous developed area, some sub surface features may be present	-1	Demolition of existing structure some known and unknown conditions.
D2	**Archeology**	0	None known	0	None known
D3	**Contamination**	0	None known	0	None known
E0	**Access/Traffic**				
E1	**Vehicular**				
E2	Service	2	Service access on 2 sides of structure	2	Service access on 2 sides of structure
E3	Maintenance	2	Maintenance easily accessible	1	Maintenance accessible
E4	Waste/Trash	1	Waste/Trash in close proximity	1	Waste/Trash in close proximity
E5	**Bicycles**	1	Area available for bicycle parking	1	Area available for bicycle parking
E6	**Pedestrian**	1	Adequate access and does not impede current circulation	1	Adequate access and does not impede current circulation
E7	**On-site parking**	1	Adequate space for on-site parking	0	Limited space for on-site parking but parallel parking avaiable on the street
	Total	**11**		**12**	

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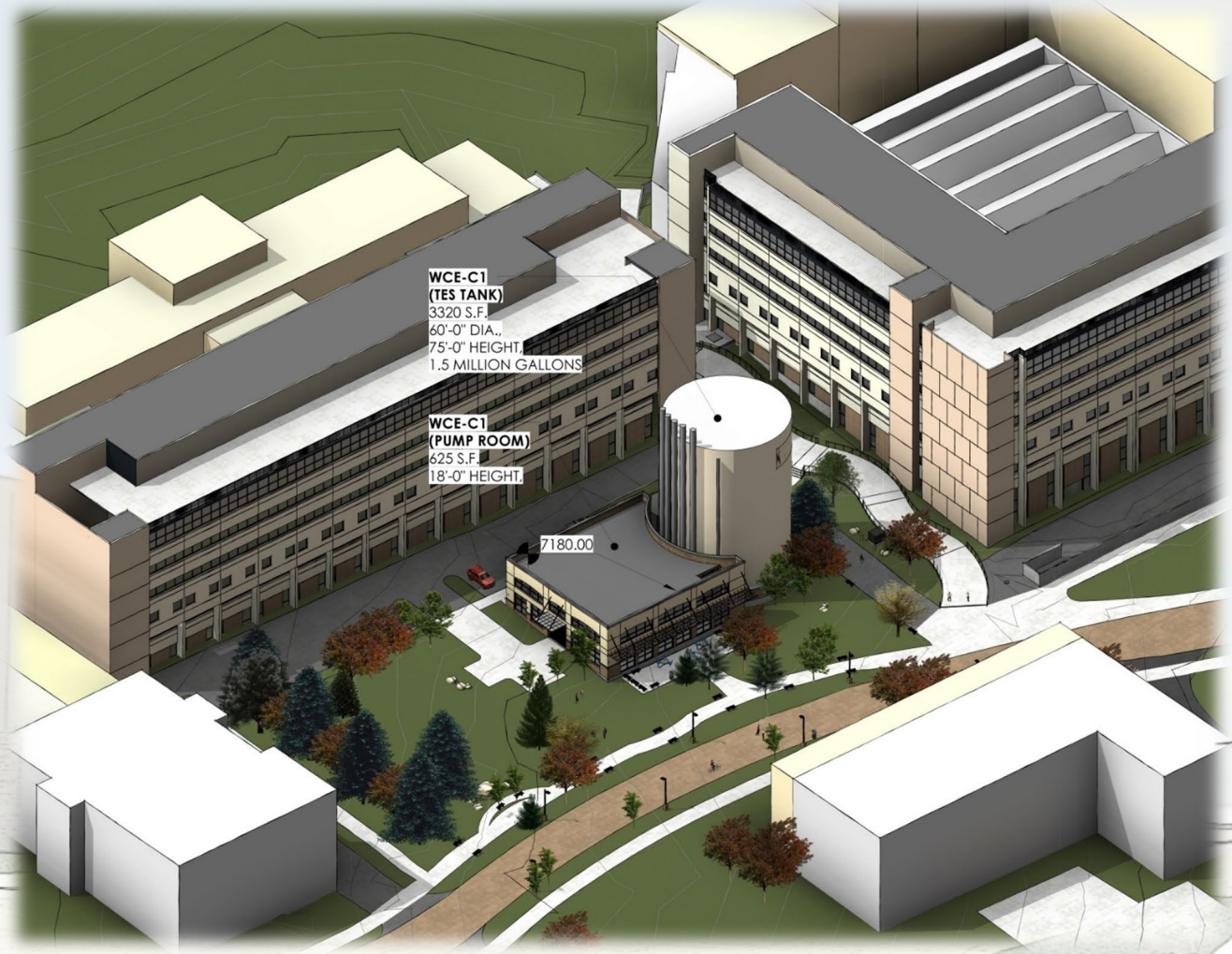
Life Cycle Cost Analysis-Basic Steps

