Lesson learned with data. Is there too much data?

‘Was a hot day at the data center.’

Cary Whitney
'Data Junkie'

HEPiX KEK 2017
Oct 16th-20th

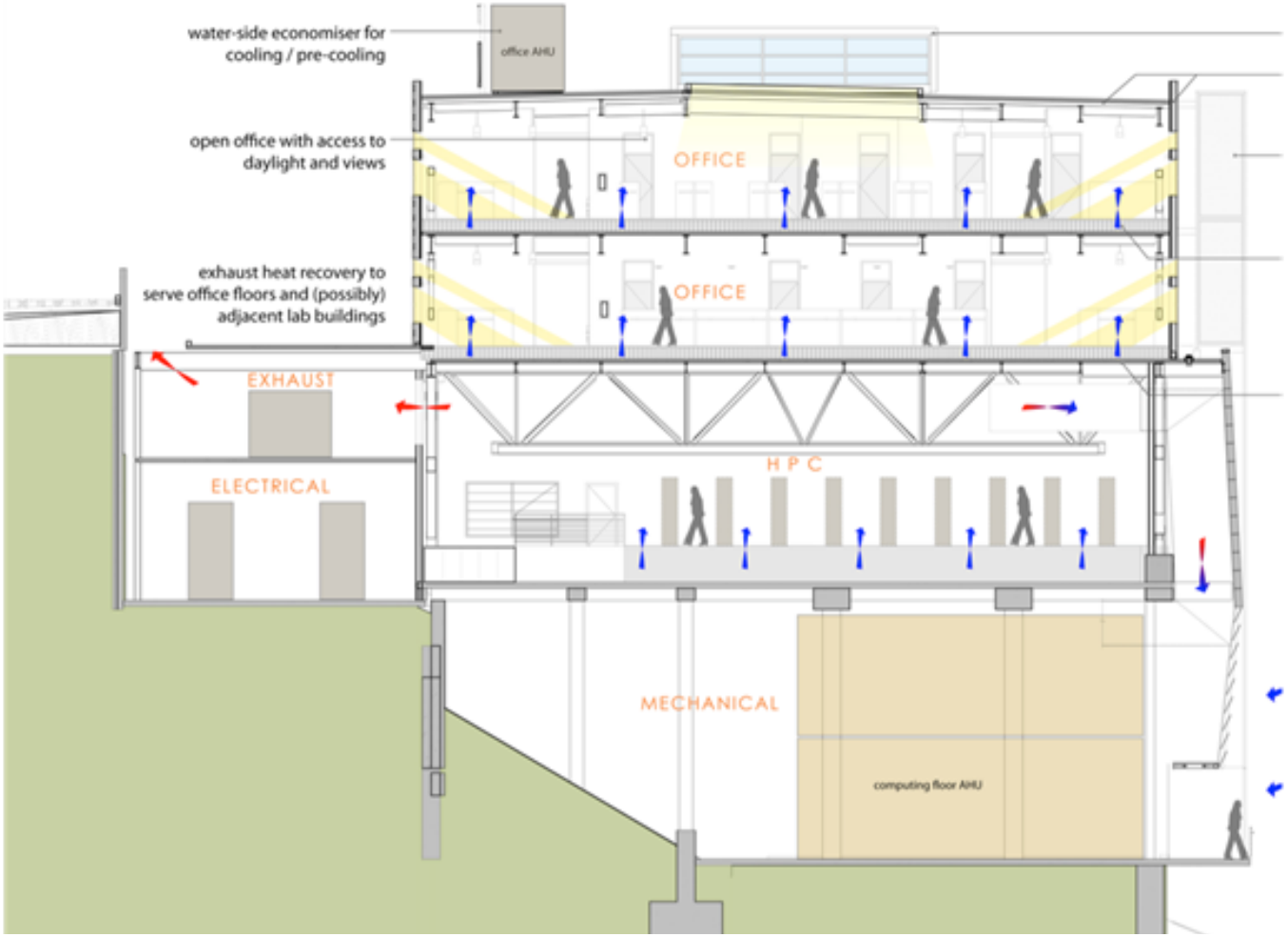
~~Can there be too much data?~~

- Actually more about; Do you know your facility?
  - The facilities people are responsible for that and they keep it going, as long as they do their job, I can do mine.
  - Yes we work closely with facilities to make sure they know what our challenges are and we know what their challenges are.
- I believe the answer is yes. NERSC may be the extreme but I hope that it will convince you to consider facilities as important as any other computing resource.

Shyh Wang Hall completed June 2015

- **Four story, 150,000 GSF**
  - Two 28Ksf office floors, 300 offices
  - 20K -> 28Ksf HPC floor
  - 500 lbs/sf
  - Mechanical floor
- **42MW to building**
  - 12.5MW initially provisioned
  - WAPA power
- **Energy efficient**
  - LEED Gold
  - PUE < 1.1
  - **Year-round free air and water cooling**

CRT Cross Section



Air Cooling

- **Air cooling**
  - Intakes outside air, optionally cooled with tower water or heated with system exhaust
  - No chillers
  - Computer room exhaust heat used to heat office floors
  - Hot aisle containment “chimneys”
- **Specs**
  - Supply **<75˚F (23.9C)** air year round, <70˚F (21.1C) for 85% of year
  - 30% to 70% RH, but can change quickly
  - (3+1) x Air handling units
    - 0.5MW, 60K CFM each
    - Space for 30!

Water Cooling

- **Cooling towers**
  - (3+1) x 3.375MW cooling towers, with expansion to 7
  - Cooling towers operate every day
- **74°F water to racks and AHUs**
  - 65°F (18.3C) water for 92% of the year
  - 65-70°F (18.3-21.1C) water for 5-6% of the year
  - **70-74°F (21.1-23.3C) water for 2-3% of the year (10 days)**
- **Water Consumption**
  - At 7.5MW 18M gallons/year (68.1M liters)
  - At 17MW 40M gallons/year (151.4M liters)

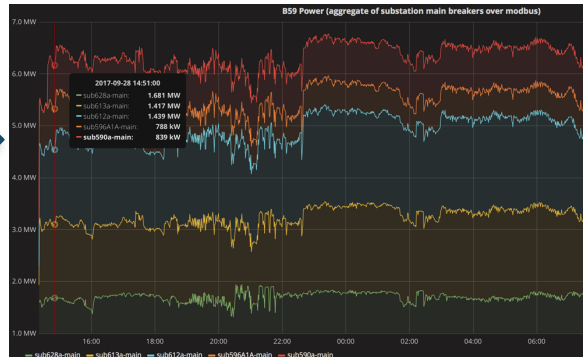
Data Collection System

- **Current Data Sources**
  - Substations, panels, PDUs, UPS
  - Cori & Edison SEDC
  - Onewire Temp & RH sensors
  - BMS through BACNET
  - Indoor Particle counters
  - Weather station

- **Future Data Sources**
  - Syslog
  - Job Data
  - Lustre + GFPS statistics
  - LDMS
  - Outdoor particle counters
  - ???

- **Rabbit MQ, Elastic, Linux**
  - Collects ~20K data items per second
  - Over 40TB data online (100TB capacity)
  - **45 days of SEDC (versus 3 hours on SMW)**
  - **180 days of BMS data (6X more than BMS)**
  - 260 days of power data

