Chris Steller

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Sent: Tuesday, March 27, 2018 4:02 PM
To: Chris Steller
Subject: Mandated Report - Military Affairs (PN 14122)
Attachments: Investment Grade Audit Report.pdf

The attached Investment Grade Audit Report is submitted as required by MN Stat 16C.08. This IGA Report was conducted on specific buildings at Camp Ripley, Little Falls, Minnesota.

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The engineer of record attests solely to the accuracy and soundness of the engineering calculations included in this report. All results are based upon data provided by the Customer as well as field survey information. No guarantee of energy savings or the survey data is made or implied.

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CONTACT INFORMATION

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SUMMARY TABLE OF RECOMMENDED ENERGY CONSERVATION MEASURES (ECM)

Minnesota Department of Military Affairs (DMA) and Camp Ripley desires to utilize performance contracting in a focused manner, focusing specifically on capital intensive HVAC equipment that has reached the end of useful service. The addition of lighting improvements and other savings generating measures provides significant savings to offset the costs of expensive equipment and provide improvements that will result in on-going energy savings. There is urgency in replacing particular equipment that is failing or likely to fail in the immediate or short term. Failure of this equipment would have a negative impact on the core functions of the National Guard. It is understood that the ESCOs approach for this project is at the behest of the customer, Minnesota Department of Military Affairs (DMA) and Camp Ripley.

Table 1 below summarizes the final scope selected by the National Guard with associated cost, sell price and estimated utility savings.

Table 1: Proposed Project Summary

	Sell Price	Electrical Consumption Savings, kWh	Electrical Consumption Cost Savings, $ kWh	Natural Gas Consumption Savings, Therms	Natural Gas Consumption Cost Savings, $ Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating	$2,438,782	4,956	$309	10,173	$5,979	$6,288	$17,761	$24,049	101	15-25
ECM 4.2A: Condensing Boiler Replacement	$763,068	-318	($20)	2,966	$1,675	$1,655	$849	$2,505	305	25
ECM 4.2B: RTU, and/or ACCU Replacement	$197,343	1,050	$65	0	$0	$65	$517	$582	339	15
ECM 3.5: Install De-stratification Fans in High Bay Spaces	$59,962	-1,806	($112)	1,041	$588	$475	$0	$475	126	25
ECM 3.2A: BAS: Base Controls Recommissioning and Upgrades	$1,652,310	230,064	$14,325	106,716	$60,267	$74,592	$65,174	$139,766	12	*15
ECM 3.2B: BAS: Complete Pneumatic Removal	$238,303	88,936	$5,538	17,119	$9,668	$15,205	$9,741	$24,946	10	15
ECM 3.3: BAS: Alternate Install Standalone Programmable Thermostat	$104,574	7,803	$486	19,800	$11,182	$11,667	$0	$11,667	9	15
ECM 5.1: Replace Interior Lighting	$2,074,115	874,379	$68,675	0	$0	$68,675	$21,739	$90,415	23	10
ECM 5.4: Replace Exterior Lighting	$803,509	541,491	$42,530	0	$0	$42,530	$8,153	$50,683	16	10
ECM 6.1: Building Envelope Improvements	$779,821	4,933	$307	69,971	$39,515	$39,822	$0	$39,822	20	10
FIM Types Total	$9,111,787	1,751,487	$132,102	227,785	$128,874	$260,976	$123,934	$384,910	24	-

Table 2 summarizes estimated utility savings in units and cost, and compares it to baseline data. The baseline data shown in Table 2 represents the total utility consumption as stated in the B3 data repository. For baseline details and explanation see the *Summary of Annual Energy Use and Cost of Base Year Condition* section within this document.

Table 2: Baseline and Savings Comparison

			Units	Total $
Energy				
	Electric Consumption			
		Baseline	7,619,278 kWh	$580,269
		Annual Savings	1,751,487 kWh	$132,102
		Post-Retrofit	5,867,791 kWh	$448,166
		% Savings	23.0%	22.8%
	Natural Gas			
		Baseline	697,985 Therms	$382,217
		Annual Savings	227,785 Therms	$128,874
		Post-Retrofit	470,200 Therms	$253,343
		% Savings	32.6%	33.7%
Total Annual Utility				
	Baseline		$ 962,485	
	Annual Savings		$ 260,976	
	Post-Retrofit		$ 701,509	
	% Savings		27.1%	

SUMMARY OF ANNUAL ENERGY USE AND COST OF BASE YEAR CONDITION

UTILITY RATES

The rates in Table 3 were calculated from utility consumption and cost data provided by the utility providers for the base. There exist only one natural gas and one electric meter monitored by utility providers, as such the rates stated in Table 3 are utilized to represent energy savings as cost for all Energy Conservation Measures (ECMs).

Table 3: Base Utility Rates

Utility	Cost per unit	Unit	Source
Electric (Consumption)	$0.0604	kWh	Minnesota Power: Consumption and cost for the 2015 year

Electric (Blended)	$0.0762	kWh	Minnesota Power: Consumption and cost for the 2015 year
Electric (Uniform Demand)	$7.29	kW	Minnesota Power: Consumption and cost for the 2015 year
Natural Gas	$0.55	Therm	Minnesota Energy Resources: Consumption and Cost for the 2014 year

ELECTRIC

The base is served by a single account, Table 4 below list details for this account.

Table 4: Electrical Account Details for Camp Ripley

Electric Account	Name & Address for Account
EMP329646	Camp Ripley - 15000 Highway 115, Little Falls, MN 56345-4173

Table 5 shows an annual summary for electrical utility consumption and cost for Camp Ripley.

Table 5: Annual Electrical Utility Data Summary for Camp Ripley

Start Date	End Date	Days	Usage (kWh)	Measured Electrical Demand, kW	Billed Electrical Demand, kW	Electrical Demand Cost, $ kW	Electrical Consumption Cost, $ kWh	Total Electrical Utility, $
12/31/2014	9/30/2015	273	12,486,000	26,994	27,000	$197,055	$753,853	$950,908
12/31/2013	12/31/2015	365	15,072,000	32,034	32,038	$232,827	$906,305	$1,139,132
12/31/2012	12/31/2013	365	14,988,000	31,689	32,035	$232,804	$818,288	$1,051,092

Table 6 shows the monthly electrical demand, consumption and cost data for Camp Ripley.

Table 6: Monthly Electrical Utility Data for Camp Ripley

Start Date	End Date	Days	Usage (kWh)	Measured Electrical Demand, kW	Billed Electrical Demand, kW	Electrical Demand Cost, $ kW	Electrical Consumption Cost, $ kWh	Total Electrical Utility, $
8/31/2015	9/30/2015	30	1,224,000	2,824	2,825	$ 20,574	$ 81,365	$ 101,939
7/31/2015	8/31/2015	31	1,392,000	3,259	3,259	$ 23,850	$ 88,343	$ 112,194
6/30/2015	7/31/2015	31	1,434,000	3,072	3,072	$ 22,439	$ 90,148	$ 112,587
5/31/2015	6/30/2015	30	1,296,000	2,894	2,894	$ 21,095	$ 81,629	$ 102,723
4/30/2015	5/31/2015	31	1,248,000	2,501	2,506	$ 18,165	$ 72,752	$ 90,917
3/31/2015	4/30/2015	30	1,296,000	2,765	2,765	$ 20,121	$ 76,276	$ 96,397
2/28/2015	3/31/2015	31	1,440,000	3,067	3,067	$ 22,401	$ 85,010	$ 107,411
1/31/2015	2/28/2015	28	1,566,000	3,341	3,341	$ 24,470	$ 87,500	$ 111,970
12/31/2014	1/31/2015	31	1,590,000	3,271	3,271	$ 23,941	$ 90,829	$ 114,770
11/30/2014	12/31/2014	31	1,392,000	2,914	2,914	$ 21,246	$ 82,678	$ 103,924
10/31/2014	11/30/2014	30	1,278,000	2,894	2,894	$ 21,095	$ 75,920	$ 97,014
9/30/2014	10/31/2014	31	1,110,000	2,278	2,278	$ 16,444	$ 65,595	$ 82,039
8/31/2014	9/30/2014	30	1,026,000	2,206	2,210	$ 15,931	$ 61,032	$ 76,962
7/31/2014	8/31/2014	31	1,254,000	2,734	2,734	$ 19,887	$ 74,427	$ 94,314
6/30/2014	7/31/2014	31	1,158,000	2,650	2,650	$ 19,253	$ 70,258	$ 89,511
5/31/2014	6/30/2014	30	1,272,000	2,707	2,707	$ 19,683	$ 78,332	$ 98,015
4/30/2014	5/31/2014	31	1,188,000	2,549	2,549	$ 18,490	$ 72,328	$ 90,818
3/31/2014	4/30/2014	30	1,164,000	2,585	2,585	$ 18,762	$ 71,169	$ 89,931
2/28/2014	3/31/2014	31	1,386,000	2,743	2,743	$ 19,955	$ 84,743	$ 104,697
1/31/2014	2/28/2014	28	1,326,000	2,827	2,827	$ 20,589	$ 80,319	$ 100,907
12/31/2013	1/31/2014	31	1,518,000	2,947	2,947	$ 21,495	$ 89,504	$ 110,999
11/30/2013	12/31/2013	31	1,392,000	2,659	2,659	$ 19,320	$ 82,075	$ 101,396
10/31/2013	11/30/2013	30	1,170,000	2,424	2,424	$ 17,546	$ 64,598	$ 82,144
9/30/2013	10/31/2013	31	1,044,000	2,302	2,363	$ 17,086	$ 58,231	$ 75,317
8/31/2013	9/30/2013	30	1,098,000	2,630	2,630	$ 19,102	$ 59,519	$ 78,621
7/31/2013	8/31/2013	31	1,314,000	2,705	2,705	$ 19,668	$ 70,203	$ 89,871
6/30/2013	7/31/2013	31	1,314,000	3,151	3,151	$ 23,035	$ 70,229	$ 93,264
5/31/2013	6/30/2013	30	1,272,000	2,875	2,875	$ 20,951	$ 69,447	$ 90,399
4/30/2013	5/31/2013	31	1,182,000	2,354	2,522	$ 18,286	$ 63,742	$ 82,028
3/31/2013	4/30/2013	30	1,236,000	2,465	2,522	$ 18,286	$ 64,960	$ 83,247
2/28/2013	3/31/2013	31	1,284,000	2,462	2,522	$ 18,286	$ 69,204	$ 87,490
1/31/2013	2/28/2013	28	1,260,000	2,782	2,782	$ 20,249	$ 69,081	$ 89,331
12/31/2012	1/31/2013	31	1,422,000	2,880	2,880	$ 20,989	$ 76,997	$ 97,986

NATURAL GAS

Camp Ripley has one main account for natural gas consumption as well as transportation of Natural Gas. Table 4 below list details for this account.

Table 7: Natural Gas Account Details for Camp Ripley

Natural Gas Account	Name & Address for Account
4078591-7	Camp Ripley - 15000 Highway 115, Little Falls, MN 56345-4173

Table 8 shows annual natural gas consumption and cost provided for Camp Ripley.

Table 8: Annual Natural Gas Data for Camp Ripley

Start Date	End Date	Days	Billed Natural Gas Consumption, Therms	Natural Gas Consumption Cost, $ Therm
12/31/2014	9/30/2015	273	726,420	$367,854.42
12/31/2013	12/31/2014	365	1,272,352	$727,741.72
12/31/2012	12/31/2013	-365	1,173,575	-$486,799.08

Table 9 shows the monthly consumption and billing data for Camp Ripley.