- Facility Condition of Existing System (Equipment, Distribution, Efficiencies)
- Identify Campus Loads (Current and Projected)
- Determine Potential Options
- Identify 30 Year Costs
- Capital-New and Renewal, Equipment, Distribution
- O&M-Utility, Labor, Taxes, Fees
- Compare Performance
- Determine Cost of Financing
- Generate Cash Flow Diagrams
- Compare Net Present Value
- Identify Intangibles
- Perform a Sensitivity Study

Analysis Results

2016 Proposed Solution

- New Heating Plant on West Campus
- Chilled Water Thermal Storage on West Campus



Appearance

Visually Acceptable?

- Overall Architectural Design
- Scale
- Existing Views
- Integration with Masterplan

University's Long Range Development Plan

Appearance

Architectural Design

Contemporary Architecture

Classical Architecture

Appearance

UNIVERSITY OF WYOMING

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Compare Costs and Acceptable Solutions

- 2018 Exterior Design Advisory Committee
  - Architectural Design
  - Location
  - Future Vision of the University

Thermal Energy Storage

Concept of TES-Pros

- An Energy Storage System
- Utilize Existing Infrastructure
- Advantageous To:
  - Nighttime Wetbulb Depression
  - Electric Rate Structure
  - Full Load Efficiency
  - Flexibility in Plant Operations
  - Firm Capacity
  - Reduction in Equipment Capacity Requirements
  - Reduced Emissions at Electric Utility
  - Possibility of Fire Water Storage

Thermal Energy Storage

Concept of TES-Cons

- Size of Tank
- Tank Appearance
- Importance of Chemical Treatment
  - PH, Corrosion Protection, Biological Control
- System Pressure Control
- Importance of System DT
- TES Tank Design
  - Insulation
  - Diffuser Design