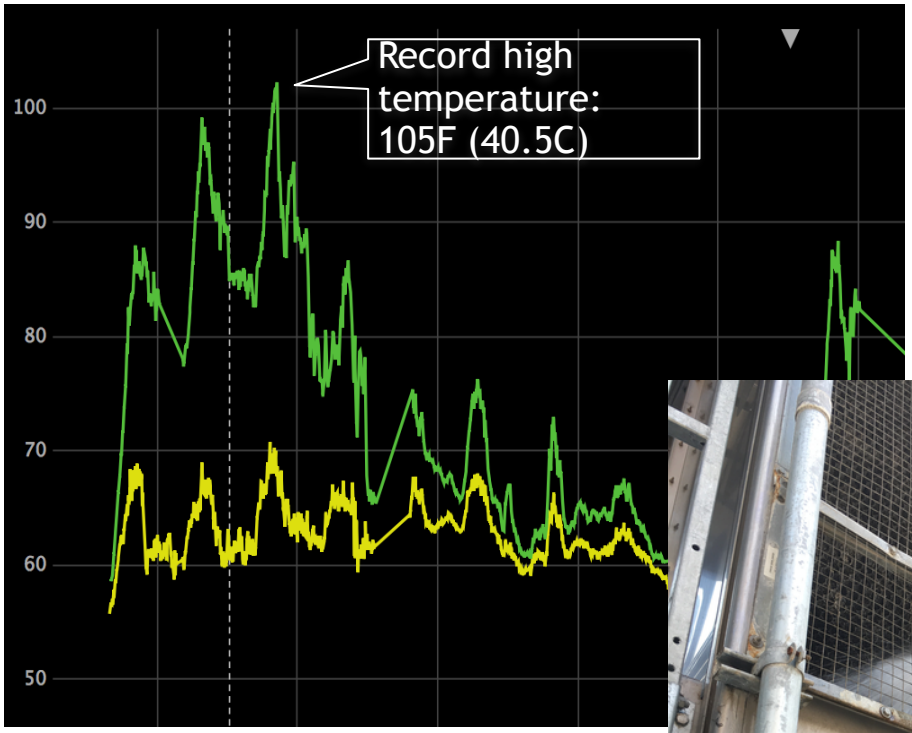
Kibana, Grafana



One? Hot Day

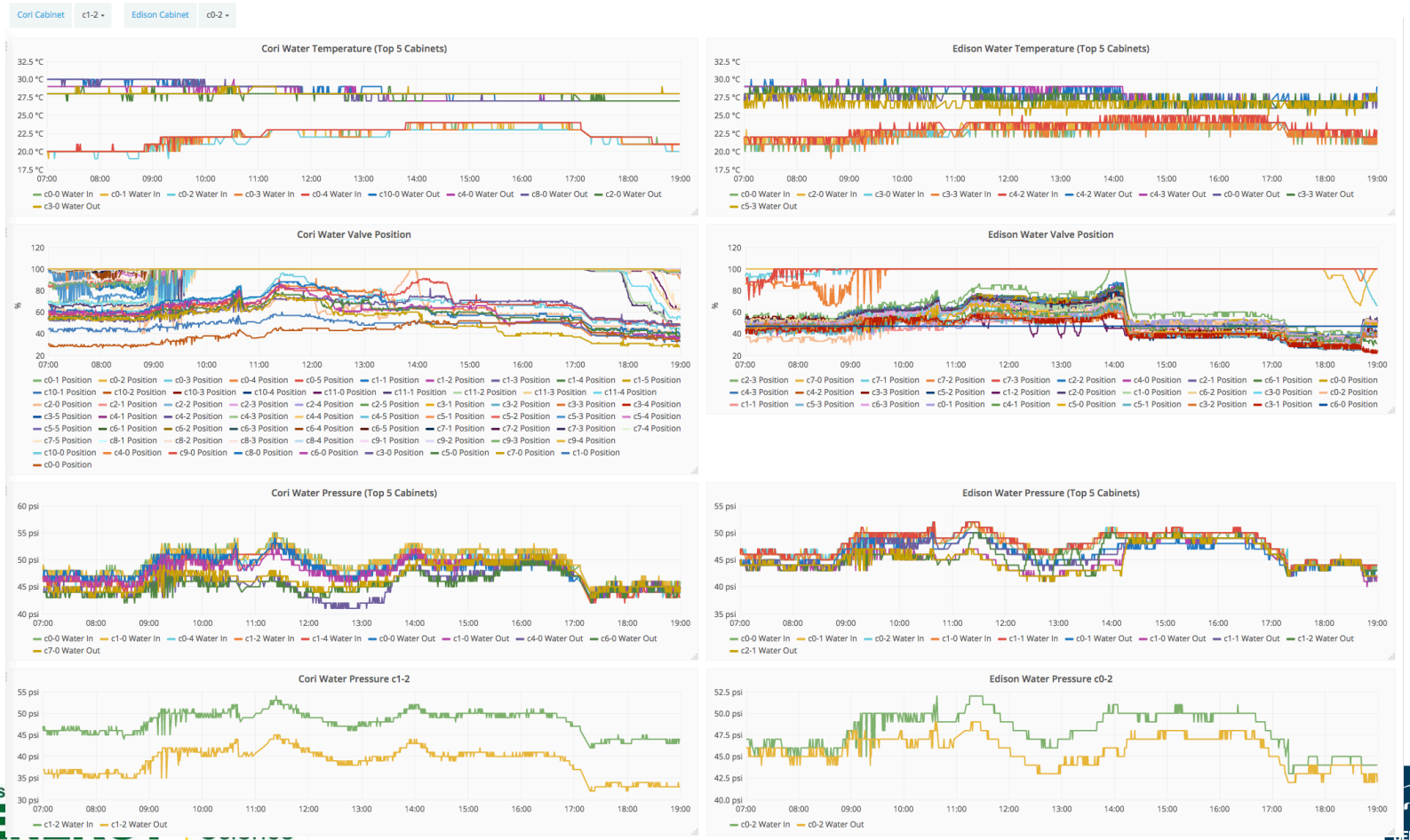
- Day 1
  - What do we think we need?
- Day 2
  - What did we use? Now need?
- Day 3
  - What did we use now? Do we know what we need?
- Next Weekend
  - Throw everything out the window?

Day 1 (Record High Temperature)

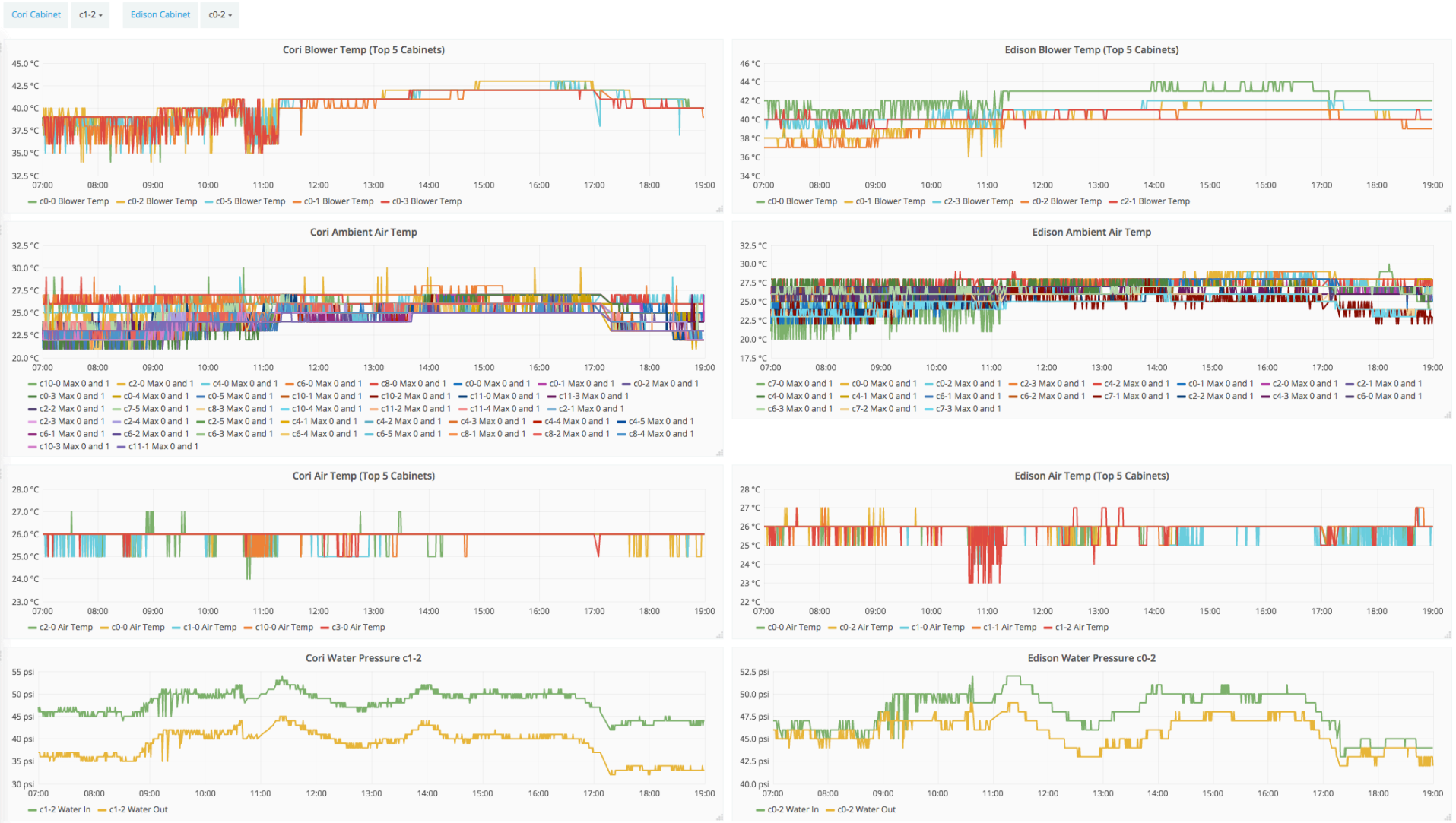


Day 1 into Day 2 (Watch supply water temp)