Table 9: Monthly Natural Gas Data for Camp Ripley

Previous Date	Present Date	Days	Billed Natural Gas Consumption, Therms	Natural Gas Consumption Cost, $ Therms
8/31/2015	9/30/2015	30	12,645	$5,598.19
7/31/2015	8/31/2015	31	12,651	$5,496.99
6/30/2015	7/31/2015	31	13,492	$5,729.51
5/31/2015	6/30/2015	30	16,411	$7,141.57
4/30/2015	5/31/2015	31	38,672	$16,159.87
3/31/2015	4/30/2015	30	79,744	$36,725.30
2/28/2015	3/31/2015	31	127,452	$69,333.89
1/31/2015	2/28/2015	28	216,114	$107,317.89
12/31/2014	1/31/2015	31	209,239	$114,351.21
11/30/2014	12/31/2014	31	171,691	$104,906.82
10/31/2014	11/30/2014	30	166,393	$98,038.47
9/30/2014	10/31/2014	31	74,149	$38,883.24
8/31/2014	9/30/2014	30	16,160	$7,894.39
7/31/2014	8/31/2014	31	11,844	$5,128.72
6/30/2014	7/31/2014	31	11,042	$5,961.93
5/31/2014	6/30/2014	30	18,333	$9,955.43
4/30/2014	5/31/2014	31	54,401	$31,224.06
3/31/2014	4/30/2014	30	109,117	$62,048.03

Previous Date	Present Date	Days	Billed Natural Gas Consumption, Therms	Natural Gas Consumption Cost, $ Therms
2/28/2014	3/31/2014	31	176,760	$93,773.20
1/31/2014	2/28/2014	28	227,677	$145,371.89
12/31/2013	1/31/2014	31	234,785	$124,555.54
11/30/2013	12/31/2013	31	221,065	$98,148.44
10/31/2013	11/30/2013	30	128,640	$54,090.55
9/30/2013	10/31/2013	31	68,832	$29,579.86
8/31/2013	9/30/2013	30	13,652	$5,816.03
7/31/2013	8/31/2013	31	13,400	$5,817.48
6/30/2013	7/31/2013	31	13,357	$5,846.63
5/31/2013	6/30/2013	30	22,931	$10,037.36
4/30/2013	5/31/2013	31	46,959	$22,650.67
3/31/2013	4/30/2013	30	117,038	$49,308.11
2/28/2013	3/31/2013	31	152,419	$61,232.81
1/31/2013	2/28/2013	28	169,068	$64,443.65
12/31/2012	1/31/2013	31	206,214	$79,827.50

B3 Benchmark Data

In addition to energy consumption monitored by utility providers Camp Ripley self-monitors and reports on numerous building level sub meters. This data is reported to a data management tool called B3 Benchmarking. Energy consumption within this repository has been manipulated in order to compare each building with data available to the energy consumption of similar buildings across the nation. This is done by converting all forms of energy use to units of kBTUs or thousand BTUs. Energy consumption for electricity is reported in units of kWh, the appropriate conversion to kBTUs is shown in Equation 1:

Equation 1: Electrical Consumption Conversion from kWh to kBTU

$$Electrical\ Energy, \frac{kBTU}{year} = Electrical\ Energy, \frac{kWh}{year} * 3.412 \frac{kBTU}{kWh}$$

Energy consumption for natural gas is reported in units of therms, the appropriate conversion to kBTUs is shown in Equation 2:

Equation 2: Natural Gas Consumption Conversion from Therms to kBTU

$$Natural\ Gas\ Energy, \frac{kBTU}{year} = Natural\ Gas\ Energy, \frac{Therms}{year} * 100 \frac{kBTU}{Therms}$$

All energy use is then summated to arrive at a total energy use for each facility regardless of fuel type. This summation is represented in Equation 3

Equation 3: Total Building Energy

$$Total\ Building\ Energy, \frac{kBTU}{year} = Electrical\ Energy, \frac{kBTU}{year} + Natural\ Gas\ Energy, \frac{kBTU}{year}$$

This total energy consumption can then be normalized to building area. This final value is referred to as a buildings Energy Utilization Intensity (EUI) and allows for comparisons across multiple buildings regardless of differing area. Equation 4 mathematical formulation to arrive at each facilities EUI.

Equation 4: Energy Utilization Intensity (EUI)

$$Building\ Energy\ Utilization\ Intensity\ (EUI), \frac{kBTU}{year - ft^2} = \frac{Total\ Building\ Energy, \frac{kBTU}{year}}{Building\ Area, ft^2}$$

Note, that only electrical consumption and natural gas consumption have been discussed. This is due to Camp Ripley only reporting electrical and natural gas consumption to B3. As such, if heat is provided from one facility to another via steam or other form of heat transfer that energy is not captured by the meter where the heat is actually required but at the facility which consumes natural gas in order to create heat. Table 10 list energy consumption by fuel type and resultant EUI values for facilities with data.

Table 10: B3 Data Summary

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
TACC (11-001)	98,000	Offices	625,779	44,671	22	46	67
DOL Office (11-159)	23,000	Light Maintenance Shop	139,236	21,209	21	92	112
CMA North (17-001)	63,568	Heavy Equipment Maintenance	530,729	73,536	28	116	144
CMA South (11-169)	145,376	Heavy Equipment Maintenance	1,251,370	143,442	29	98	127

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Maintenance Shop (11-160)	7,296	Garage	37,950	10,005	14	110	124
USPFO Warehouse (11-062)	47,604	Storage	140,194	12,738	10	25	35
CIF (11-063)	54,988	Storage	325,477	17,649	18	28	46
RTSM (11-076)	23,292	Offices	220,968	34,662	26	119	144
S&SD Warehouse (02-207)	12,000	Storage	57,367	7,527	16	63	79
Central Steam Plant (02-246)	4,800	Mechanical Room	13,780	58,276	8	59	67
Unit Housing (10-142)	18,714	Light Dorms/Barracks	96,506	10,741	18	57	75
MOB/DEMOB (15-001)	33,796	Gym	131,616	15,105	13	45	58
Education Center (06-076)	31,000	Classrooms	479,673	23,671	53	76	129

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
EMTC (06-078)	15,000	Classrooms	195,362	11,368	29	49	78
Unit Housing (07-131)	20,240	Heavy Dorms/Barracks	292,730	17,013	49	84	133
Unit Housing (07-132)	20,240	Heavy Dorms/Barracks	122,268	13,523	21	67	87
Unit Housing (07-133)	20,240	Heavy Dorms/Barracks	136,280	15,033	23	74	97
Unit Housing (07-134)	20,240	Heavy Dorms/Barracks	142,651	15,578	24	77	101
Unit Housing (07-135)	20,240	Heavy Dorms/Barracks	143,930	15,015	24	74	98
PX (07-067)	14,156	Retail Store	242,089	6,027	58	43	101
Snack Bar (08-022)	4,612	Restaurant	166,117	2,432	123	53	176
TMC (08-081)	15,456	Offices	99,380	6,922	29	58	87

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
RTI (02-001)	32,323	Offices	412,268	0	44	0	44
Storage/DPW (02-099)	8,850	Offices	52,733	0	37	0	37
Public Works (02-268)	4,000	Offices	21,628	0	18	0	18
Old FMS (02-166)	44,176	Light Maintenance Shop	117,535	28,681	9	65	74
DNR Warehouse (02-204)	6,000	Storage	11,349	2,526	6	42	49
Warehouse (02-206)	12,000	Storage	14,120	2,608	13	70	84
Warehouse (02-214)	12,000	Storage	0	6,852	0	57	57
Warehouse (02-215)	12,000	Storage	0	6,168	0	51	51
Housing Services (02-219)	12,000	Storage	27,694	6,875	8	57	65

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Warehouse (02-220)	12,000	Storage	9,092	5,383	3	45	47
ATS Warehouse (02-221)	12,000	Storage	8,012	5,996	2	50	52
Maid Service Shop (02-222)	12,000	Storage	14,799	6,171	4	51	56
FMO Warehouse (02-223)	12,000	Storage	28,983	5,759	8	48	56
WWTP Shed (02-247)	12,000	Water Treatment Light	40,885	6,482	70	324	394
WWTP Shed (02-248)	200	Water Treatment Light	0	0	70	324	394
WWTP Shed (17-246)	200	Water Treatment Light	0	0	70	324	394
WWTP Shed (17-247)	200	Water Treatment Light	0	0	70	324	394
Ground Maint (02-271)	3,024	Light Maintenance Shop	27,566	2,852	31	94	125

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Three Year Average Electrical Consumption (2012-2015), kWh	Three Year Average Natural Gas Consumption (2012-2015), Therms	Stated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Roads (02-272)	12,432	Light Maintenance Shop	0	20,661	0	172	172
USPFO (15-002)	13,765	Data Center	1,007,295	0	250	0	250
MWR Building (08-195)	18,258	Offices	194,209	7,392	36	40	77
Aviation Simulator Building (08-196)	7,070	Classrooms	34,495	6,537	17	92	109
Museum Building (01-010)	2,122	Offices	5,162	899	8	42	51
Total/Average Values	1,234,413	N/A	7,619,278	697,985	33	92	113

Not all facilities included in this study have data within the B3 repository. In order to estimate a baseline each facility was given a building type; if a facility has no baseline data then the average usage for that particular building type was utilized. Table 11 list facilities without B3 data, what building type was assigned to each facility, and the subsequent passed through EUI baseline.

Table 11: Estimated EUI Data for Non-B3 Buildings

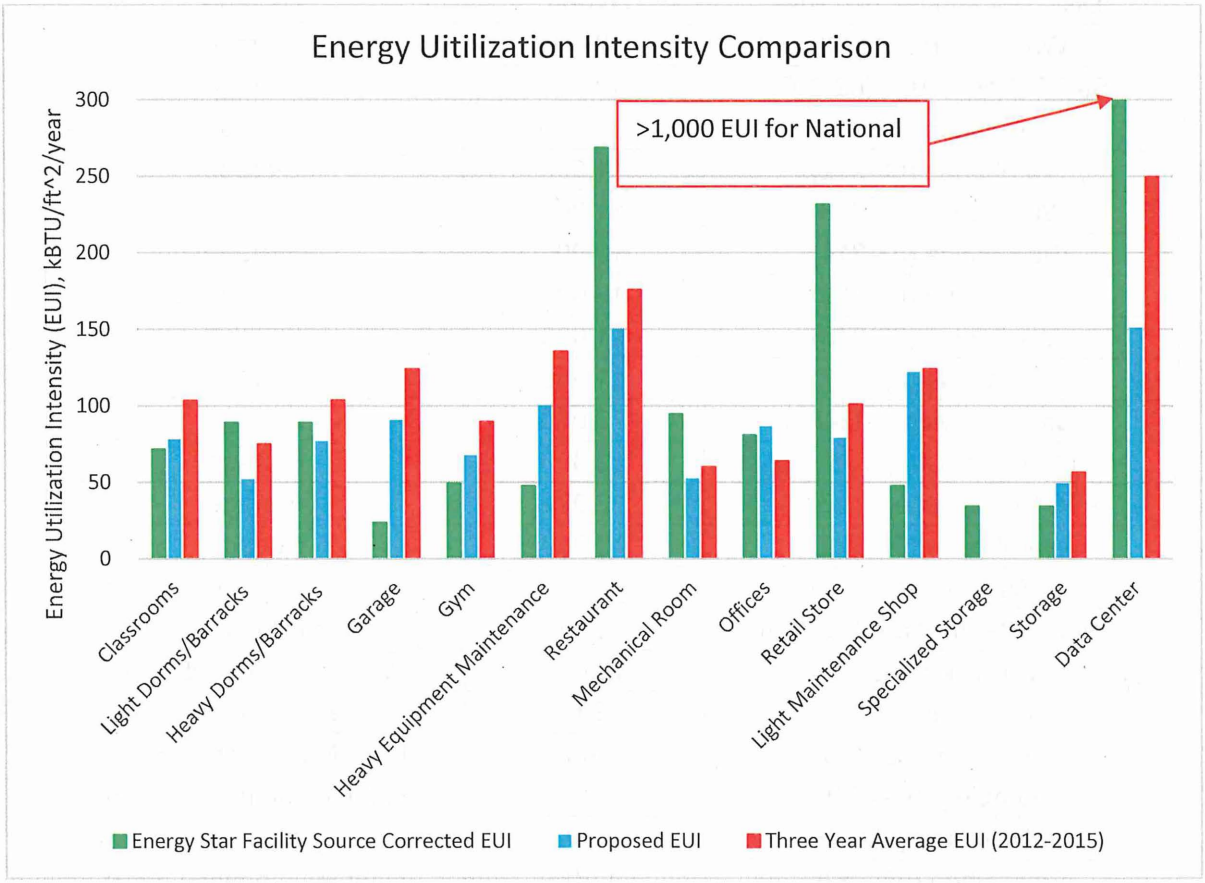
Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Estimated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Estimated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Estimated Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Unit Housing (09-131)	15,800	Light Dorms/Barracks	18	57	75
Unit Housing (09-132)	15,800	Light Dorms/Barracks	18	57	75
Unit Housing (09-133)	15,800	Light Dorms/Barracks	18	57	75
Unit Housing (09-134)	15,800	Light Dorms/Barracks	18	57	75
Unit Housing (09-135)	15,800	Light Dorms/Barracks	18	57	75
Unit Housing (10-137)	13,725	Light Dorms/Barracks	18	57	75
Unit Housing (10-138)	13,725	Light Dorms/Barracks	18	57	75
Unit Housing (10-139)	13,725	Light Dorms/Barracks	18	57	75
Unit Housing (10-140)	13,725	Light Dorms/Barracks	18	57	75