Thermal Energy Storage

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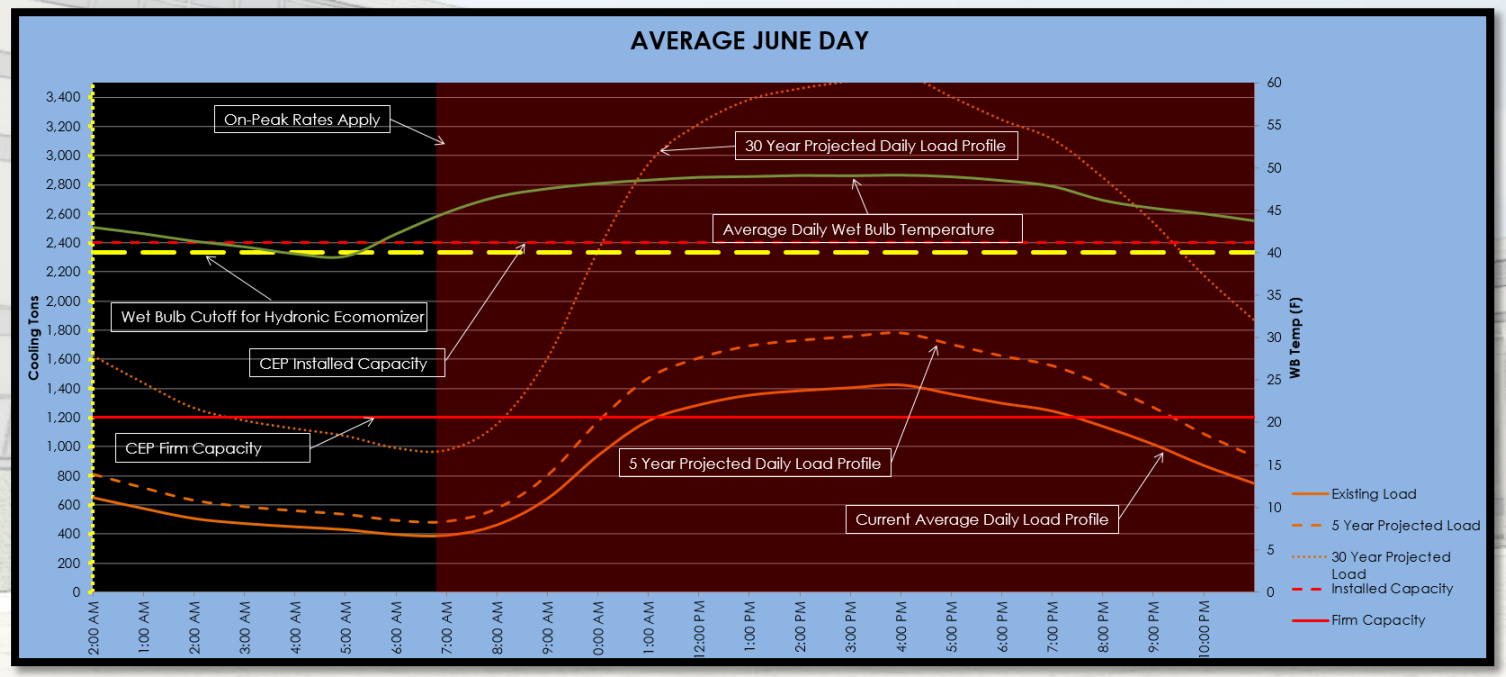
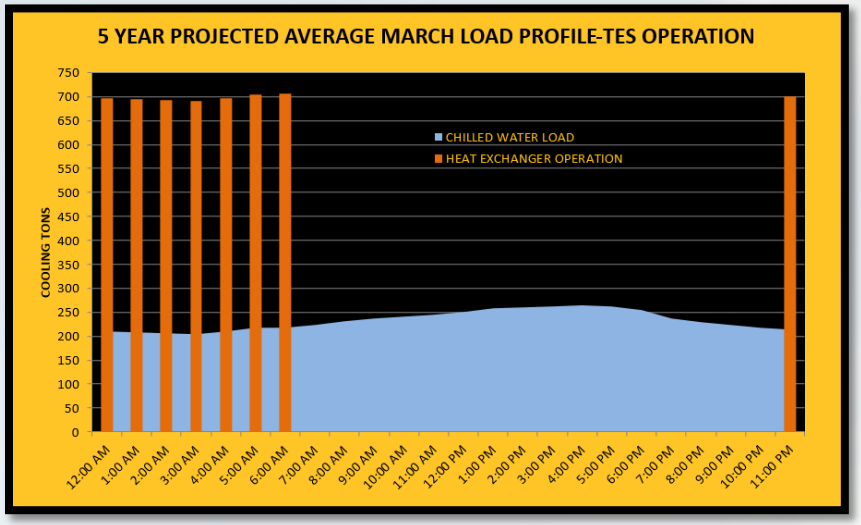
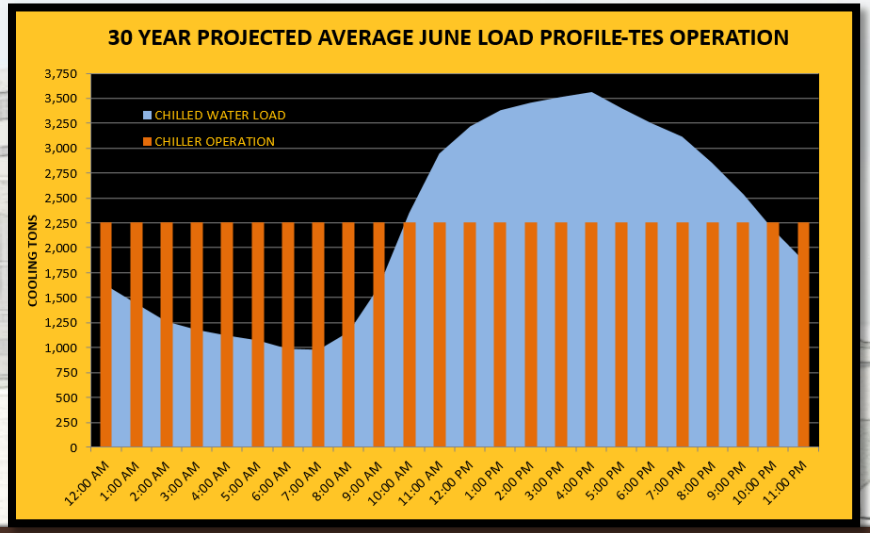
Engineering Design