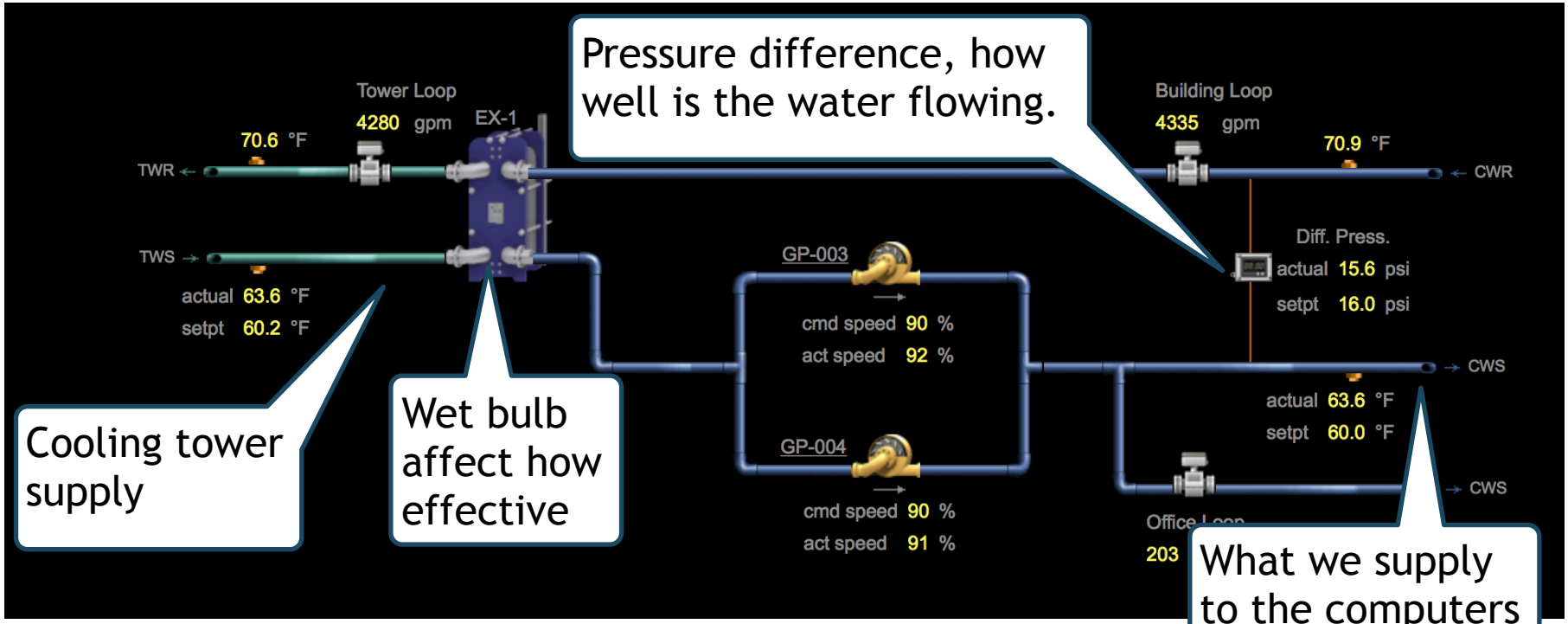
- Cray's did well under watch; physical and general dashboards of data.



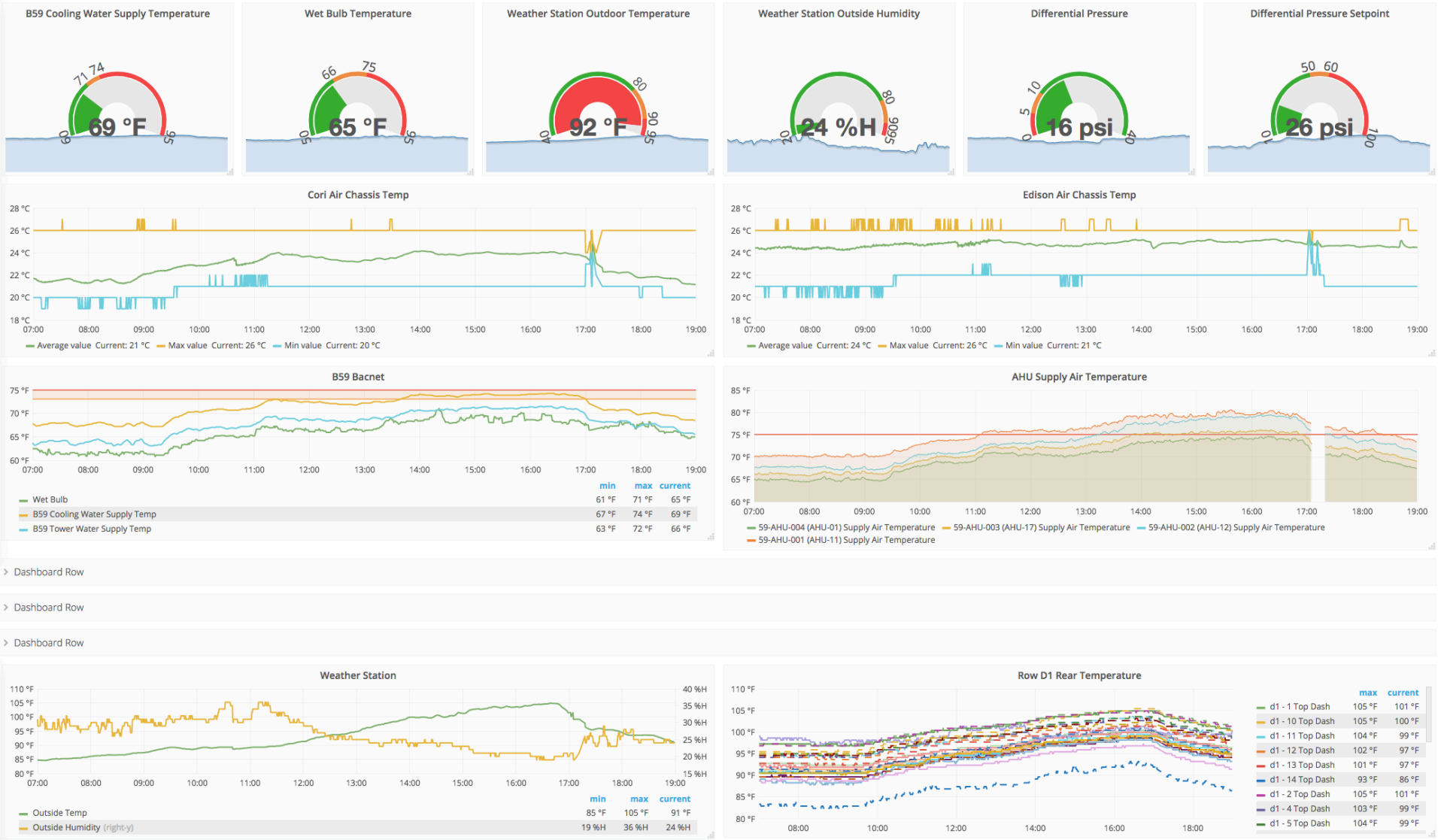
Day 2 to Day 3 (It's the cabinet air!)