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Estimated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Estimated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Estimated Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Unit Housing (10-141)	13,725	Light Dorms/Barracks	18	57	75
Unit Housing (10-143)	13,725	Light Dorms/Barracks	18	57	75
Unit Housing (10-144)	13,725	Light Dorms/Barracks	18	57	75
J6/IT (02-202)	4,080	Offices	24	61	86
Security (02-203)	12,200	Offices	0	61	61
Carpentry (02-266)	4,000	Light Maintenance Shop	20	106	126
Plumbing (02-267)	1,100	Light Maintenance Shop	20	106	126
Paint Shop (02-269)	1,100	Light Maintenance Shop	20	106	126
Warehouse (02-211)	11,000	Storage	9	49	58

Facility Name and ID	Facility Area, ft^2	Primary Facility Type	Estimated Three Year Average EUI Electrical Energy Use (2012-215), kBTU/ft^2/year	Estimated Three Year Average EUI Natural Gas Energy Use (2012-215), kBTU/ft^2/year	Estimated Stated Three Year Average EUI (2012-2015), kBTU/ft^2/year
Warehouse (02-212)	11,000	Storage	9	49	58
Warehouse (02-213)	11,000	Storage	9	49	58
Warehouse (02-216)	11,000	Storage	9	49	58
Warehouse (02-217)	11,000	Storage	9	49	58
Air Ops Building (08-197)	6,480	Offices	24	61	86
Air Tower Building (08-192)	900	Offices	24	61	86

The building type categories assigned to each facility in Table 10 and Table 11 correlate to categories provided by Energy Star for comparisons sake. Energy Star data is based on national consumption. Typically in colder climates, which Camp Ripley resides in, site energy use is higher due to the need for more heat which often comes from burning fuel as opposed to a heat pump system. In order to compensate for this, Commercial Building Energy Consumption Survey (CBECs) data was utilized to correct Energy Star data based off of climate zone. Camp Ripley resides in the East North Central climate zone which consumes 120% more energy than the national average. As a part of the preliminary analysis for Camp Ripley each building type was compared to the corrected average and a final EUI target designated based off of potential scope. Note, not all facilities discretely fall into a particular category and are utilized for multiple purposes. Prior projects and engineering experience was utilized in order to determine the appropriate baseline level and projected EUI target for such facilities. Figure 1 graphically represents the results of this comparison effort.

Figure 1: Energy Star Comparison to Baseline and Potential Target



Calculations shown in this study expand upon this approach. Nevertheless, the baseline from B3 data was utilized for more complicated calculations and resultants compared to the established target in order to verify the integrity of all calculations. For further details on the calculation methodology utilized as a part of this study please see the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section.

DESCRIPTION OF EXISTING FACILITIES

LIST OF FACILITIES

Table 12: Building List

Building Name	Square Footage	Space Use
Museum Building (01-010)	2,122	Offices
RTI (02-001)	32,323	Offices
Storage/DPW (02-099)	8,850	Offices
Old FMS (02-166)	44,176	Light Maintenance Shop
J6/IT (02-202)	4,080	Offices
Security (02-203)	12,200	Offices
DNR Warehouse (02-204)	6,000	Storage
Warehouse (02-206)	12,000	Storage
S&SD Warehouse (02-207)	12,000	Storage
Warehouse (02-211)	11,000	Storage
Warehouse (02-212)	11,000	Storage
Warehouse (02-213)	11,000	Storage
Warehouse (02-214)	12,000	Storage
Tent Drying (02-215)	12,000	Storage
Warehouse (02-216)	11,000	Storage
Warehouse (02-217)	11,000	Storage
Housing Services (02-219)	12,000	Storage
Maid Service Shop (02-220)	12,000	Storage
ATS Warehouse (02-221)	12,000	Storage
Warehouse (02-222)	12,000	Storage
FMO Warehouse (02-223)	12,000	Storage
Central Steam Plant (02-246)	4,800	Mechanical Room
WWTP Shed (02-247)	12,000	Water Treatment Light
WWTP Shed (02-248)	200	Water Treatment Light
Carpentry (02-266)	4,000	Light Maintenance Shop
Plumbing (02-267)	1,100	Light Maintenance Shop
Public Works (02-268)	4,000	Offices
Paint Shop (02-269)	1,100	Light Maintenance Shop
Ground Maint (02-271)	3,024	Light Maintenance Shop
Roads (02-272)	12,432	Light Maintenance Shop
Education Center (06-076)	31,000	Classrooms
EMTC (06-078)	15,000	Classrooms
PX (07-067)	14,156	Retail Store
Unit Housing (07-131)	20,240	Heavy Dorms/Barracks

Building Name	Square Footage	Space Use
Unit Housing (07-132)	20,240	Heavy Dorms/Barracks
Unit Housing (07-133)	20,240	Heavy Dorms/Barracks
Unit Housing (07-134)	20,240	Heavy Dorms/Barracks
Unit Housing (07-135)	20,240	Heavy Dorms/Barracks
Snack Bar (08-022)	4,612	Restaurant
TMC (08-081)	15,456	Offices
Air Tower Building (08-192)	900	Offices
MWR Building (08-195)	18,258	Offices
Aviation Simulator Building (08-196)	7,070	Classrooms
Air Ops / Crash Rescue (08-197)	6,480	Offices
Unit Housing (09-131)	15,800	Light Dorms/Barracks
Unit Housing (09-132)	15,800	Light Dorms/Barracks
Unit Housing (09-133)	15,800	Light Dorms/Barracks
Unit Housing (09-134)	15,800	Light Dorms/Barracks
Unit Housing (09-135)	15,800	Light Dorms/Barracks
Unit Housing (10-137)	13,725	Light Dorms/Barracks
Unit Housing (10-138)	13,725	Light Dorms/Barracks
Unit Housing (10-139)	13,725	Light Dorms/Barracks
Unit Housing (10-140)	13,725	Light Dorms/Barracks
Unit Housing (10-141)	13,725	Light Dorms/Barracks
Unit Housing (10-142)	18,714	Light Dorms/Barracks
Unit Housing (10-143)	13,725	Light Dorms/Barracks
Unit Housing (10-144)	13,725	Light Dorms/Barracks
TACC (11-001)	98,000	Offices
USPFO Warehouse (11-062)	47,604	Storage
CIF (11-063)	54,988	Storage
RTSM (11-076)	23,292	Offices
DOL Office (11-159)	23,000	Light Maintenance Shop
Maintenance Shop (11-160)	7,296	Garage
CMA South (11-169)	145,376	Heavy Equipment Maintenance
MOB/DEMOB (15-001)	33,796	Gym
USPFO (15-002)	13,765	Data Center
CMA North (17-001)	63,568	Heavy Equipment Maintenance
WWTP Shed (17-246)	200	Water Treatment Light
WWTP Shed (17-247)	200	Water Treatment Light
Cantonment Area	0	""
TOTALS	1,234,413	

Building Name	Square Footage	Space Use
TACC (11-001)	98,000	Offices
DOL Office (11-159)	23,000	Light Maintenance Shop
CMA North (17-001)	63,568	Heavy Equipment Maintenance
CMA South (11-169)	145,376	Heavy Equipment Maintenance
Maintenance Shop (11-160)	7,296	Garage
USPFO Warehouse (11-062)	47,604	Storage
CIF (11-063)	54,988	Storage
RTSM (11-076)	23,292	Offices
S&SD Warehouse (02-207)	12,000	Storage
Central Steam Plant (02-246)	4,800	Mechanical Room
Unit Housing (10-142)	18,714	Light Dorms/Barracks
Unit Housing (09-131)	15,800	Light Dorms/Barracks
Unit Housing (09-132)	15,800	Light Dorms/Barracks
Unit Housing (09-133)	15,800	Light Dorms/Barracks
Unit Housing (09-134)	15,800	Light Dorms/Barracks
Unit Housing (09-135)	15,800	Light Dorms/Barracks
Unit Housing (10-137)	13,725	Light Dorms/Barracks
Unit Housing (10-138)	13,725	Light Dorms/Barracks
Unit Housing (10-139)	13,725	Light Dorms/Barracks
Unit Housing (10-140)	13,725	Light Dorms/Barracks
Unit Housing (10-141)	13,725	Light Dorms/Barracks
Unit Housing (10-143)	13,725	Light Dorms/Barracks
Unit Housing (10-144)	13,725	Light Dorms/Barracks
MOB/DEMOB (15-001)	33,796	Gym
Education Center (06-076)	31,000	Classrooms
EMTC (06-078)	15,000	Classrooms
Unit Housing (07-131)	20,240	Heavy Dorms/Barracks
Unit Housing (07-132)	20,240	Heavy Dorms/Barracks
Unit Housing (07-133)	20,240	Heavy Dorms/Barracks
Unit Housing (07-134)	20,240	Heavy Dorms/Barracks
Unit Housing (07-135)	20,240	Heavy Dorms/Barracks
PX (07-067)	14,156	Retail Store
Snack Bar (08-022)	4,612	Restaurant
TMC (08-081)	15,456	Offices
RTI (02-001)	32,323	Offices
Storage/DPW (02-099)	8,850	Offices
J6/IT (02-202)	4,080	Offices
Security (02-203)	12,200	Offices
Carpentry (02-266)	4,000	Light Maintenance Shop
Plumbing (02-267)	1,100	Light Maintenance Shop
Public Works (02-268)	4,000	Offices
Paint Shop (02-269)	1,100	Light Maintenance Shop
Old FMS (02-166)	44,176	Light Maintenance Shop
DNR Warehouse (02-204)	6,000	Storage
Warehouse (02-206)	12,000	Storage
Warehouse (02-211)	11,000	Storage

Building Name	Square Footage	Space Use
Warehouse (02-212)	11,000	Storage
Warehouse (02-213)	11,000	Storage
Warehouse (02-214)	12,000	Storage
Tent Drying (02-215)	12,000	Storage
Warehouse (02-216)	11,000	Storage
Warehouse (02-217)	11,000	Storage
Housing Services (02-219)	12,000	Storage
Maid Service Shop (02-220)	12,000	Storage
ATS Warehouse (02-221)	12,000	Storage
Warehouse (02-222)	12,000	Storage
FMO Warehouse (02-223)	12,000	Storage
WWTP Shed (02-248)	200	Water Treatment Light
WWTP Shed (02-247)	12,000	Water Treatment Light
WWTP Shed (17-246)	200	Water Treatment Light
WWTP Shed (17-247)	200	Water Treatment Light
Ground Maint (02-271)	3,024	Light Maintenance Shop
Roads (02-272)	12,432	Light Maintenance Shop
USPFO (15-002)	13,765	Data Center
MWR Building (08-195)	18,258	Offices
Aviation Simulator Building (08-196)	7,070	Classrooms
Air Ops Building (08-197)	6,480	Offices
Museum Building (01-010)	2,122	Offices
Air Tower Building (08-192)	900	Offices
Cantonment Area	0	""
TOTALS	**1,234,413**	

MUSEUM BUILDING (01-010)

FACILITY DESCRIPTION

Museum Building (01-010) is a single story facility in Area 1 of the camp. As the facility name implies, the facility is primarily utilized as museum that houses exhibits and artifacts. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the museum facility is presented in Table 13. Lighting at the Museum facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 13: Museum Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade construction consists of a grey brick masonry. Interior wall construction primarily consists of gypsum board (drywall). Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of dark grey asphalt shingles. Interior ceilings primarily consist of gypsum board (drywall). Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by residential split systems. These constant volume units are capable of heating via forced air, natural gas fired sections, and cooling via direct expansion systems.

OTHER HVAC CONTROLS OBSERVATIONS:

Museum building is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving. This is done to provide a constant temperature and humidity level to preserve the artifacts.

RTI (02-001)

Figure 2: Picture: RTI

Facility Description

RTI (02-2001), more commonly referred to as FMO, is a three story facility in Area 2 of the camp. A basement exists throughout; a second floor is present in the older eastern portion of the facility. It is primarily utilized for offices and conference rooms specifically for facilities management of the camp. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the RTI facility is presented in Table 14. Lighting at RTI facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 14: RTI Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade differs based on location. The newer western partition, which constitutes the majority of the facility, consists of a tan plaster most likely over concrete block walls. The older eastern partition consists of a red brick masonry. Interior wall construction primarily consists of gypsum board (drywall). An exception exist in the basement where walls consist of white painted bricks. Additional wall construction layers which are not visible are unknown.

