The National Institutes of Health – Bethesda

Thermal Energy Storage System Installation & Optimization

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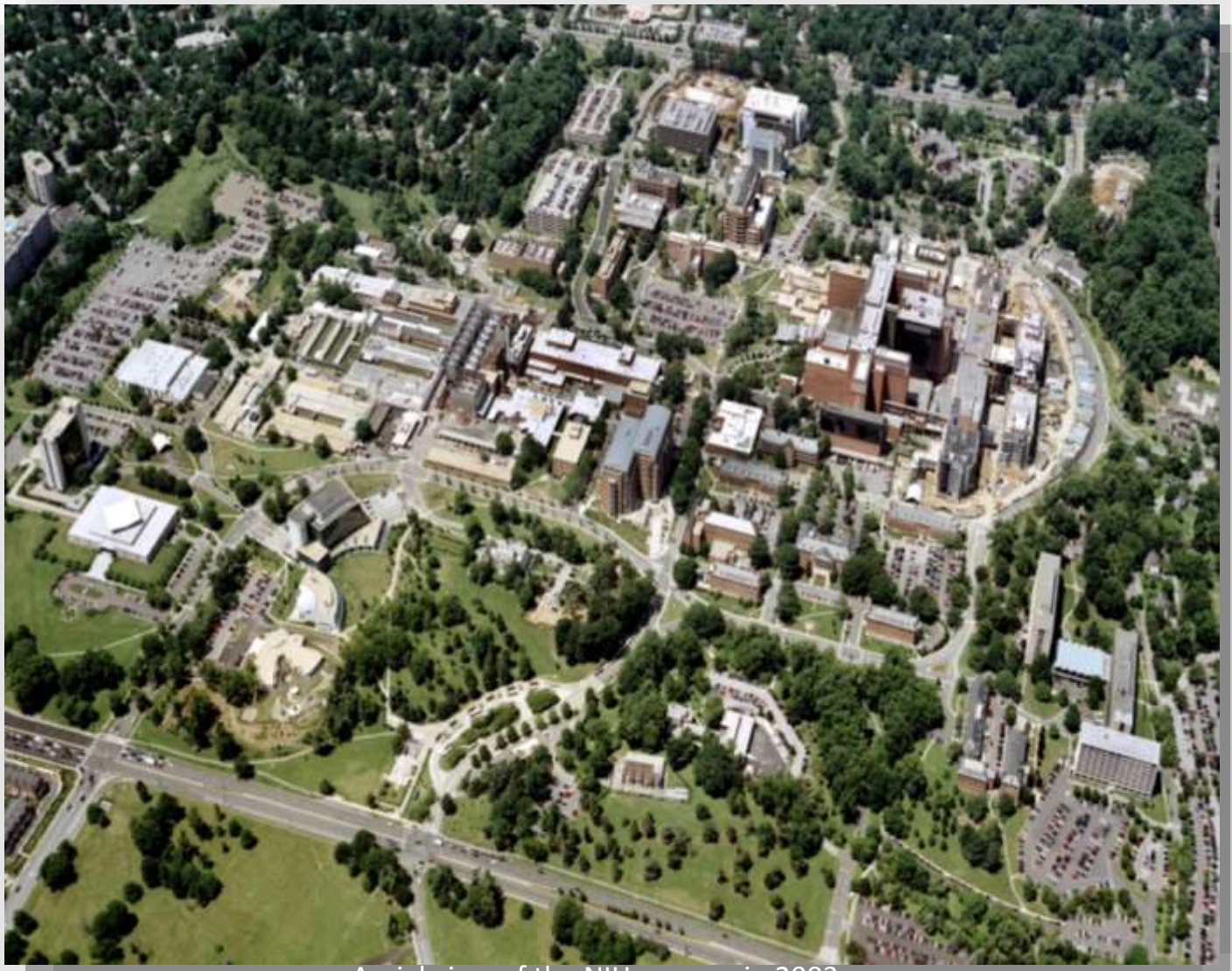
IDEA Campus Energy Conference | February 2019

About NIH

- 75 buildings over 300 acres
- Total area~12 million sqft, many state-of-the-art biomedical research facilities
- World-Class Research Hospital
  - 240 Bed Capacity
- $37 billion annually in medical research
- Leading Biomedical Research Center