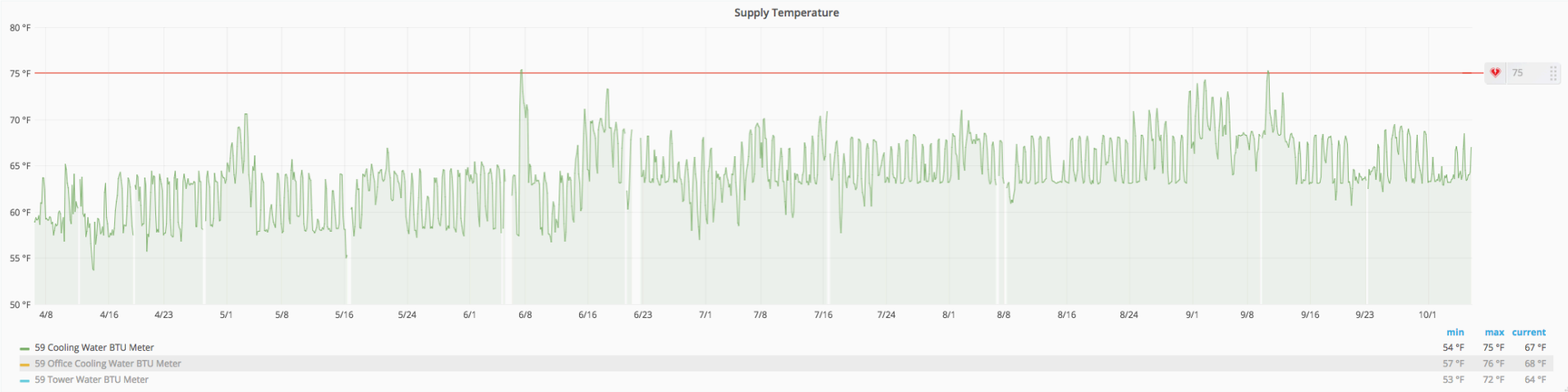
What Does the Facilities Look Like?