The roof also differs based on location. The newer western partition roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space ~12" of batt insulation was observed. The roof of the older western portion is flat and consists of black EDPM (rubber) material. Ceilings throughout primarily consist of acoustic tiles. An exception exists in the basement where no hanging ceiling exist; the first floor slab is visible along with piping and wiring conduit. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by three Air Handling Units (AHUs). Each AHU consists of a supply fan and return fan both of which are controlled by variable frequency drives at each unit. The variable frequency drive allows for speed control of the motor which thus allows each unit to vary the amount of air volume delivered and returned. AHUs which are capable of varying are volume are often called Variable Air Volume (VAV) AHUs or VAV AHUS for short. Each of the three VAV AHUs is capable of heating via hot water coils with three way electronic valve control and capable of cooling via chilled water coils with three way electronic valve control. Each unit has direct control of outside air dampers and return air dampers where a relief pathway exist if return air dampers are closed further than outside air dampers. Supply air is delivered to nine VAV boxes which regulate flow from the air handler to satisfy the needs of the served space. These VAV boxes do not have enclosed fans but are capable of reheating the air stream delivered by the air handlers. Additional heating elements exist in perimeter zones in the form of baseboard radiation heat exchangers. An exhaust fan does exist in what is labeled as AHU1s service area.

Table 15: RTI Air Handler Information

AHU ID	Type	Make	Model Number	Serial Number
AHU_1	VAV AHU	McQuay	CAH006FDAC	FB0U00100069
AHU_2	VAV AHU	McQuay	CAH014FDAC	FB0U00100067
AHU_2	VAV AHU	McQuay	CAH014FDAC	FB0U00100067

All of the heat for the building is produced at the Central Steam Plant and is delivered to the facility in the form of steam. All of the steam is converted to hot water in a single shell and tube heat exchanger. A single, 1.5 Horse Power (HP) constant volume hot water pump serves the building hot water loop.

Table 16: RTI Heat Exchanger Information

Make	Model	Type	Heat Exchanger Capacity, 1000s BTUs	Source Information	Sink Fluid Liquid Type	Sink Entering Medium Temperature, °F	Sink Leaving Medium Temperature, °F	Sink Flow rate, Air-CFM Water-GPM	Sink Coil Restriction Losses, Water-ft. H20
Taco, Inc.	G10408-S	Shell and Tube	1275	Steam @ 5 PSIg 1301 lbm/hr	Hot Water	170	200	85	4.72

Table 17: RTI Hot Water Pump Information

Pump ID	Pump Location	Serves	Pump Make	Pump Model Number	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM	Pump Motor, HP
HWP-1	Boiler Mechanical Room	HW Loop	Taco	V12507 2.5x2.5x5.4	85.00	1,760.00	30.00	1.5

All of the chilled water for the facility is produced by a single, 47.5 ton McQuay air cooled chiller. The chilled water distribution system is served by a single, five Horse Power (HP), constant volume pump. Some small supplemental mini split systems also serve areas with greater than normal internal heat gain sources (e.g. server rooms, computer labs).

Table 18: RTI Chiller Information

Chiller ID	Chiller Location	Make	Model Number	Type	System Transfer Medium	Chiller Capacity, Tons	Chiller Efficiency, COP
CH-1	Outside Ground Level	McQuay	AGZ060B512-ER10	Air Cooled Chiller	Water	47.5	3.20

Table 19: RTI Chilled Water Pump Information

Pump ID	Pump Make	Pump Model Number	Pump Type	System Fluid Type	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM	Pump Motor, HP	Pump Motor Voltage & Phase
CHWP-1	Taco	V13008 3x3x8.2	Chilled Water Pump	Water	136.00	1,760.00	73.00	5	208V/3ph

OTHER HVAC CONTROLS OBSERVATIONS:

A total of 500 control points are visible on the Building Automation System (BAS) workstation for RTI. Four of these points have an "Out of service" status. One of these points is labeled as an occupied command. It is unsure if this forces the facility to stay in an occupied state, utility usage seems to correlate to the condition where an occupied state is constant for the facility.

STORAGE/DPW (02-099)

FACILITY DESCRIPTION

The Storage building is a two story facility, with a ground floor and basement, in Area 2 of the camp. The facility is primarily utilized for offices and storage but also contains a decent sized server rack. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the Storage facility is presented in Table 20. Lighting at the Storage facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 20: Storage Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall). Additional wall construction layers which are not visible are unknown. The roof for the facility is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by two system types, one dedicated to cooling and the other to heating. Cooling is only available to offices located on the ground floor where heat is rejected by numerous small direct expansion refrigerant systems often referred to as *mini-splits*. Each office has a dedicated evaporator and condenser section with the exception of the server room which is served by two dedicated mini-split systems due to excessive heat complaints.

None of the cooling systems are visible on the Metasys Building Automation System (BAS) workstation; unit control is based off of local thermostat feedback and set point.

Table 21: Storage Building Condenser Units

Chiller ID	Chiller Location	Serves	Make	Model Number	Type	System Transfer Medium	Chiller Capacity, Tons	Refrigerant Type
COND-1	Outside Ground Level	EVAP_DXWALL_1	Firedrich	CL2472	Mini Split	Direct Exchange	1.92	R22
COND-2	Outside Ground Level	EVAP_DXSPLIT_1	Firedrich	MR24DY3F	Mini Split	Direct Exchange	2	R22
COND-3	Outside Ground Level	EVAP_DXSPLIT_2	Firedrich	MR24DY3F	Mini Split	Direct Exchange	2	R22
COND-4	Outside Ground Level	EVAP_DXSPLIT_3	Firedrich	MR24DY3F	Mini Split	Direct Exchange	2	R22

Heating for the entire facility is provided by perimeter steam radiators. Steam radiators are not visible on the Metasys BAS workstation; radiator controls is based off of local thermostat feedback and set point. Staff have indicated excessive heat in the server room occurring during the winter which leads to a hypothesis that steam valves located in the basement of the building have malfunctioned where heat is always provided regardless of thermostat feedback. The heat from these radiators rises to the server room overhead. This hypothesis was somewhat verified by warm radiators in rooms where set point appeared to be satisfied.

Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility.

OTHER HVAC CONTROLS OBSERVATIONS:
The Storage facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

OLD FMS (02-166)

Table 22: Picture; Old FMS

FACILITY DESCRIPTION

Old FMS is a single story facility in Area 2 of the Camp. The facility consists of workshop areas and storage space for the facility maintenance department. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for old FMS is presented in Table 23. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 23: Old FMS Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily grey concrete block walls. Interior wall construction primarily consists of concrete blocks as well. Additional wall construction layers which are not visible are unknown. The roof is flat with the exception of a southern high bay area; the exterior layer for both flat and pitched roofs consist of dark grey EPDM (rubber) material. Ceilings of occupied spaces primarily consists of a corrugated metal material. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane clear glass within a white aluminum frame.

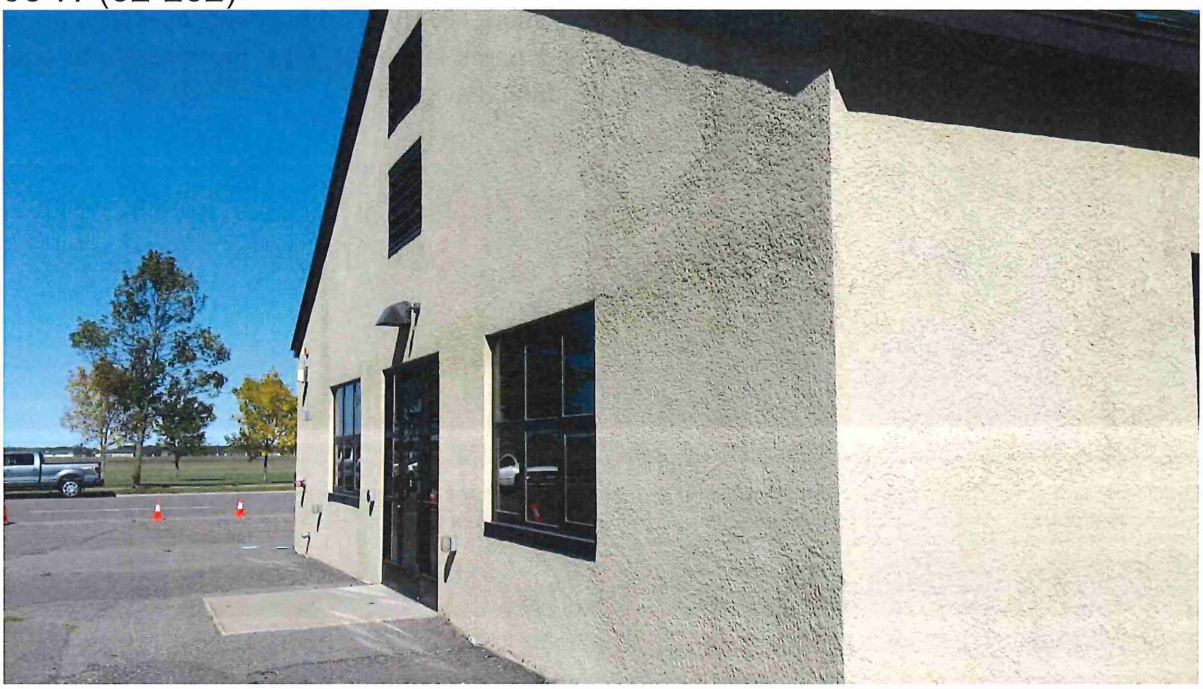
HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

HVAC equipment which serves old FMS is capable of heating only via constant volume Roof Top Units (RTUs). These RTUs provide heat via forced air, natural gas fired sections. At one point or another, these units where utilized to make up exhausted air from hoods. Based on staff interviews, the facility is mostly not utilized or repurposed as storage. As such, hoods are not switched on and RTU outside air dampers are closed.

OTHER HVAC CONTROLS OBSERVATIONS:

Old FMS is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

J6-IT (02-202)



Facility Description

The J6-IT building is a single story facility in Area 2 of the Camp which has been recently remodeled. The facility is primarily utilized to house IT staff and equipment and mainly consists of offices. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the J6-IT facility is presented in Table 24. Lighting at the J6-IT facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 24: Security Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall). Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation was observed on the interior ceiling. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by a single, Variable Air Volume (VAV) Air Handling Unit (AHUs) located in the penthouse of the facility. The unit utilizes an air cooled direct expansion system in order to cool air and a steam coil with a face and by-pass damper and two way electronic valve control to provide heat. The unit consists of a supply fan and return fan each with a Variable Frequency Drive (VFD). Supply air from the unit feeds five VAV boxes each of which contain steam coils for additional reheat. VAV boxes do not contain additional fans. The

unit along with the five VAV boxes are visible on the Metasys Building Automation System (BAS) workstation.

Table 25: J6-IT Building Air Handling Units

AHU ID	Serves	Type	Make	Model Number
AHU_OFFICES	Entire Facility	Variable Air Volume Unit	Trane	MCCB008UA0B0UA

Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility.

The facility is cooled by a single direct expansion refrigerant system which serves the main air handling unit for the facility. The unit has a capacity of 10 tons and the status for the cooling coil is visible on the BAS work station.

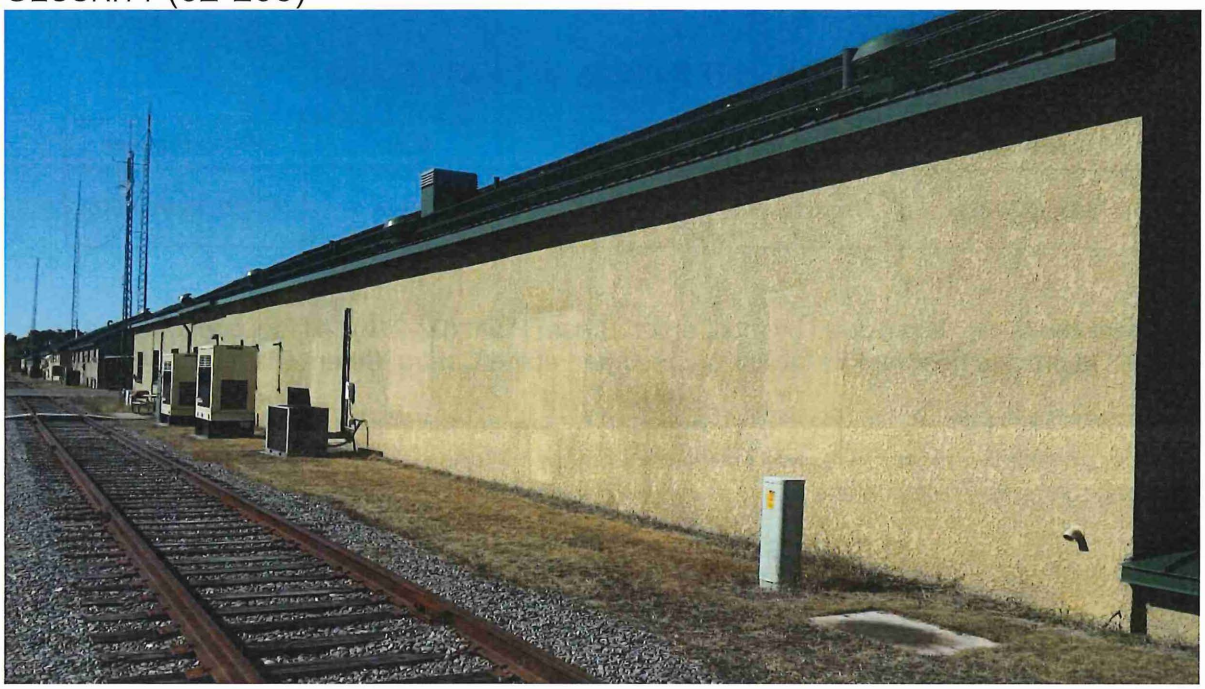
Table 26: J6-IT Building Condenser Unit

Chiller ID	Chiller Location	Serves	Make	Model Number
COND-1	Outside Ground Level	AHU_OFFICES	Trane	TTA120B300EA

OTHER HVAC CONTROLS OBSERVATIONS:

The J6-IT facility has been recently remodeled, as such, the BAS architecture and number of controllable HVAC points is extensive. Subsequent energy savings controls sequences such as: night setup and setback, economizing, and outside air ventilation control, have been verified as functioning based on BAS workstation observations. Furthermore, natural gas consumption at the Central Steam Plant (02-246) does not indicate the use of available reheat for dehumidification during the summer months.