Aerial view of the NIH campus in 2003

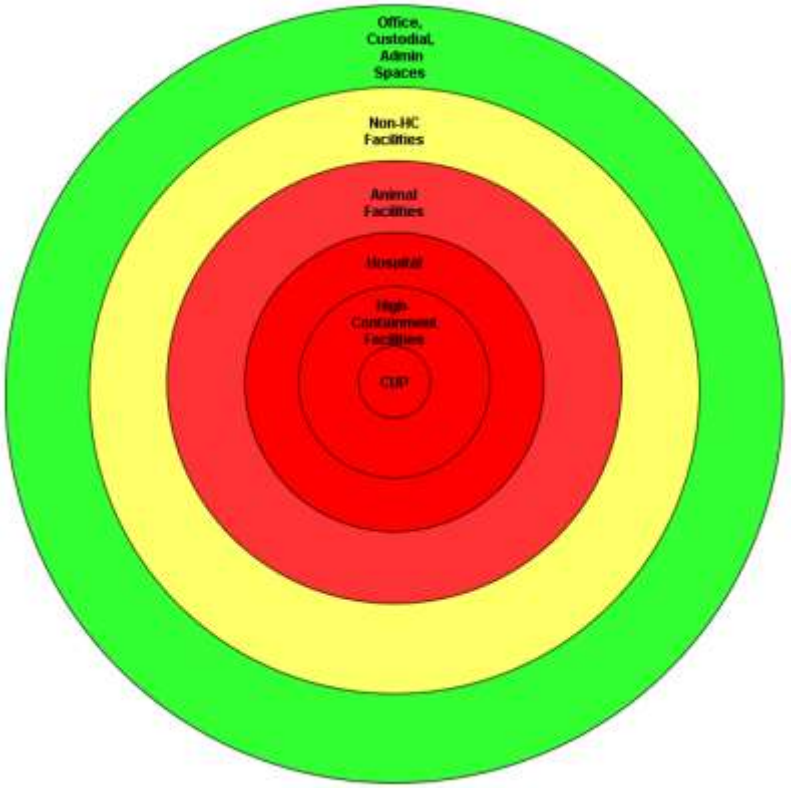
NIH Central Utility Plant (CUP) Overview

- One of the largest CUPs under one roof
  - Provides campus with chilled water, steam, electricity, and compressed air
- CUP Components
  - Twelve 5,000 Ton capacity chillers
  - 7.75 million gal CHW thermal storage tank
  - 5 million gal Industrial Water System
  - Five gas/ diesel dual fuel fired boilers
    - 800 KPPH, 980 KPPH with Cogen
- Cogeneration Power Plant
  - One of the largest US government Cogen plants
  - 23 MW, 180KPPH steam (40% of campus demand)

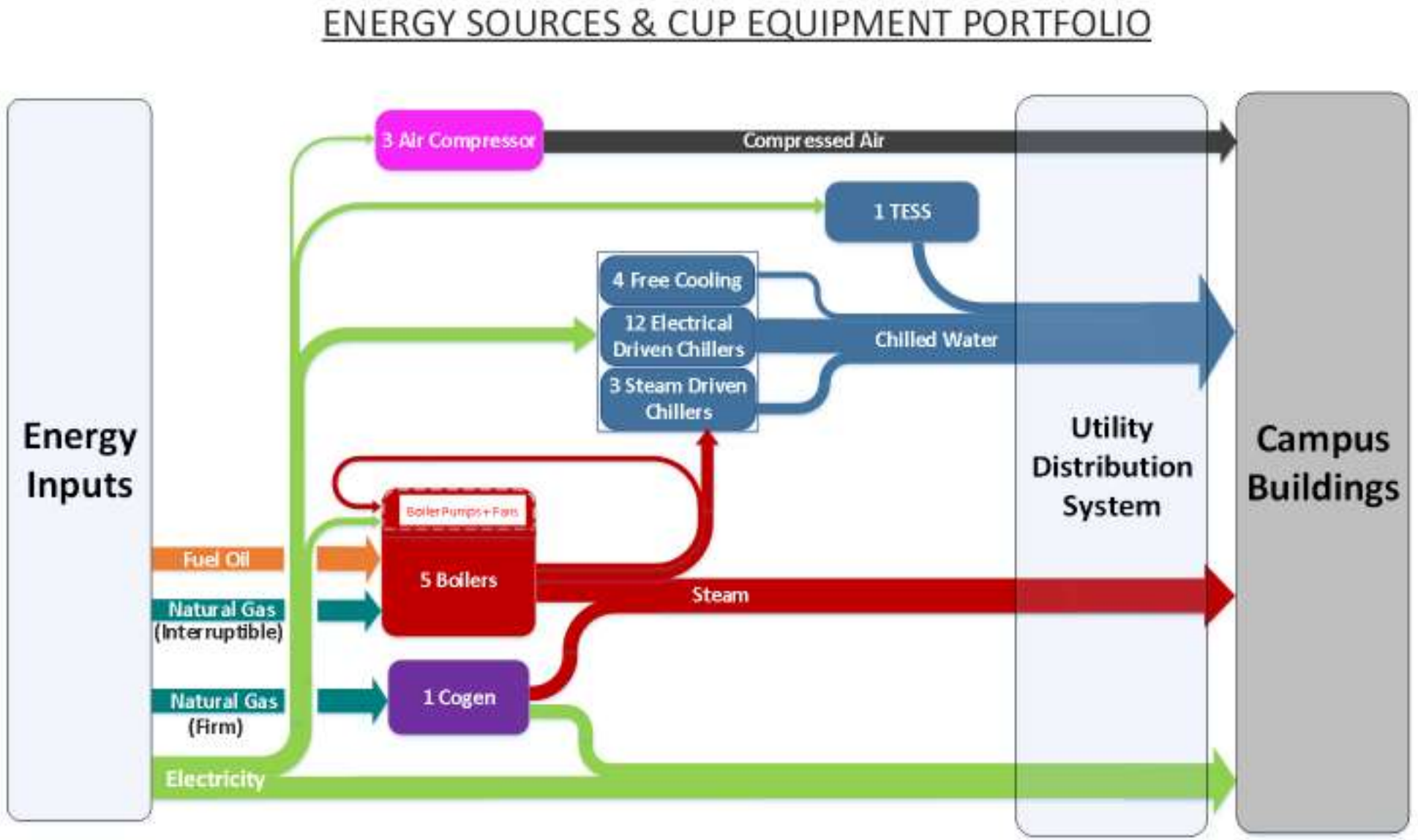
Why is Operation of NIH CUP So Special?