Following Weekend

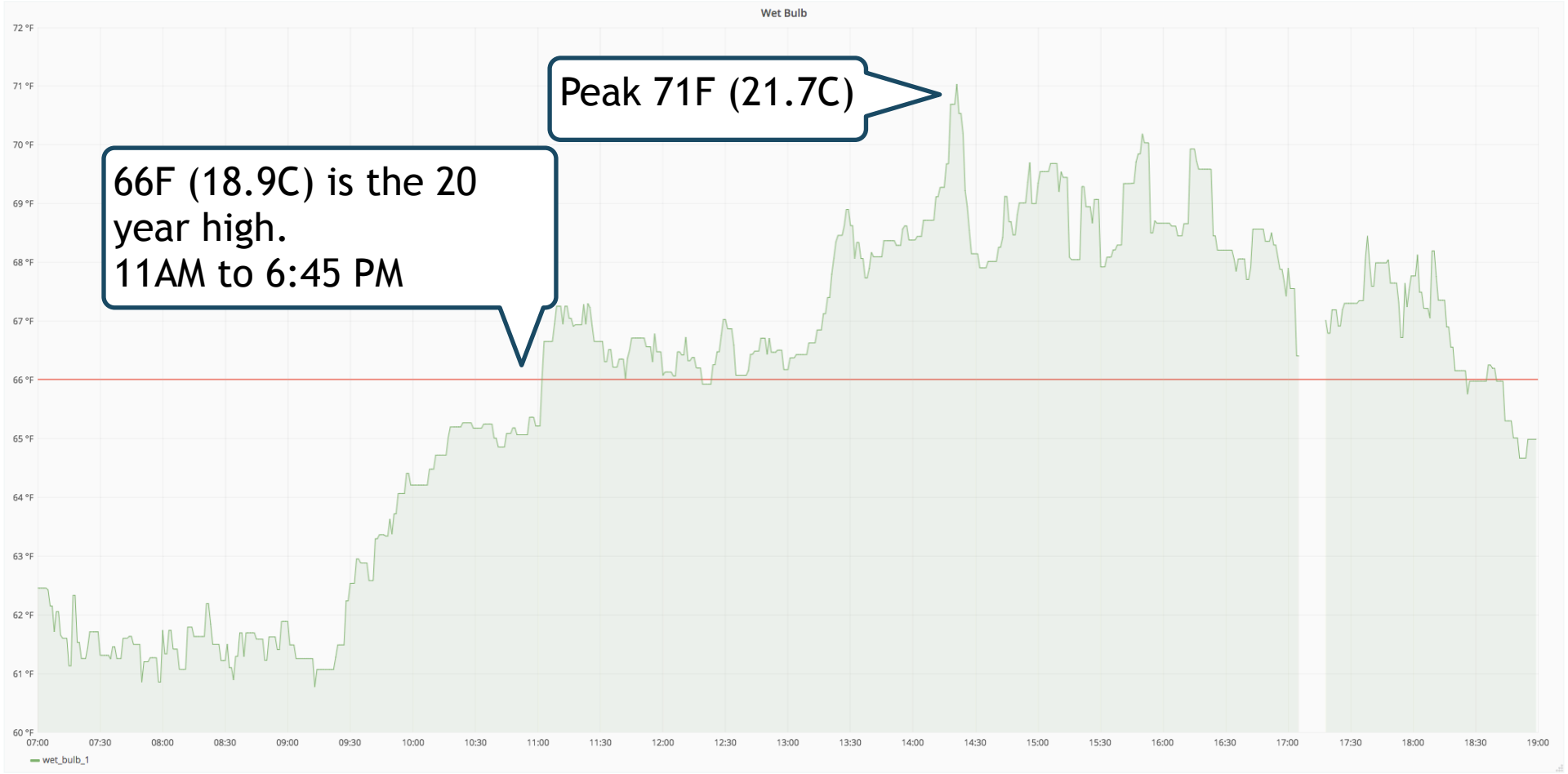


Water Supply 75F (23.9C) is critical

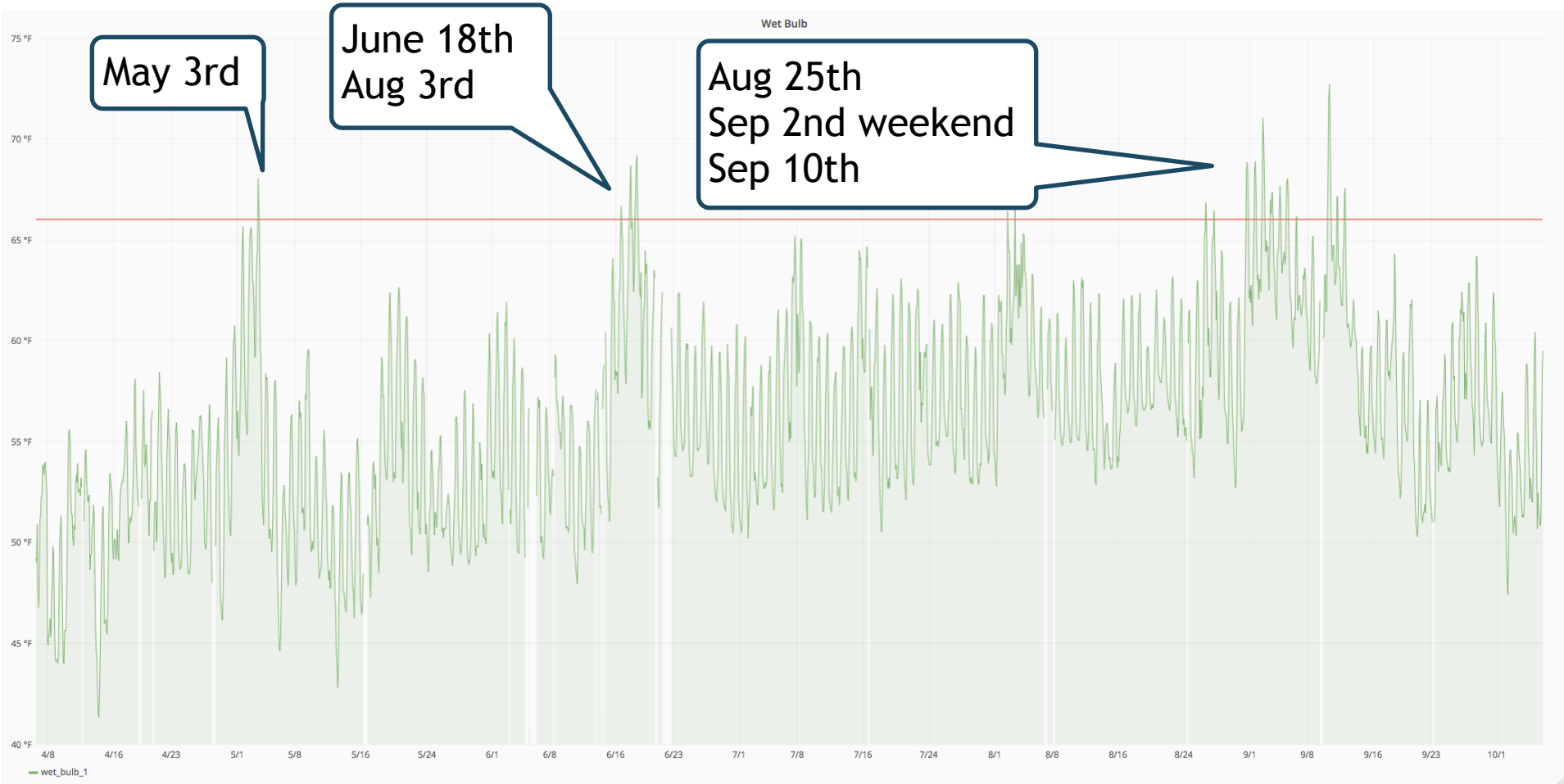


Why is this critical? This along with wet bulb determines how much cooling we can get from the water.

Issues: Wet bulb



Wet Bulb: Was there other times?



Lesson: Need to start watching data. Or center can handle higher wet bulb.

Lessons

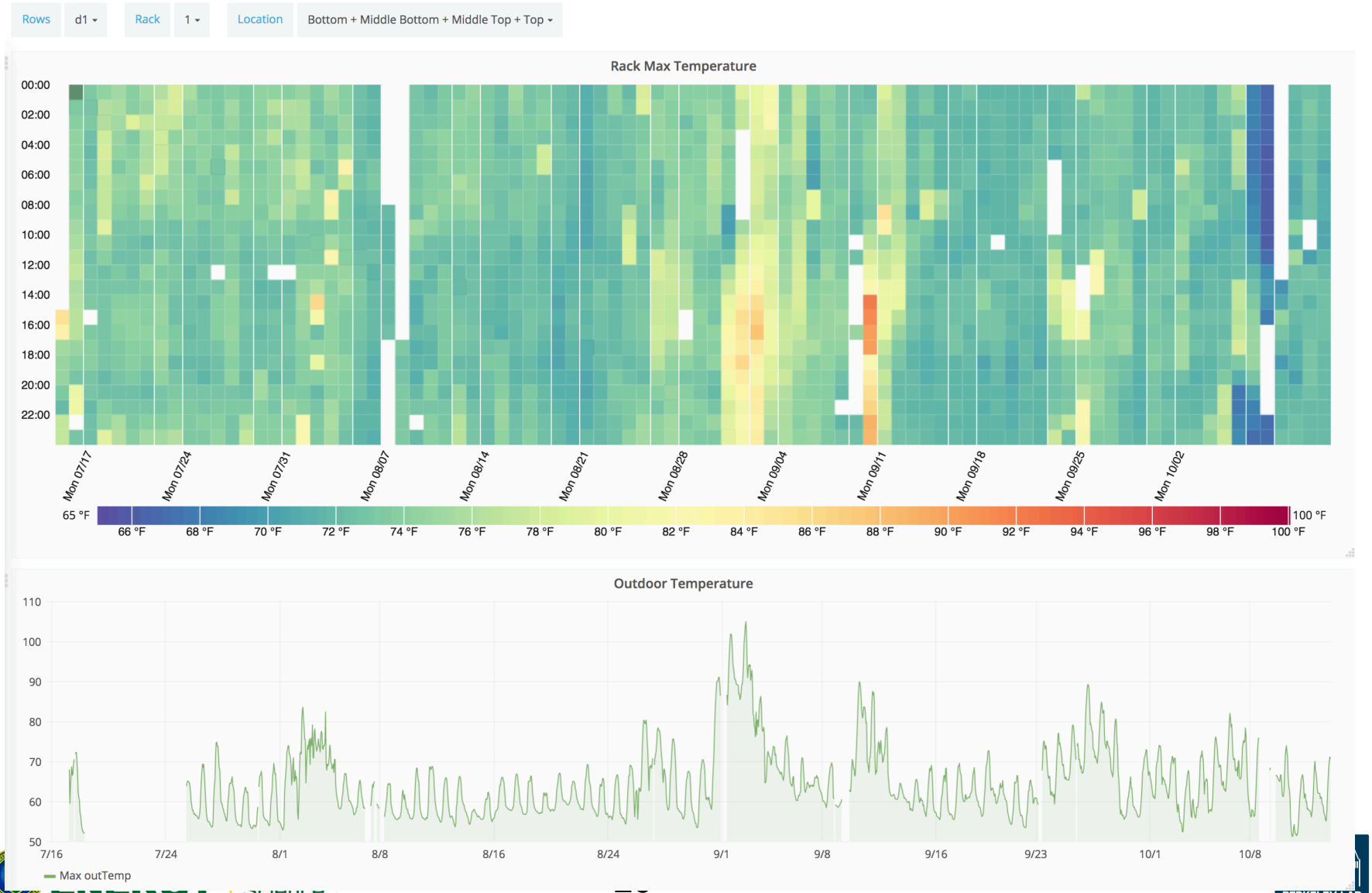
- Don’t be afraid to change data requirements.
- Visualization can be tough, sometimes working through a situation can give one insight into how data should be displayed.
- The physical plant can be as complex as the compute job environment and can require many of the same skills to manage.
- The physical system may be more resilient then expected.
- Don’t become too focused on any single system.

Hot Aisle Containment

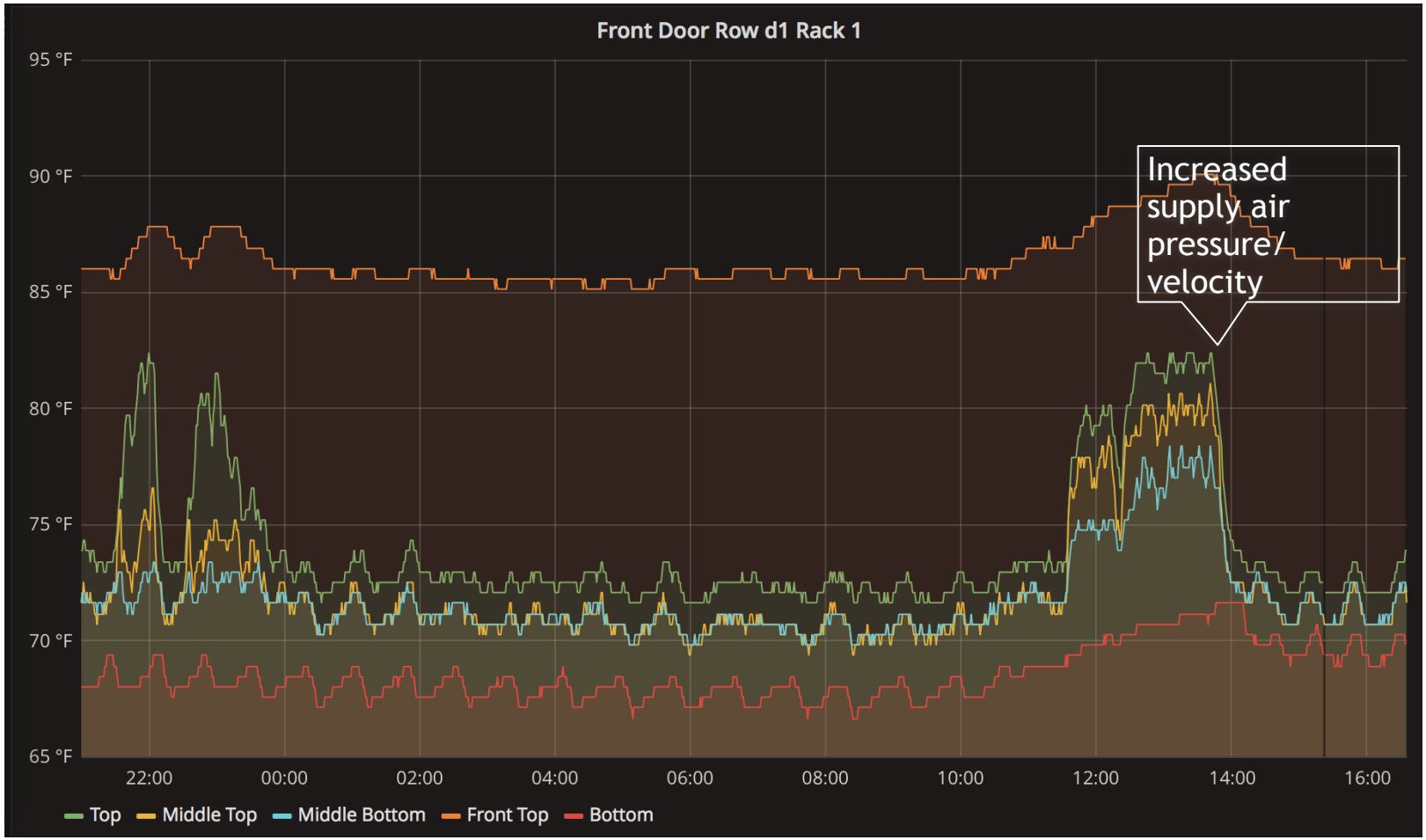
- Installing new containment system
- Drives hot air to ceiling.
- Exhaust fans suck hot air out of the building, or recirculate to temper incoming air
- Panelized system allows full access to run cables inside