SECURITY (02-203)



FACILITY DESCRIPTION

The Security building is a single story facility in Area 2 of the Camp which has been recently remodeled. The facility is primarily utilized to house security staff and equipment and mainly consists of offices and a large garage. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the security facility is presented in Table 27. Lighting at the security facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 27: Security Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall). Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation was observed on the interior ceiling. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location within the facility. The offices primarily located in the western portion of the facility are served by a single, Variable Air Volume (VAV) Air Handling Unit (AHU) located in the attic of the facility. The unit utilizes an air cooled direct expansion system in order to cool air and a hot water coil with three way electronic valve control to provide heat. The unit consists of a supply fan and return fan each with a Variable Frequency Drive (VFD). Supply air from the unit feeds twelve VAV boxes each of which contain hot water coils for additional reheat. VAV boxes do not contain additional fans. The unit

along with the twelve VAV boxes are visible on the Metasys Building Automation System (BAS) workstation.

The garage area primarily located in the eastern portion of the facility is served by a single, heating only, Make-up Air Unit (MAU). This unit can only cycle on to provide constant volume air. Heat from the unit is produced by a hot water coil with three way electronic valve control. A paired exhaust fan exist to relieve air introduced by the MAU. Both the exhaust fan and MAU are visible on the Metasys BAS. The graphic page for both units notes the existence of a carbon monoxide sensor. Neither unit were observed to operate during the audit nor were there any vehicles ever operating within the garage during the audit. It is postulated that this sequence along with the sensor are still functional.

Both the MAU and office unit route exhaust air through a heat exchanger. This heat exchanger transfers heat to an outside air stream which is routed to both units. The heat exchanger is capable of only transferring sensible heat, in other words, no moisture is transferred between the two air streams. This heat exchanger also has two dedicated fans in each air stream.

Table 28: Security Building Air Handling Units

AHU ID	Serves	Type	Make	Model Number	Serial Number	Supply Air Flow Rate, ft^3/min	Supply Fan Design Static Pressure Differential, in. of H20	Supply Fan Motor Power Input, HP
AHU_OFFICES	Offices on East side of facility	Variable Air Volume Unit	York	XTI-036X054-BAJA117A	ANSM XT0104	4,000	1.50	7.50
HR_GARAGE	Heat Recovery for AHU_OFFICES	Heat Recovery Unit	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
MAU_GARAGE	Make Up Air for Garage	Make-up Air Unit	York	XTI-045X078-BAKA117A	ANSM XT0105	8,700	1.00	10.00

Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility. The steam is converted to hot water entirely in one mechanical room by a pair of shell and tube heat exchangers. The hot water distribution system is served by four hot water pumps, two of which utilize Variable Frequency Drives (VFDs) to vary water flow. The other two smaller pumps are only capable of discharging constant volume water.

Table 29: Security Hot Water Pumps and Pump Motors

Pump ID	Pump Location	Serves	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make
HWP-2	HX Mech Room	HW Loop	45.00	1,750.00	5	208/3	90.20%	Baldor
HWP-2A	HX Mech Room	HW Loop	45.00	1,750.00	5	208/3	90.20%	Baldor
HWP-3	HX Mech Room	HW Loop	7.00	1,750.00	FRAC	120/1	Unknown	Unknown
HWP-4	HX Mech Room	HW Loop	16.00	1,750.00	0.75	208/3	Unknown	Unknown

The facility is cooled by a single direct expansion refrigerant system which serves the main air handling unit for the facility. The unit has a capacity of 10 tons and the status for the cooling coil is visible on the BAS work station. Two additional mini split units were also observed, these units are assumed to serve discrete rooms with higher than average heat load.

Table 30: J6-IT Building Condenser Unit

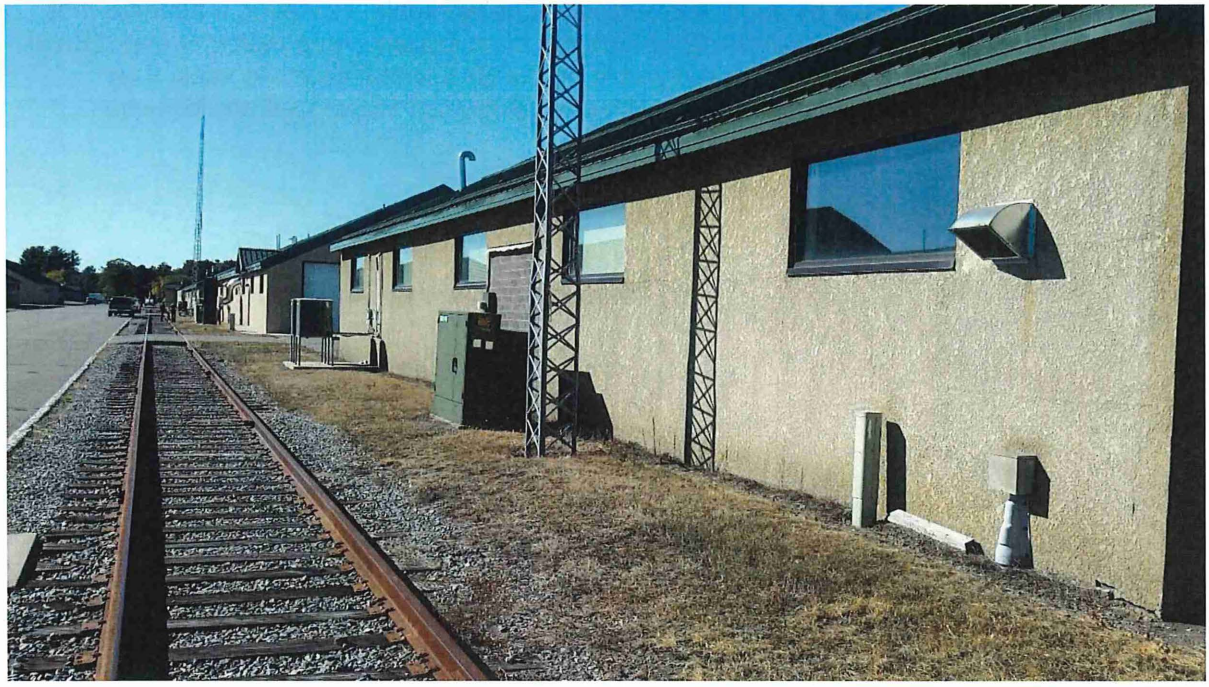
Chiller ID	Chiller Location	Serves	Make	Model Number
COND-1	Outside Ground Level	AHU_OFFICES	York	H3CE120A225A

OTHER HVAC CONTROLS OBSERVATIONS:

The Security facility has been recently remodeled, as such, the BAS architecture and number of controllable HVAC points is extensive. Subsequent energy savings controls sequences such as: night setup and setback, economizing, and outside air ventilation control, have been verified as functioning based on BAS workstation observations. Furthermore, natural gas consumption at the Central Steam Plant (02-246) does not indicate the use of available reheat for dehumidification during the summer months.

DNR WAREHOUSE (02-204)

Figure 3: Picture; DNR Warehouse



FACILITY DESCRIPTION

DNR warehouse is a single story facility in Area 2 of the Camp. The facility consists of mostly storage space. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the paint shop is presented in Table 31. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 31: DNR Warehouse Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with grey tint within a black aluminum frame. Other additional building envelope openings include an overhead door along the east and western walls.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioning of the space is primarily handled by two constant volume Air Handling Units (AHUs). These AHUs are capable of heating via a forced air natural gas section, and cooling via direct expansion systems. The AHUs are horizontally oriented and are hanging from the ceiling within the main warehouse space.

OTHER HVAC CONTROLS OBSERVATIONS:

The two main units are served by controllers which are networkable. However, it appears that the equipment responsible for communicating with the main Building Automation System (BAS) is not connected. Hence, the AHUs are not visible on the BAS workstation. As such, it is assumed that no occupancy schedule along with energy savings sequences are followed.

S&SD Warehouse (02-207)

I don't have an exterior shot of this building

Facility Description

The S&SD Warehouse (02-207) building is a single story facility in Area 2 of the camp. The facility is primarily utilized as a storage warehouse. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the Storage facility is presented in Table 32. Lighting at the Storage facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 32: Storage Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade for the facility consists primarily of a tan plaster most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall). Additional wall construction layers which are not visible are unknown. The roof for the facility is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

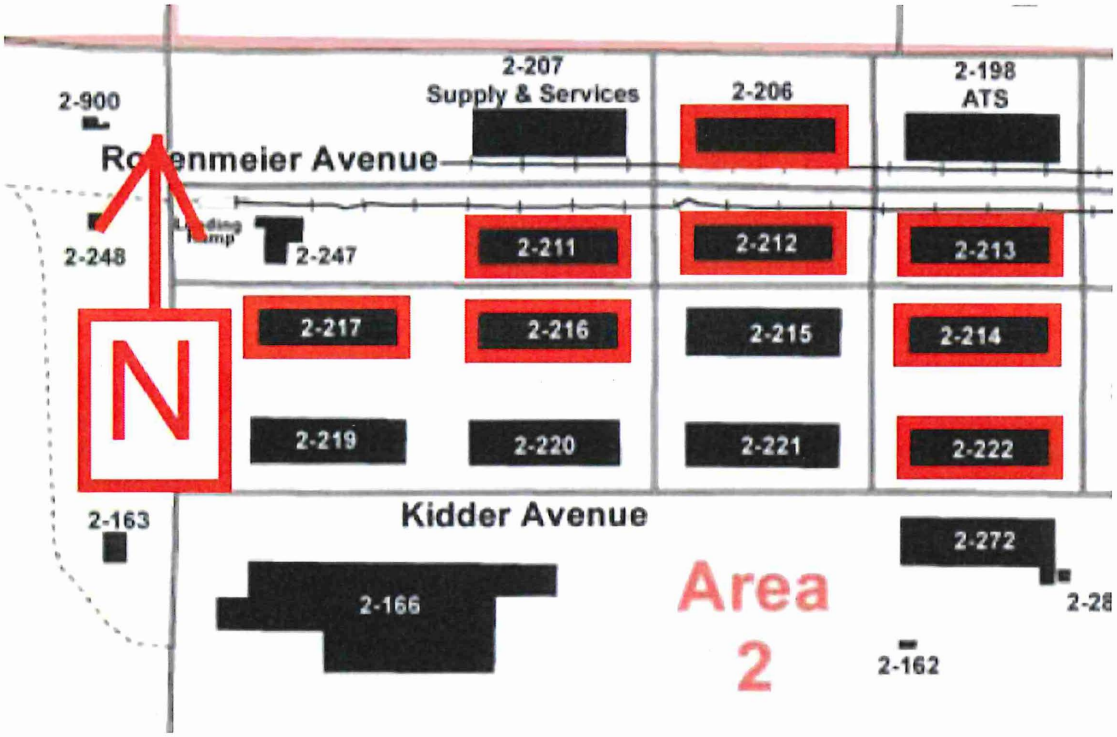
Conditioned air is primarily delivered by constant volume gas fired unit heaters. No ventilated conditioned air is provided nor is any form of cooling provided for the facility.