- Project Chilled Water Hourly Load Profile
- Determine “Free” vs “Chiller” Cooling Hours
- Identify Associated Costs
- Daily ton-hour Production/Storage Requirements





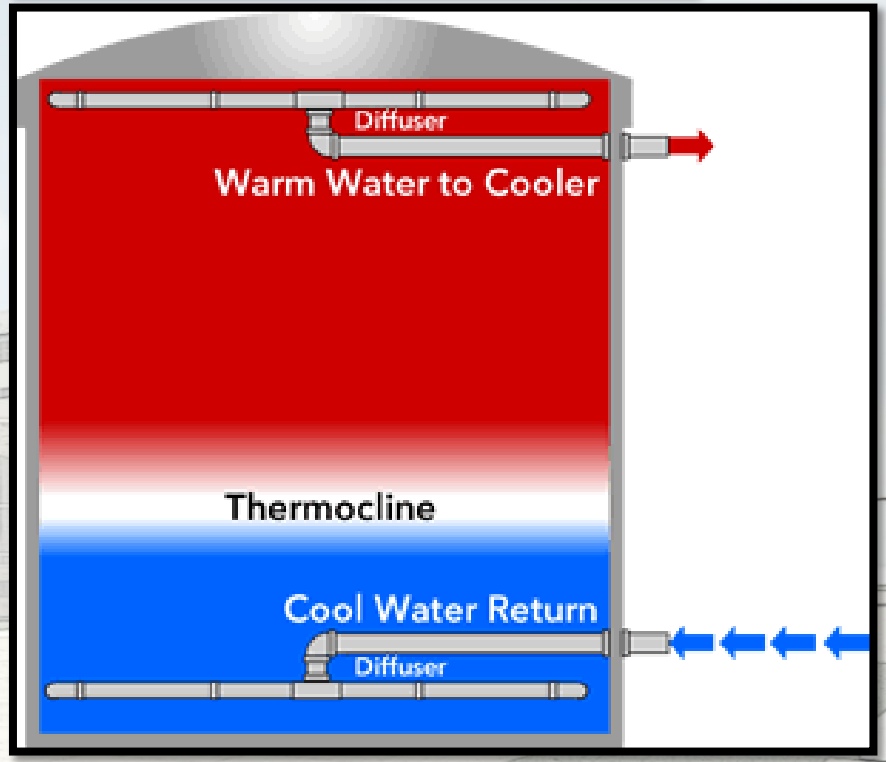


Thermal Energy Storage

Engineering Design

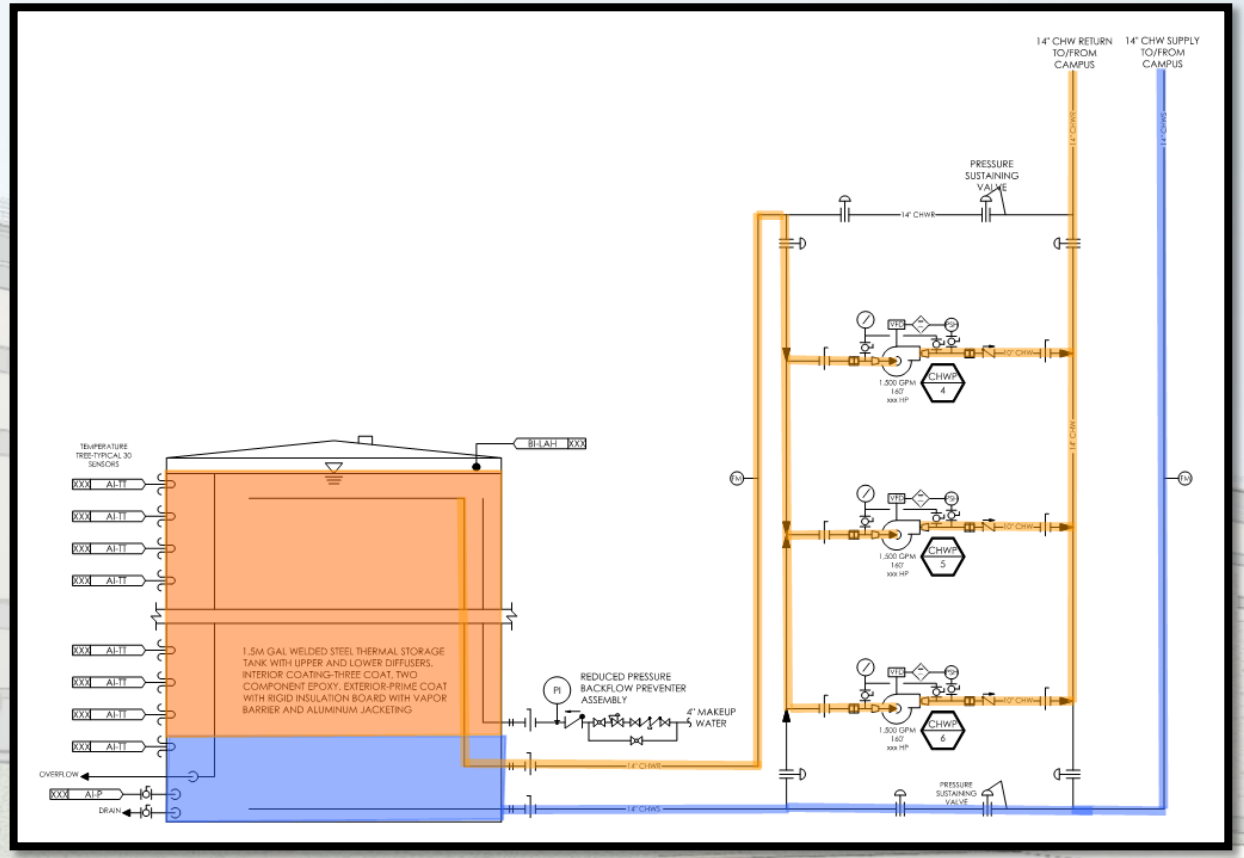
- Size Tank
  - System DT
  - Tank Height to Diameter Ratio-Efficiency
  - Diffuser Design-Thermocline Efficiency (2-10')
- Determine Required Volume
- Determine Tank Cost ($1.50/gal)

Tank Height (Ft)		Tank Diameter (Ft) 55	60	65	70	75	80
100	-	$2.67M	$3.17M	$3.72M	$4.32M	$4.96M	$5.64M
95	-	$2.53M	$3.01M	$3.54M	$4.10M	$4.71M	$5.36M
90	-	$2.40M	$2.86M'	$3.35M	$3.89M	$4.46M	$5.08M
85	-	-	$2.70M	$3.16M	$3.67M	$4.21M	$4.79M
80	-	-	$2.57M	$2.98M	$3.45M	$3.97M	$4.51M
75	-	-	-	$2.79M	$3.24M	$3.72M	$4.23M
70	-	-	-	$2.61M	$3.02M	$3.47M	$3.95M
65	-	-	-	-	$2.81M	$3.22M	$3.67M
60	-	-	-	-	$2.59M	$2.97M	$3.38M
55	-	-	-	-	-	$2.73M	3.10M
50	-	-	-	-	-	-	$2.82M
45	-	-	-	-	-	-	-