What about the racks?

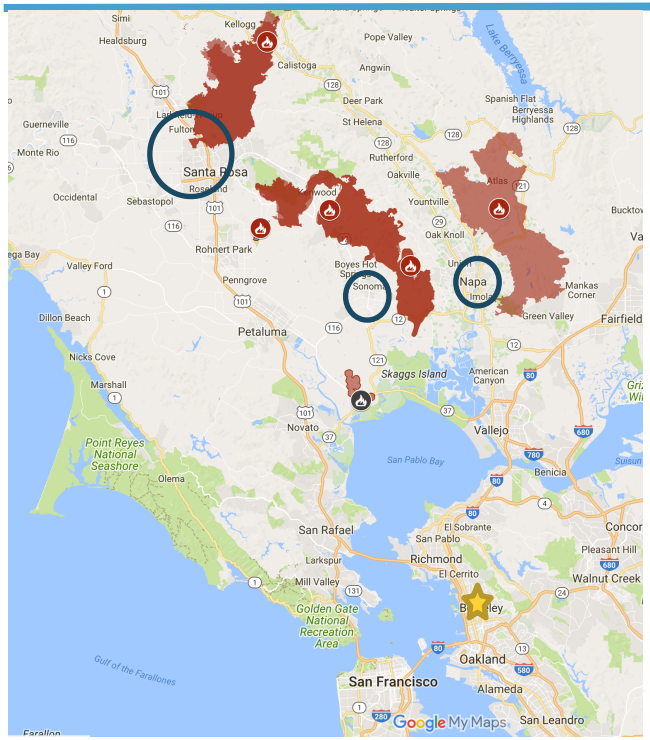
What happened in other parts of the floor?

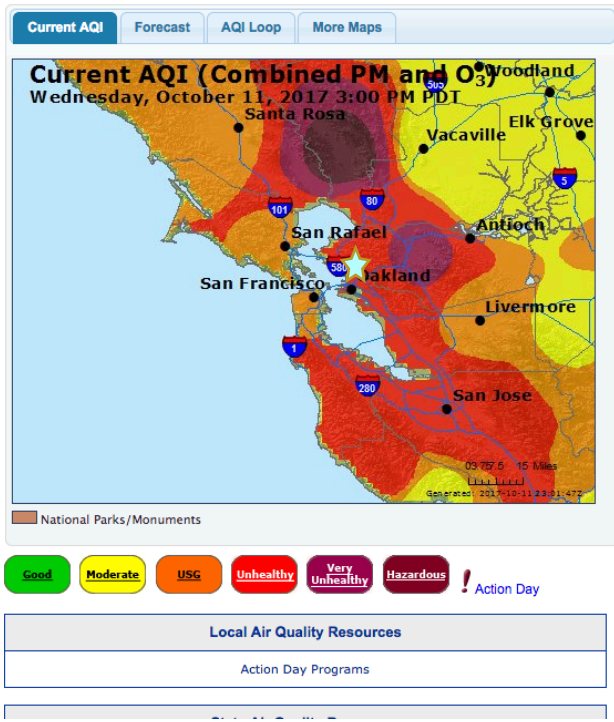


Rack Air temperature responds to supply air pressure/ velocity



Air Quality (Wine Country Fire)





Current Conditions

Air Quality Index (AQI)
observed at 15:00 PDT

184 **Unhealthy**

Health Message: People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.

Note: Values above 500 are considered Beyond the AQI. Follow recommendations for the Hazardous category. Additional information on reducing exposure to extremely high levels of particle pollution is available here.

AQI - Pollutant Details

Ozone	35	Good
Particles (PM2.5)	184	Unhealthy

Air Quality Forecast

Today	Tomorrow
Air Quality Index (AQI)	Air Quality Index (AQI)
137 Unhealthy for Sensitive Groups	137 Unhealthy for Sensitive Groups
Health Message: People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.	**Health Message:** People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.

AQI - Pollutant Details

Today		Tomorrow	
Particles (PM2.5)	137 Unhealthy for Sensitive Groups	Particles (PM2.5)	180 Unhealthy

O_3 (ppb)	O_3 (ppb)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2 (ppb)	NO_2 (ppb)	AQI	AQI
C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	C_{low} - C_{high} (avg)	I_{low} - I_{high}	Category
0-54 (8-hr)	-	0.0-12.0 (24-hr)	0-54 (24-hr)	0.0-4.4 (8-hr)	0-35 (1-hr)	0-53 (1-hr)	0-50	Good
55-70 (8-hr)	-	12.1-35.4 (24-hr)	55-154 (24-hr)	4.5-9.4 (8-hr)	36-75 (1-hr)	54-100 (1-hr)	51-100	Moderate
71-85 (8-hr)	125-164 (1-hr)	35.5-55.4 (24-hr)	155-254 (24-hr)	9.5-12.4 (8-hr)	76-185 (1-hr)	101-360 (1-hr)	101-150	Unhealthy for Sensitive Groups
86-105 (8-hr)	165-204 (1-hr)	55.5-150.4 (24-hr)	255-354 (24-hr)	12.5-15.4 (8-hr)	186-304 (1-hr)	361-649 (1-hr)	151-200	Unhealthy
106-200 (8-hr)	205-404 (1-hr)	150.5-250.4 (24-hr)	355-424 (24-hr)	15.5-30.4 (8-hr)	305-604 (24-hr)	650-1249 (1-hr)	201-300	Very Unhealthy
-	405-504 (1-hr)	250.5-350.4 (24-hr)	425-504 (24-hr)	30.5-40.4 (8-hr)	605-804 (24-hr)	1250-1649 (1-hr)	301-400	Hazardous
-	505-604 (1-hr)	350.5-500.4 (24-hr)	505-604 (24-hr)	40.5-50.4 (8-hr)	805-1004 (24-hr)	1650-2049 (1-hr)	401-500	