- Reliability is crucial for the mission critical spaces served
  - High Containment Facilities
  - Research Labs
  - Animal facilities
  - World Renowned Research Hospital

NO CUP = NO FUNCTIONING NIH



Energy Sources & CUP Equipment Portfolio



Purpose of Thermal Storage at NIH

- Energy Savings
  - Load Shift from Day to Night
  - Load Leveling
- Optimization of Chiller Operation
- Source of Emergency Chilled Water
- Allows Bldg. 11 Chiller Replacement
- Increase System Reliability

System Basics

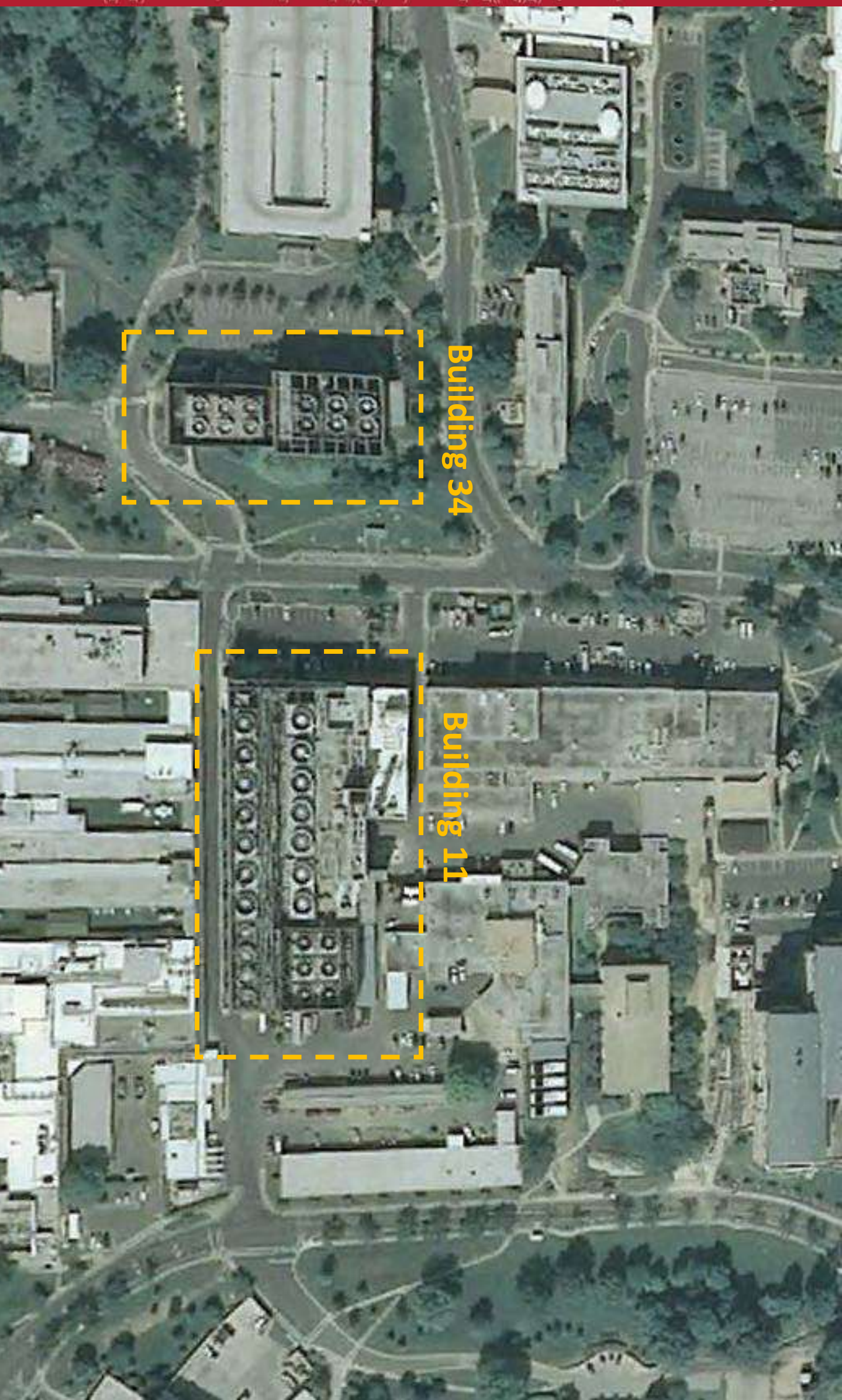
- Volume: 7.75 MG
- Diameter: 120’-0”
- Height: 96’-6”
- Design DT: 10°F
- Capacity: 47,500 Ton-hour
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
  - 3,000 GPM to 24,000 GPM
- Steel - API 650