Other HVAC Controls Observations:

The S&SD Warehouse facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

WAREHOUSES (02,206, 02-211 THROUGH 02-214, 02-016, 02-017, 02-222)

Figure 4: Map; Warehouses in Area 2



FACILITY DESCRIPTION

Buildings 02-206, 02-211 through 02-217 and 02-220 are single floor warehouses in area 2 of the camp. As the building labels indicate, the facilities are utilized as storage spaces. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the facilities is presented in Table 33. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 33: Warehouses Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed at these locations. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

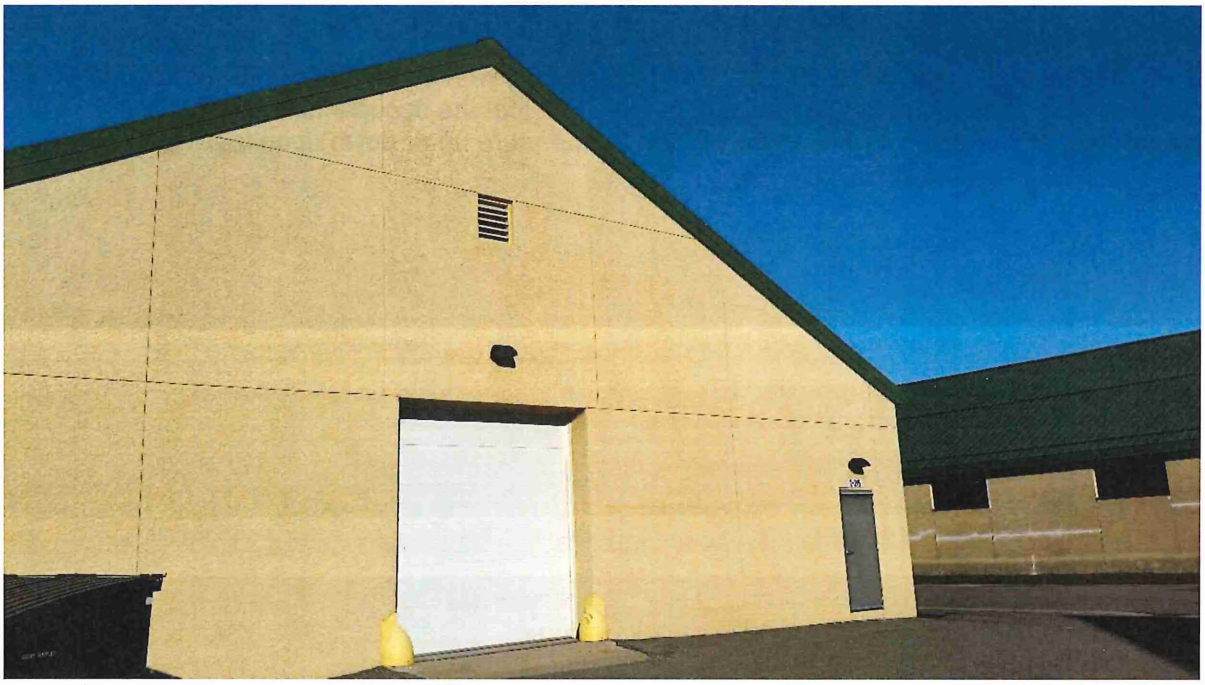
Conditioned air is primarily delivered by unit heaters and furnaces. These constant volume units are capable of heating only via forced air, natural gas fired sections. No outside air is purposefully introduced and heated by these units.

OTHER HVAC CONTROLS OBSERVATIONS:

None of the warehouses are visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

TENT DRYING (02-215)

Figure 5: Picture; Tent Drying



FACILITY DESCRIPTION

Building 02-215 is a single floor warehouse in area 2 of the camp that serves as a tent drying facility and storage space. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the facilities is presented in Table 33. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 34: Tent Drying Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed at these locations. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

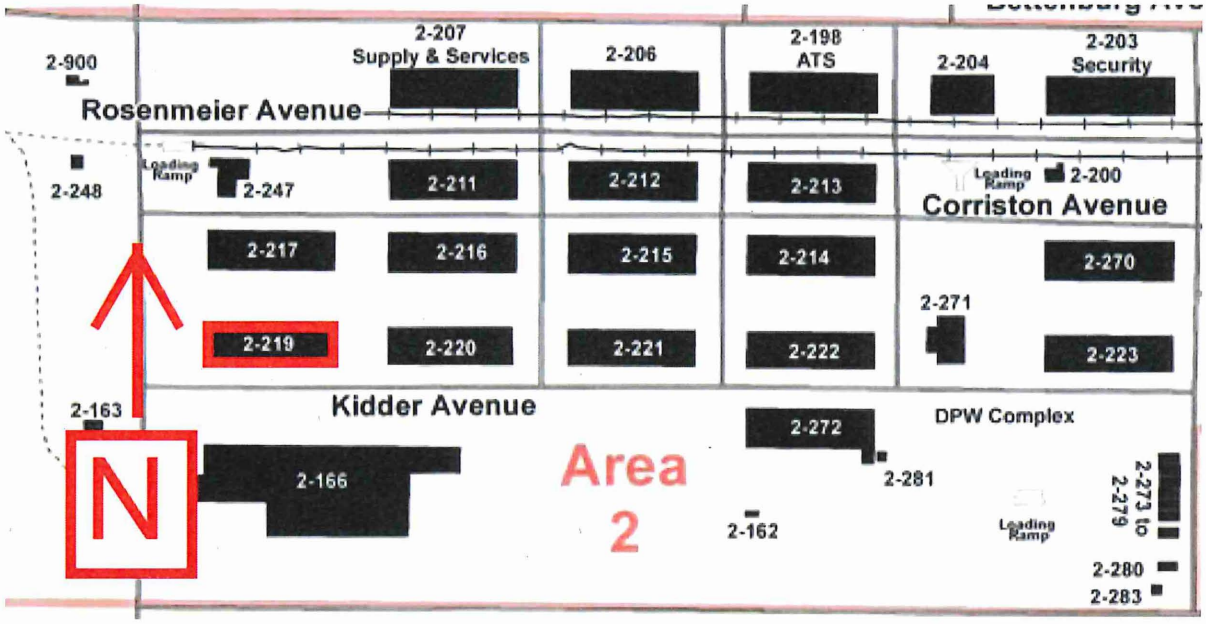
Conditioned air is delivered by a dehumidification Air Handling Unit (AHU) for the tent drying space and a constant volume AHU for the storage area. The storage area AHU is capable of heating only. The AHU serving the tent drying area was designed specifically for that purpose.

OTHER HVAC CONTROLS OBSERVATIONS:

None of the HVAC equipment are visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

HOUSING SERVICES (02-219)

Figure 6: Map; 02-219 location in Area 2



FACILITY DESCRIPTION

Housing services (02-219) is a single floor facility in Area 2 of the camp. The facility is primarily used as a storage are and workshop but also has an office area. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the facilities is presented in Table 35. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 35: Housing Services Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by unit heaters and furnaces. These constant volume units are capable of heating only via forced air, natural gas fired sections. No outside air is purposefully introduced and heated by these units.

OTHER HVAC CONTROLS OBSERVATIONS:

Housing Services is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

ATS Warehouse (02-221)

Facility Description

ATS Warehouse (02-222) is a single floor facility in area 2 of the camp. The facility is primarily utilized as a storage space. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 36. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 36: ATS Warehouse Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

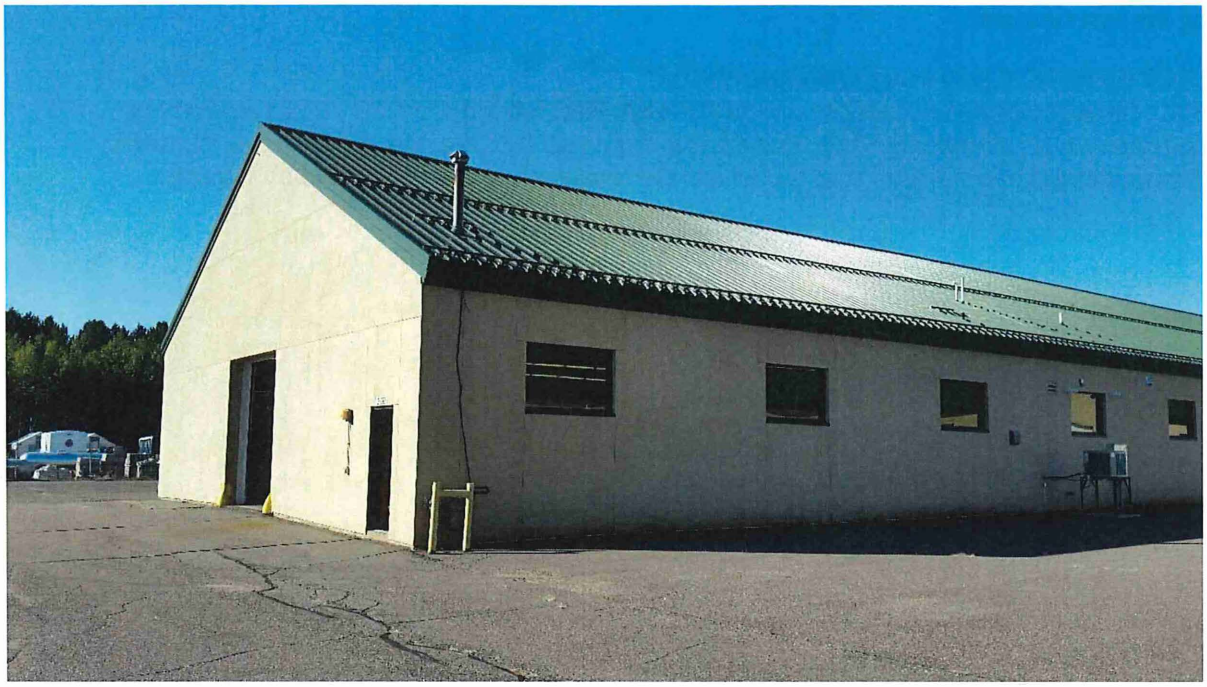
Conditioned air is primarily delivered by unit heaters and furnaces. These constant volume units are capable of heating only via forced air, natural gas fired sections. No outside air is purposefully introduced and heated by these units.

Other HVAC Controls Observations:

ATS Warehouse is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

MAID SERVICE SHOP (02-220)

Figure 7: Pictures; Maid Service Shop



FACILITY DESCRIPTION

Maid Service Shop (02-220) is a single floor facility in area 2 of the camp. The facility is primarily utilized as a laundry facility with part of the building used as storage. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 37. As an exception, staff has stated that occupants drop off laundry and leave the facility soon thereafter. Furthermore, utility consumption profile for this facility indicates a lower usage rate during summer months. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 37: Maid Service Shop Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

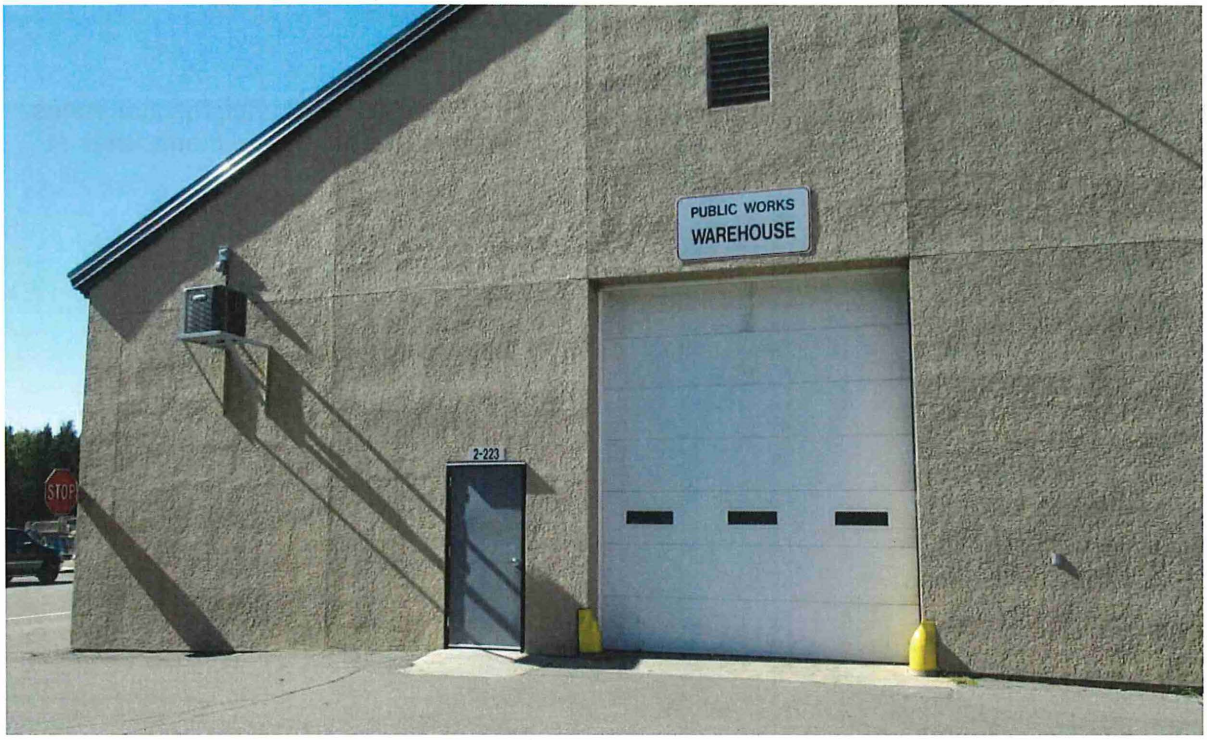
Conditioned air is primarily delivered by an Air Handling Unit (AHU) and furnace for the laundry site and unit heaters for the storage space. No outside air is purposefully introduced and heated by the unit heaters.