Data Center Abatement

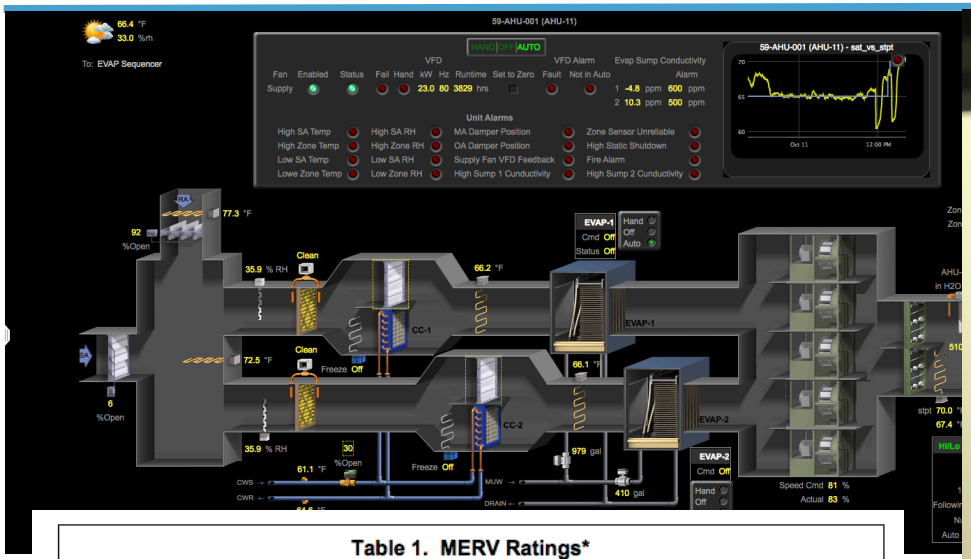


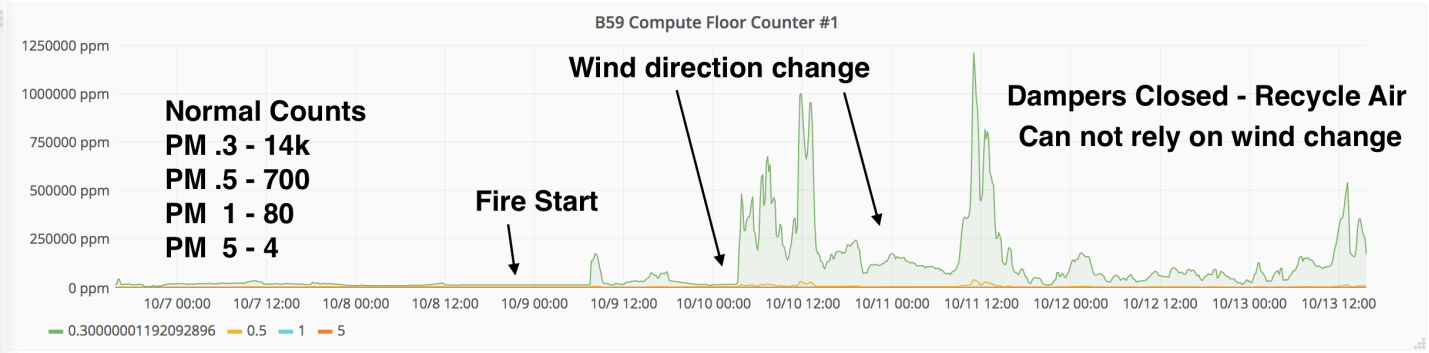
Table 1. MERV Ratings*

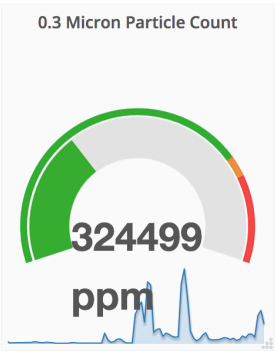
MERV Rating	Average Particle Size Efficiency (PSE), microns – % Removal			Typical Controlled Contaminant or Material Sources (ASHRAE 52.2)	Typical Building Applications
	0.3-1.0	1.0-3.0	3.0-10.0		
1-4			<20%	**> 10 Microns** Textile Fibers Dust Mites, Dust, Pollen	Window AC units Common Residential Minimal Filtration
5			20-35	**3.0 to 10.0 Microns** Cement Dust, Mold Spores, Dusting Aids	Industrial Workplace Better Residential Commercial
8			>70		
9		<50	>85	**1.0 to 3.0 Microns** Legionella, Some Auto Emissions, Humidifier Dust	Hospital Laboratories Better Commercial Superior Residential
12		>80	>90		
13	<75	>90	>90	**0.3 to 1.0 Microns** Bacteria, Droplet Nuclei (sneeze), Most Tobacco Smoke, Insecticide Dust	Superior Commercial Smoking Lounge Hospital Care General Surgery
16	>95	>95	>90		
17**	≥ 99.97			**<0.3 Microns (HEPA/ULPA filters)** Viruses, Carbon Dust, Fine Combustion Smoke	Clean Rooms Carcinogenic & Radioactive Matls., Orthopedic Surgery
18**	≥ 99.99				
19, 20**	≥ 99.999				

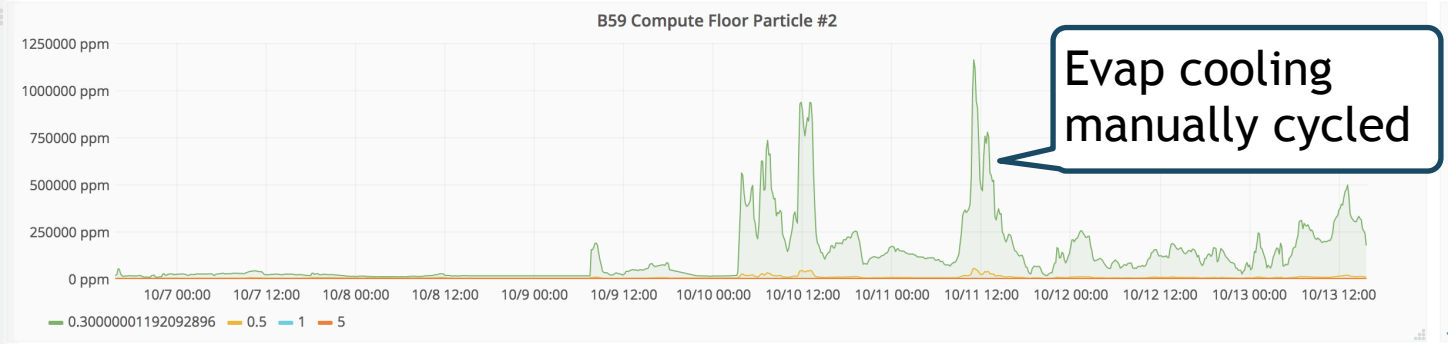
* Adapted from EPA 2009; originally from ANSI/ASHRAE Standard 52.2-2007. Not all levels are shown.

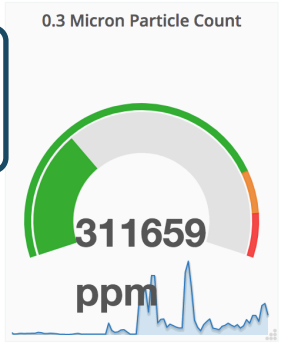
** Not part of the official ASHRAE Standard 52.2 test, but added by ASHRAE for comparison purposes.