Division of Technical Resources The National Institutes of Health

Office of Research Facilities

The formulae $\frac{\partial \rho U_i}{\partial t} + \frac{\partial}{\partial x_j}(\rho U U_j) = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_j}\left(\mu \frac{\partial U_i}{\partial x_j}\right) + g_i(\rho - \rho_0)$ $\frac{\partial \rho U_i U_j}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_i}\right) + P + G - \rho\varepsilon$ *for building* $\frac{\partial \rho U_i \varepsilon}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_i}\right) + (C_1 - C_{3\varepsilon})\frac{\varepsilon}{k}(P + C_3 G) - C_2 \rho \frac{\varepsilon^2}{k}$ $\frac{\partial}{\partial x_i}(\rho U_i H) = \frac{\partial}{\partial x_i}\left(\lambda \frac{\partial T}{\partial x_i} - \rho \overline{u_i h}\right)$

$-\rho \overline{u_i u_j} = \mu_t\left(\frac{\partial U_i}{\partial x_j} + \frac{\partial U_j}{\partial x_i}\right) - \frac{2}{3}\rho k$ *state of the art* $\frac{\partial}{\partial x_i}(\rho U T) = -\frac{\partial p}{\partial x_i} + \frac{\partial}{\partial x_i}\left(\mu \frac{\partial U_i}{\partial x_i} - \rho \overline{u_i t}\right) + g_i(\rho - \rho_0)$ $\frac{\partial \rho U_i \varepsilon}{\partial x_i} = \frac{\partial}{\partial x_i}\left(\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_i}\right) + C_1 \frac{\varepsilon}{k}(P + C_3 G) - C_2 \rho \frac{\varepsilon^2}{k}$ *biomedical research facilities.*