OTHER HVAC CONTROLS OBSERVATIONS:

Maid Service Shop is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

FMO Warehouse (02-223)

Figure 8: Picture; FMO Warehouse



Facility Description

FMO Warehouse (02-223) is a single floor facility in area 2 of the camp. As the building label indicates, the facility is primarily utilized as a storage space with a small office area. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 38. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 38: FMO Warehouses Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame. Two additional overhead doors exist along the eastern and western walls.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

The facility storage area is heated only via linear infrared heating systems. These infrared heaters are gas fired. The office area for the facility is heated by a constant volume natural gas fried furnace with cooling provided via a direct expansion system.

OTHER HVAC CONTROLS OBSERVATIONS:

FMO Warehouse is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

CENTRAL STEAM PLANT (02-246)

Figure 9: Photo: Central Steam Plant

FACILITY DESCRIPTION

The Central Steam Plant (02-246) building is a single story facility in Area 2 of the camp. The facility is primarily utilized to produce steam for the purpose of building heat at the following 10 facilities:

1) Central Steam Plant (02-246)
2) RTI (02-001)
3) Storage/DPW (02-099)
4) J6/IT (02-202)
5) Security (02-203)
6) Carpentry (02-266)
7) Plumbing (02-267)
8) Public Works (02-268)
9) Paint Shop (02-269)
10) USPFO (15-002)

Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the Central Steam Plant facility is presented in Table 39. An exception to scheduling does exist where the building is lightly utilized during the cooling season. Lighting at the Central Steam Plant is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 39: Storage Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

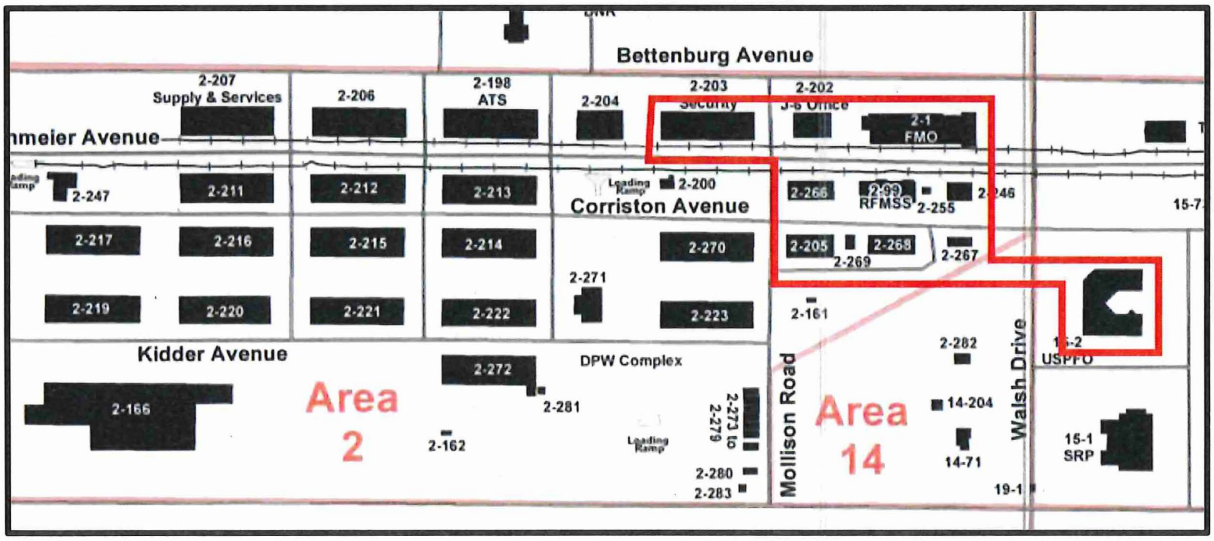
Exterior wall façade for the facility consists primarily of red brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat with the exterior layer consisting of dark grey EDPM (rubber) material. Ceilings of occupied spaces primarily consists of corrugated metal material. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by constant volume unit heaters which utilize live steam coils to provide heat. No form of cooling exist within the facility.

Other HVAC Controls Observations:

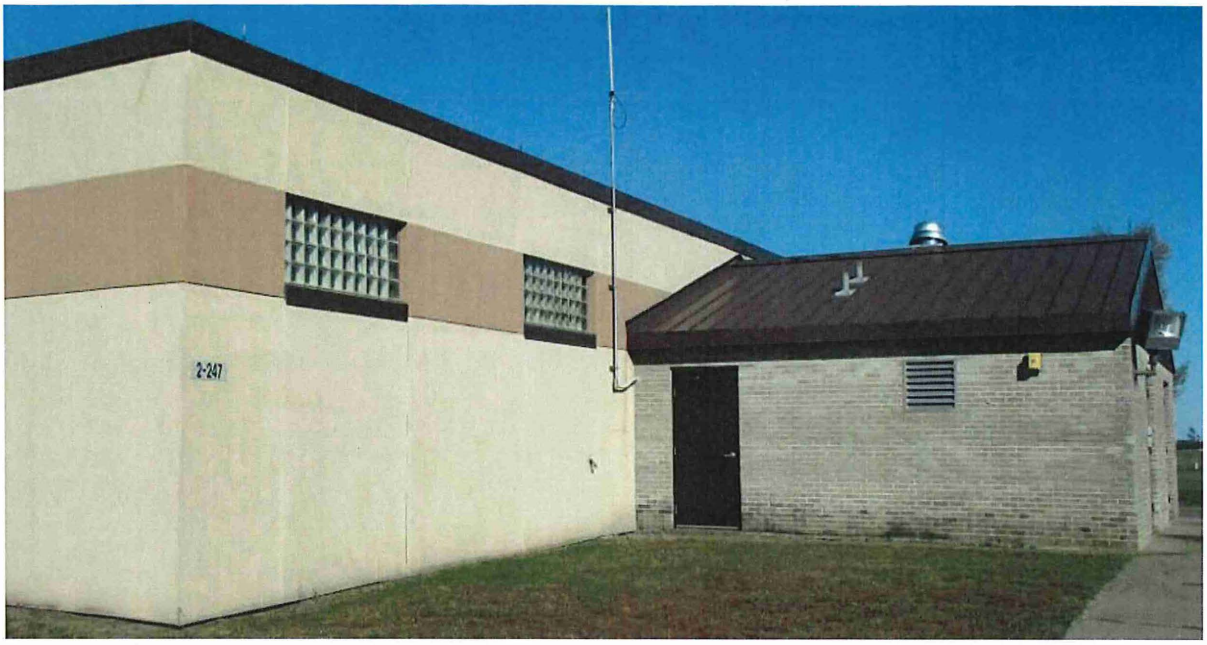
The Central Steam Plant facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.



Note: Steam heating area outlined in red

WATER TREATMENT PLANT (02-247)

Figure 10: Picture; Water Treatment Plant



FACILITY DESCRIPTION

Water Treatment Plant (WTP) (02-247) is a single floor facility in area 2 of the camp. The facility is primarily utilized to house pumping equipment and other equipment dedicated to water treatment. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 40. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 40: WWTP Shed Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction façade differs based on location, however, exterior construction façade primarily consists of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof is mostly flat with the exterior layer consisting of tan stones over a tar surface. A small addition to the facility does have a pitched roof with an exterior layer consisting of a brown metal surface. Ceilings of occupied spaces primarily consist of visible concrete. Additional non-visible roof construction material is unknown. Most windows consists of clear glass blocks of unknown thickness.

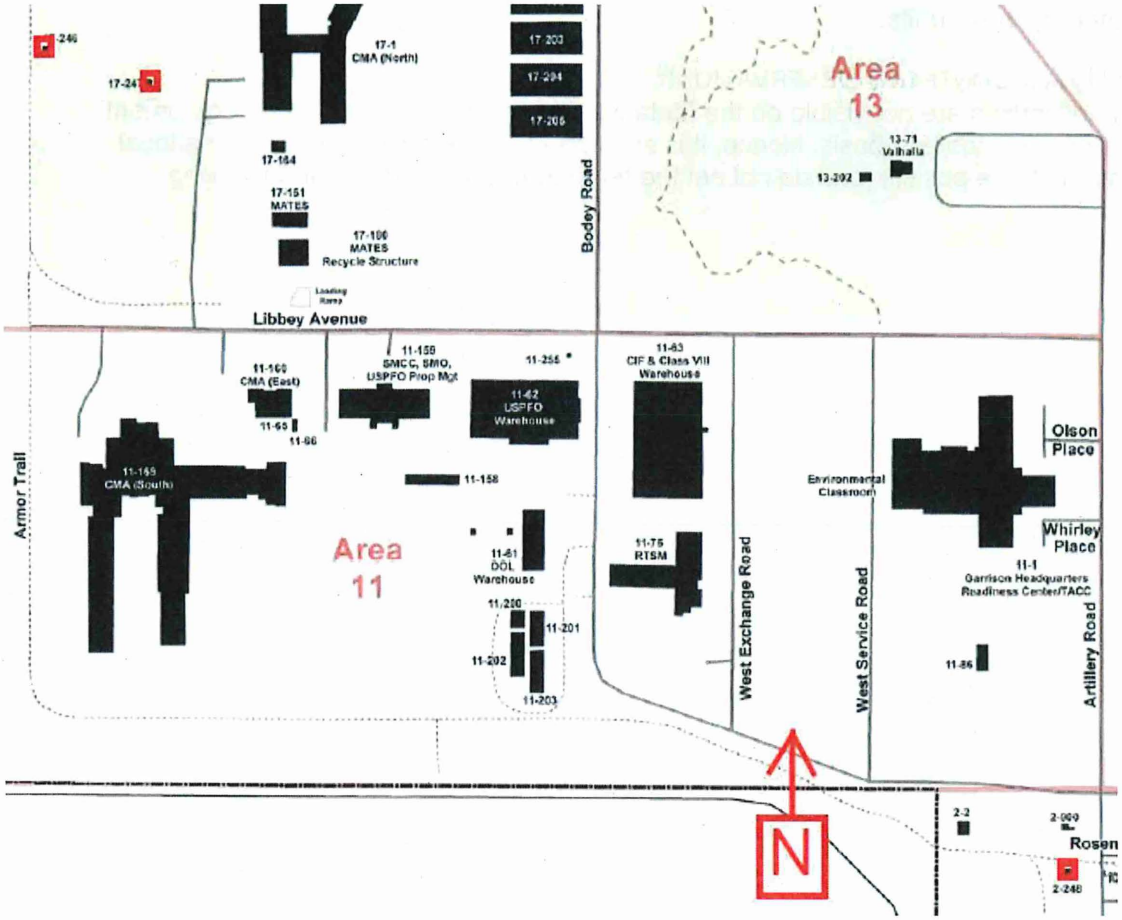
HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by unit heaters and furnaces. Two units for dehumidification serve this facility as well. These constant volume units are capable of heating only via forced air, natural gas fired sections. No outside air is purposefully introduced and heated by these units.

OTHER HVAC CONTROLS OBSERVATIONS:
WWTP Shed is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

WELL PUMP HOUSES (02-248, 17-246, 17-247)

Figure 11: Map; Well Pump House Locations



FACILITY DESCRIPTION

Three Well Pump Houses serve the camp. Each is a single floor facility, one house located in area 2 and two houses in area 17. Each facility is utilized to house pumping equipment dedicated to pumping ground water. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 41. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 41: Well Pump House Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of painted concrete block. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roofs are pitched with the exterior layer consisting of a metal surface. Additional non-visible roof construction material is unknown. Most windows consists partially operable double pane glass within a black aluminum frame.