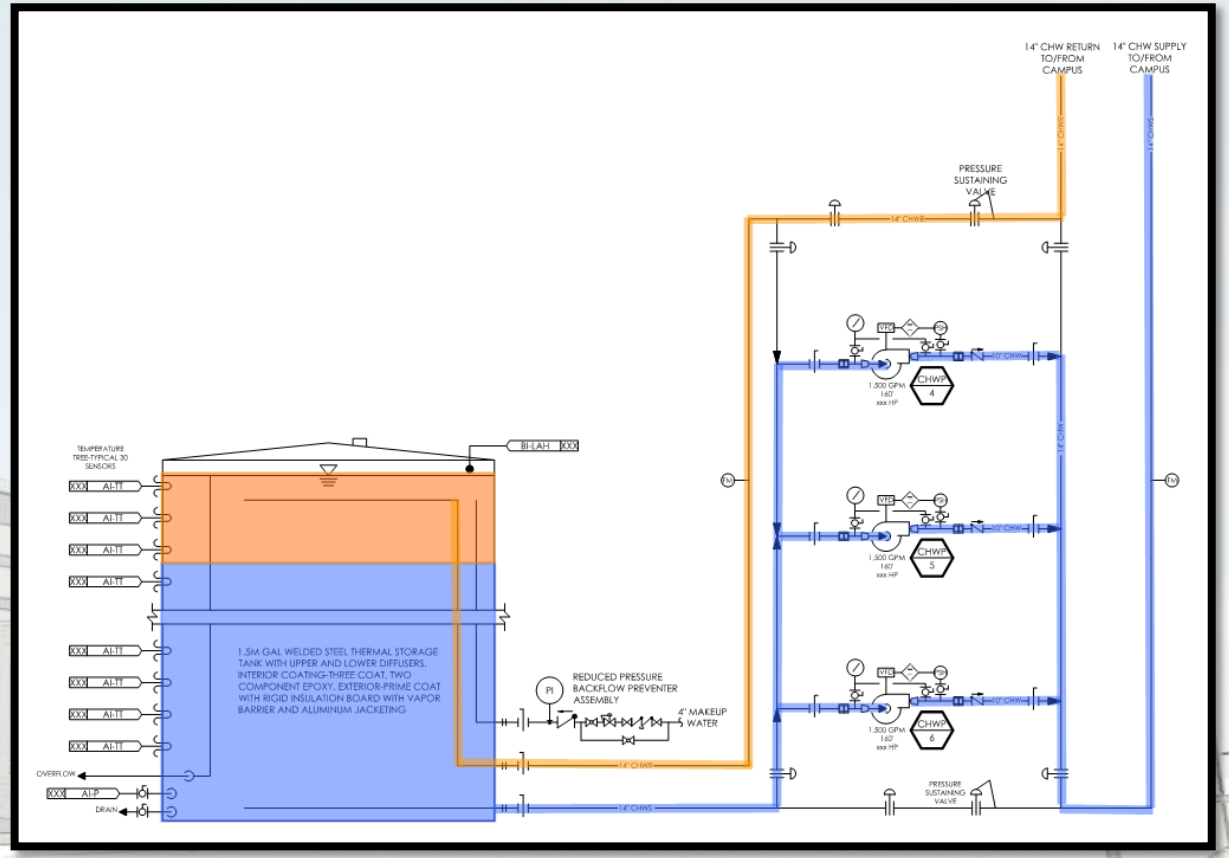


Thermal Energy Storage

Engineering Design



Charging Schematic



Discharging Schematic

University of Wyoming

Outcome

- Upsize (1) Chiller at Existing CEP
- 20 Deg F Coil Requirements
- 11,000 Ton-Hr Tank
- 1.8M Gallon
- 15’ Tank Burial Depth
- Northern Location
- Pumps Integral to New HW Plant
- Minimal Distribution Upgrades
- Groundbreaking Summer 2019

Q&A

Thank You!

Open Question Session

Contact Information
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