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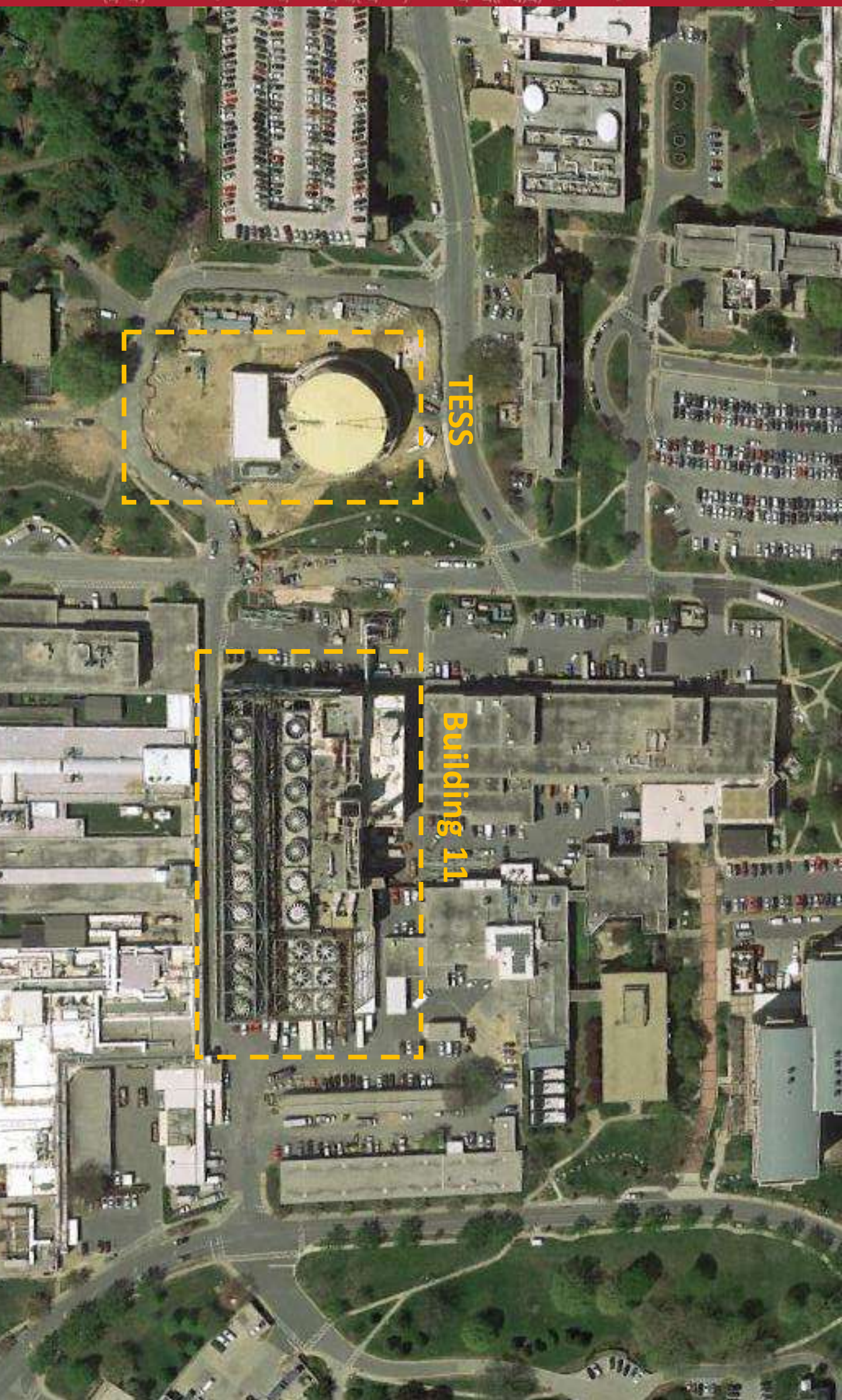
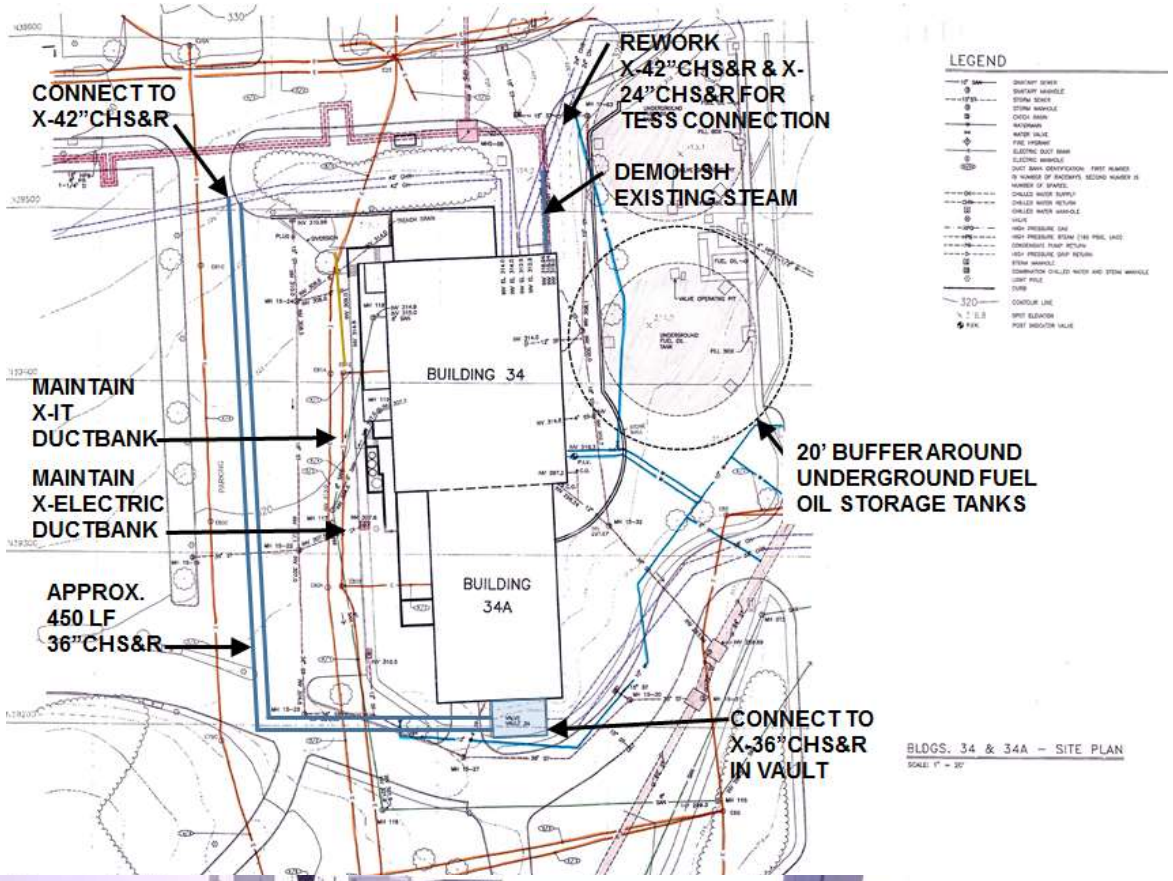