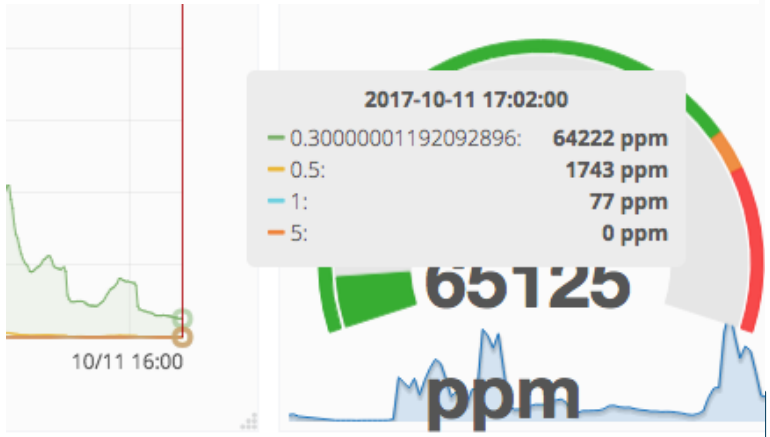
In Room Particle Count







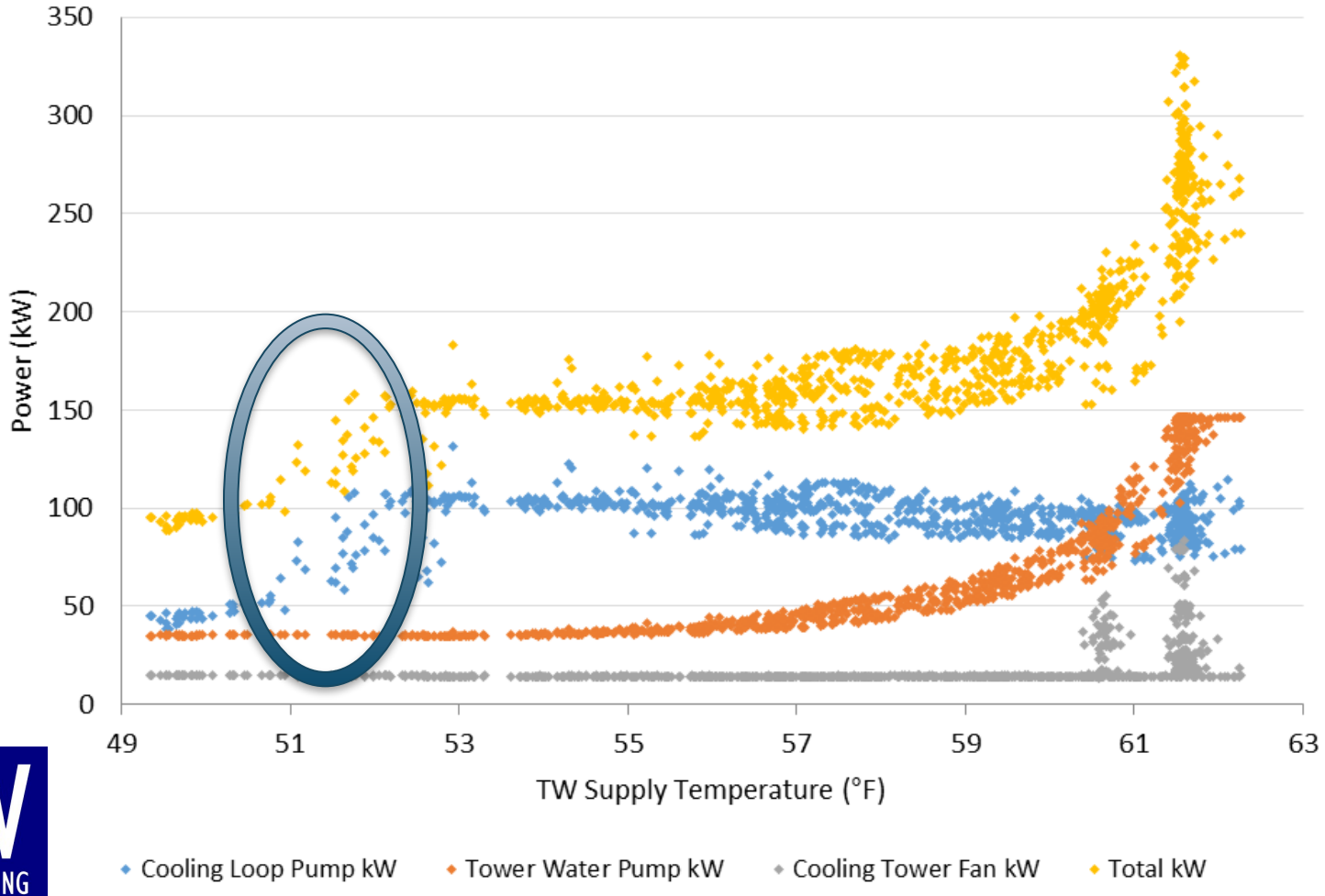




Lessons

- Need more data. Even though we do not want to experience this again, a particle counters located outside of the filtered area would help gauge the situation
  - We had planned for this and an extra sensor arrived Friday before I left.
- Knowledge of how the building and cooling systems worked is important.
- Can the BMS (Building Management System) be programmed to handle situations of high particle counts?

Liquid Cooling Performance Baseline



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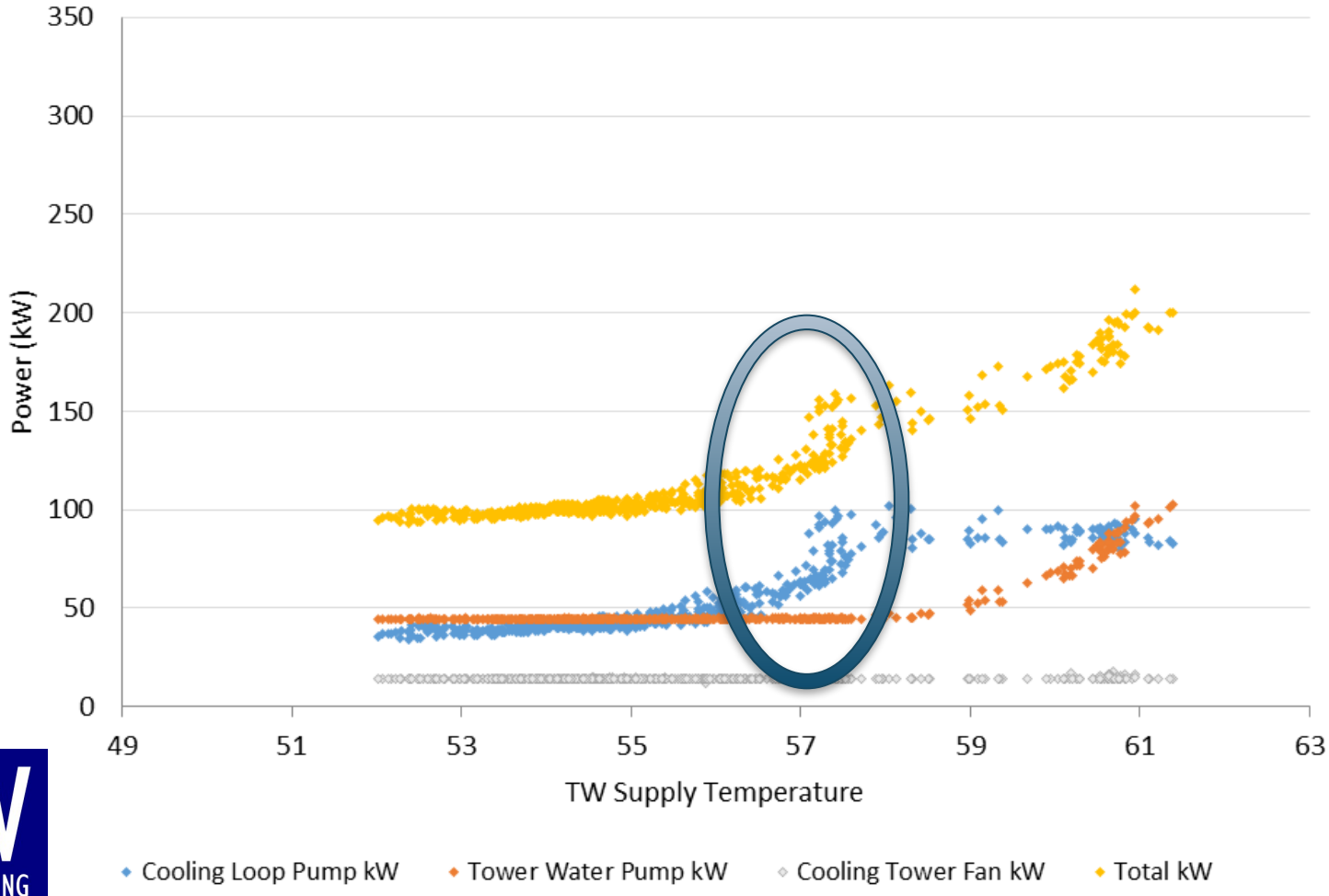
Liquid Cooling Performance Balanced



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NERSC Optimization Project

- **Have saved 700,000 kWh/year**
  - Energy saving tradeoff:
    - Reducing water temperature by increasing CT fan speed saves pump energy by reducing cooling water demand
  - Used energy saving Eaton UPS mode
    - Dual conversion to sub-cycle online
- **In progress: ~540,000 kWh/year**
  - Installation of booster pump for roof-top HVAC reduces allows main pumps to run at lower speeds
  - Optimization of supply air fan speed
- **Under investigation: ~600,000 kWh/year**
  - Cray fan speed optimization
  - Adjust bypass valves to minimize pump energy

What if we did not have the data collect?

- Would not have been able to see that 75F (23.9C) water temperature was as critical as expected.
- Historic web bulb also not as critical.
- Particle sensors actually showed effectiveness of filters/evap cooling in outside air design.
- Amount of data providing real dollar savings for the center.
- Why? The data collect is more than just the computers, it is the whole center.

National Energy Research Scientific Computing Center