Site

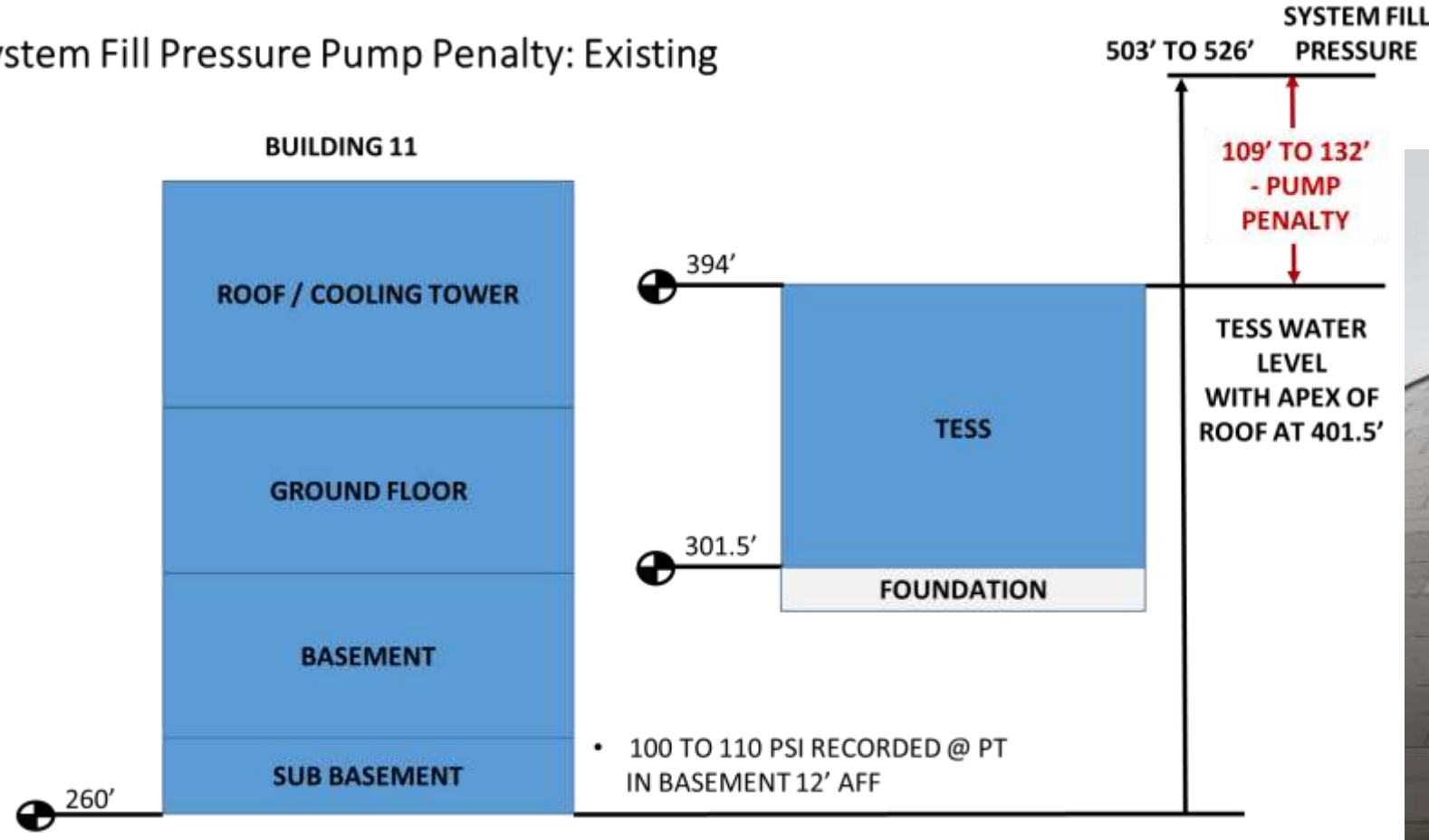
Building 34

- Chilled Water
- Fuel Oil Tanks
- Electrical Ductbanks
- IT Ductbanks
- Fire Alarm



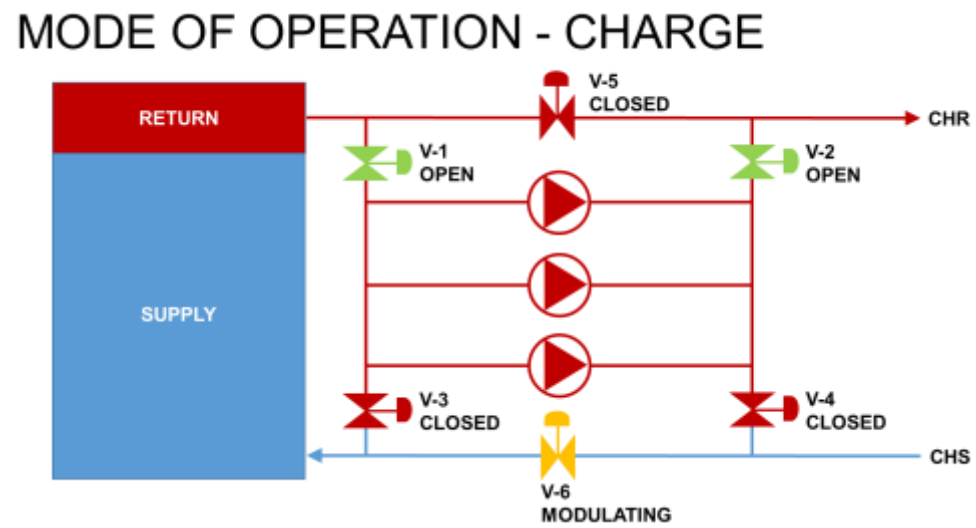
System Arrangement & Basic Operation

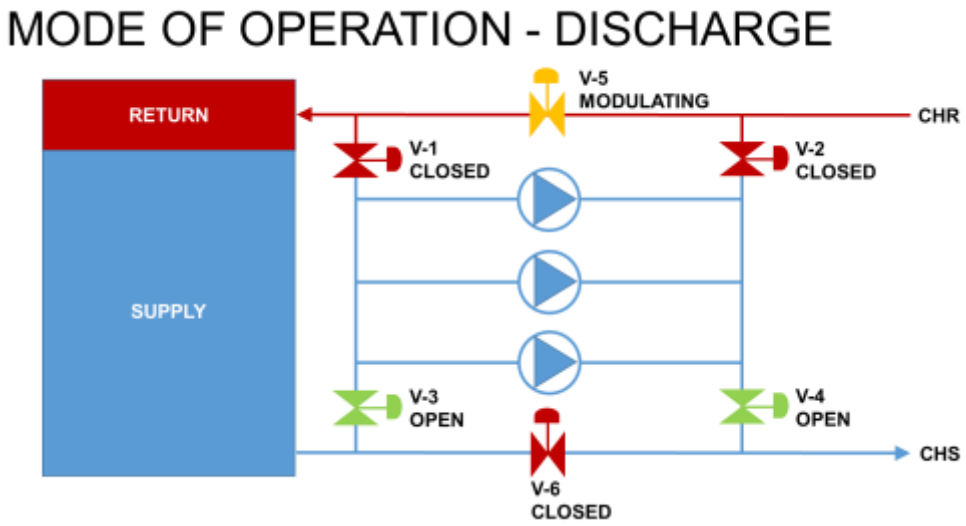
System Fill Pressure Pump Penalty: Existing



System Arrangement & Basic Operation

- Operating Modes
  - Manual
  - Time of Day
  - Load Leveling
- System Pressure Control Modes
  - Fixed Return Pressure (Building 11)
  - Differential Pressure
  - Remote Return Pressure

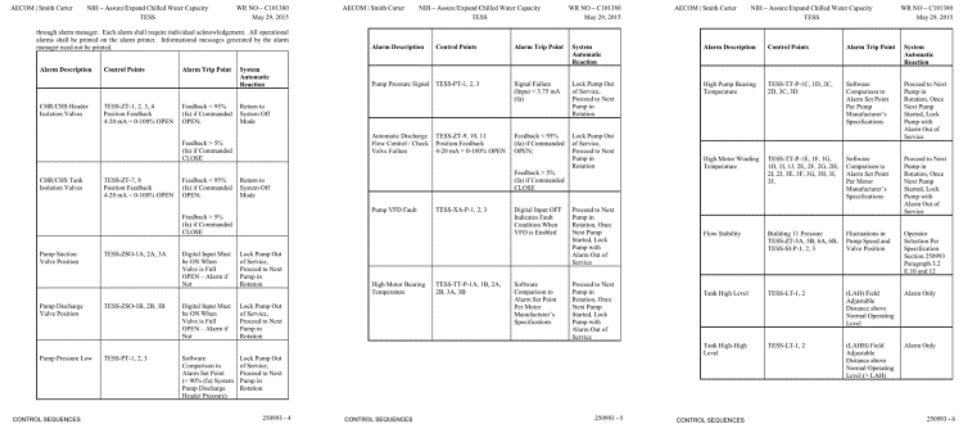




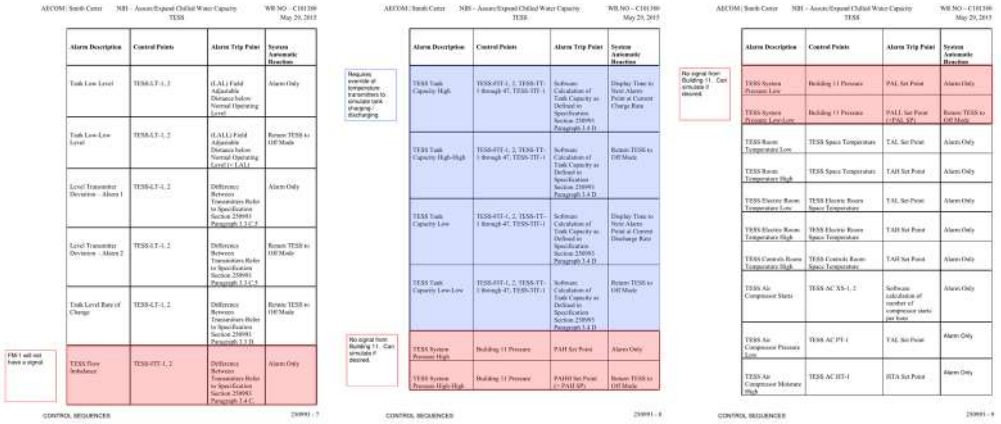
Startup Process -1 Close Loop

- Testing Operation Prior to Open to System
  - Charge
  - Discharge
  - Alarm Testing
  - Automatic Shutdown
  - Makeup level control
  - Power Failure

Alarm Management



Alarm Management



Startup Process -2 Live Testing

- Live Testing w/ Contingency Planning
  - Building 11 Secondary Pumps
  - Primary / Secondary Decoupler Flow
  - Chilled Water Supply Temp
  - Reserve Chiller Capacity
  - Recording / Monitoring Plan (data)
  - Failure Testing (wait…)

Training

- Introduction (Why a tank?)
- Principles of Operation
- System Operating Modes
- System Pressure Control Modes
- Tank Level Control and Alarms
- System Initiation and Start-up
- System Planning Prior to Initiation of Charge/Discharge Cycle
- Key Items to Watch

Optimization

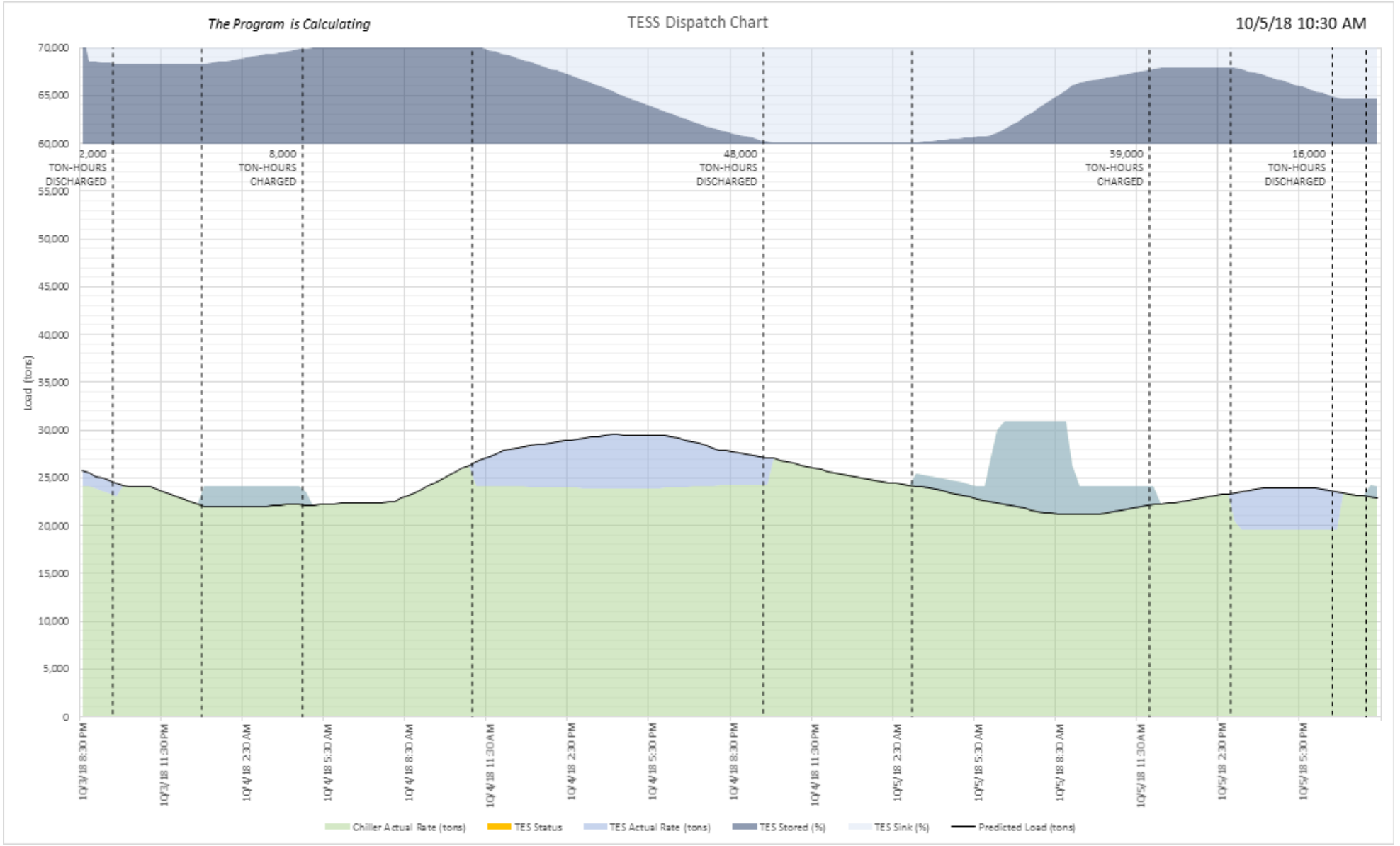
- Excel Based Dispatch Model
  - Inputs
    - 72 hours of future load prediction based on weather forecast
    - 72 hours of future forecasted wet bulb temperature
    - Current TESS capacity (ton-hours)
    - Current chiller lead/lag order
  - Criteria
    - Load-level (limit cycles)
    - Wet bulb temperature (efficiency)
    - Real-time LMP for electricity (cost)
  - Result
    - 48 hour future TESS charging/discharging setpoints

Optimization

- Up to 3,600 TESS dispatch strategies are calculated
- The results are weighted based on input criteria
- The best result is plotted to the screen
- The model repeats the calculation on set interval (5-15 minutes)

Model logic flowchart

Optimization



System Summary

- Volume: 7.75 MG
- Diameter: 120’-0”
- Height: 96’-6”
- Design DT: 10°F
- Capacity: 47,500 Ton-hour
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
  - 3,000 GPM to 24,000 GPM
- Steel - API 650

System Summary

- Volume: 7.75 MG
- Diameter: 120’-0”
- Height: 96’-6”
- Design DT: **14°F**
- Capacity: **66,500+ Ton-hour**
- Max Discharge/Charge: 5 hours
- Flow Rate Range:
  - 3,000 GPM to 24,000 GPM
- Steel - API 650

Contact Information

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