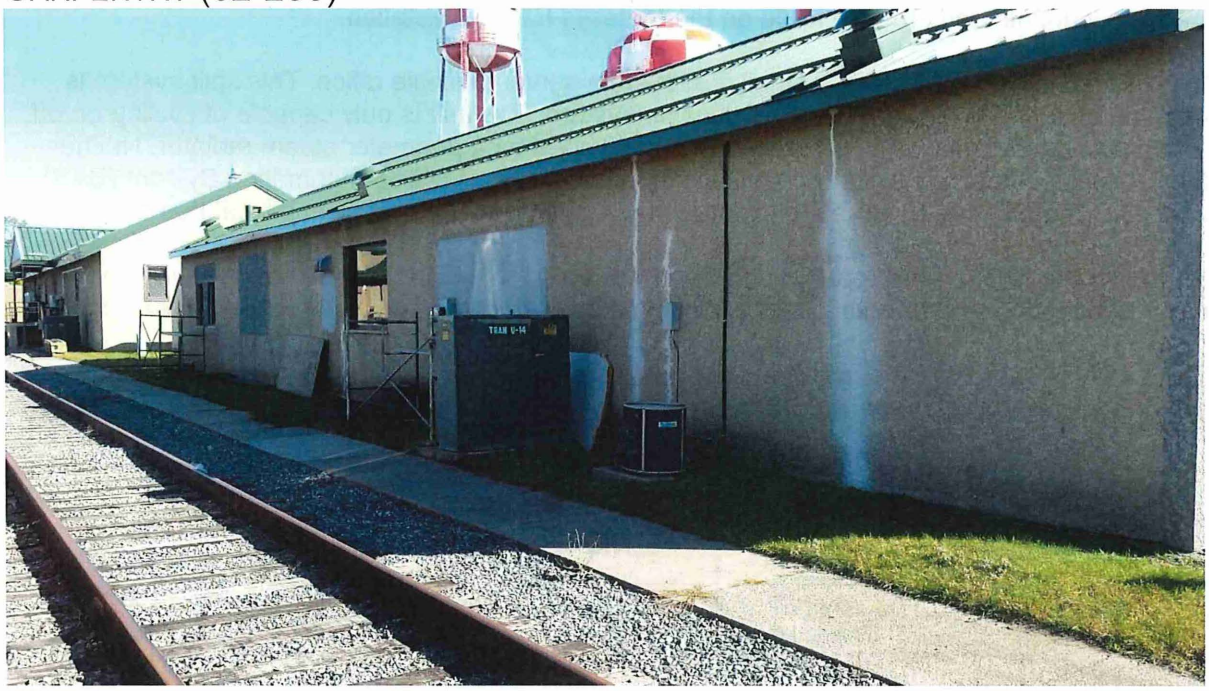
HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by unit heaters. These constant volume units are capable of heating only via forced air, electric fired sections. No outside air is purposefully introduced and heated by these units.

OTHER HVAC CONTROLS OBSERVATIONS:

Well Pump Houses are not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

CARPENTRY (02-266)



FACILITY DESCRIPTION

The Carpentry building is a single story facility in Area 2 of the Camp. The facility is primarily utilized as a wood working shop. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the Carpentry facility is presented in Table 42. Lighting at the Carpentry facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 42: Carpentry Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by a three units heaters located in the main wood shop of the facility. Each unit utilizes a steam coils with two way electronic control valves to provide heat. Each unit consists of a small constant speed fan. None of the units are visible on the Metasys Building Automation System (BAS) workstation and operate on a standalone basis based on feedback from a local thermostat.

Several dust filtration systems exist in the wood shop as well. Each of these are switch operated by the occupants and are not visible on the Metasys BAS workstation.

In addition to the unit heaters, a small split system serves a single office. This split system is capable of cooling only via a direct expansion system. The unit is only capable of cycling on/off and providing constant air volume. Heating is provided by a perimeter steam radiator. Neither the radiator nor the split system are visible on the Metasys Building Automation System (BAS) workstation; both operate on a standalone basis based on feedback from a local thermostat.

Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility.

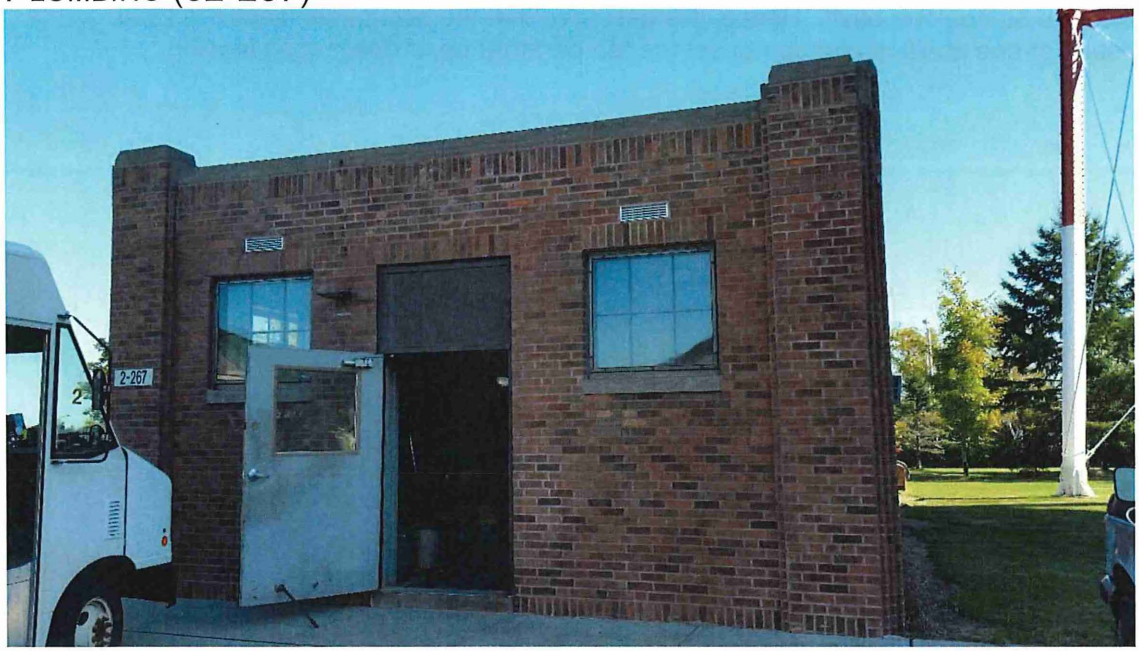
The facility is cooled by a single direct expansion refrigerant system which serves the office split system. The unit has a capacity of 1.5 tons and is not visible on the Metasys BAS workstation.

Table 43: J6-IT Building Condenser Unit

Chiller ID	Chiller Location	Serves	Make	Model Number
COND-1	Outside Ground Level	AHU_OFFICES	Inter-City Products	AD018CD

OTHER HVAC CONTROLS OBSERVATIONS:
The Carpentry facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

PLUMBING (02-267)



FACILITY DESCRIPTION

The plumbing building is a two story facility in Area 2 of the Camp. The facility is primarily utilized as a plumbing shop housing a workstation and storage for parts. The basement of the facility is used for storage and also houses the steam heating system for the neighboring water towers. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the plumbing facility is presented in Table 44. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 44: Carpentry Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Heating is provided via steam fin tube radiators. No outside air is purposefully introduced and conditioned in this facility.

Two small mini direct expansion wall unit are utilized to cool the break room. These constant volume units are capable of cooling only and provide no purposefully introduced outside air.

OTHER HVAC CONTROLS OBSERVATIONS:

The plumbing facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

PUBLIC WORKS (02-268)

FACILITY DESCRIPTION

Public Works is a single story facility in Area 2 of the Camp. The facility is primarily consists of office space. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for public works is presented in Table 45. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 45: Public Works Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist drop ceilings. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by three Fan Coil Units (FCUs). These constant volume FCUs are capable of heating via steam coils. Additional heat is introduced in perimeter zones via steam fin tube radiators. No conditioned ventilated air is purposefully provided by either FCUs or steam fin tube radiators.

A few zones make use of direct expansion units. These constant volume units are capable of cooling only and provide no purposefully introduced outside air.

Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility.

OTHER HVAC CONTROLS OBSERVATIONS:
The public works facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

PAINT SHOP (02-269)

FACILITY DESCRIPTION

The Paint Shop is a single story facility in Area 2 of the Camp. The facility consists of paint workshop areas and storage space for the facility maintenance department. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the paint shop is presented in Table 46. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 46: Paint Shop Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a tan plaster most likely over concrete block walls. Interior wall construction primarily consists of gypsum board (drywall) or wood material. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of a green metal surface. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of hard gypsum board or wood. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Providing heat to the building are perimeter steam fin tube radiators that have been repurposed for hot water via a steam to hot water heat exchanger. A Makeup Air Handling Unit (MAU) provides outside air for painting operation.

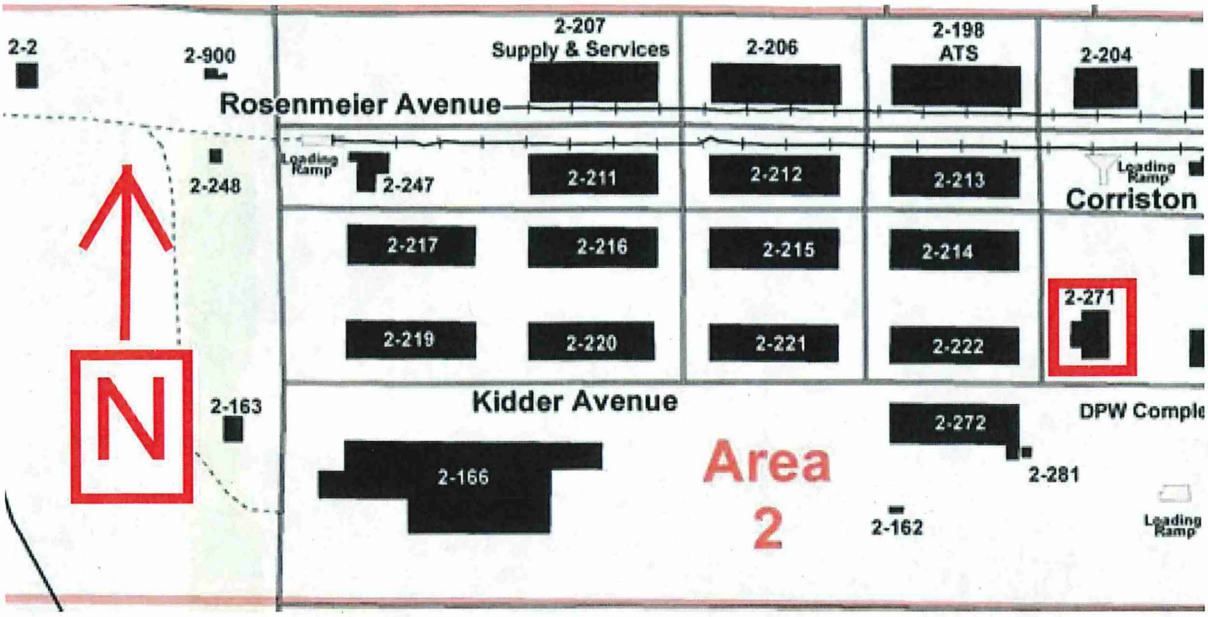
Steam for the facility is provided by the Central Steam Plant (02-246). All fuel consumption required to provide heat for this facility is consumed at the Central Steam Plant (02-246) facility.

OTHER HVAC CONTROLS OBSERVATIONS:

The paint shop is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

GROUND MAINTENANCE (02-271)

Figure 12: Map; Ground Maintenance location in Area 2



FACILITY DESCRIPTION

Ground Maintenance (02-271) is a single floor facility in area 2 of the camp. The facility is primarily utilized to as a work shop with storage area for ground maintenance. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 41. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 47: WWTP Shed Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of a tan plaster most likely over concrete block walls. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of dark grey asphalt shingles. Ceilings of occupied spaces primarily consist of hard gypsum board with occupied office areas consisting of a drop ceiling. Additional non-visible roof construction material is unknown. Most windows consists partially operable double pane glass within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by unit heaters and furnaces. These constant volume units are capable of heating only via forced air, natural gas fired sections. No outside air is purposefully introduced and heated by these units.

OTHER HVAC CONTROLS OBSERVATIONS:

The ground maintenance facility is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

ROADS (02-272)

Figure 13: Picture; Roads

FACILITY DESCRIPTION

Roads (02-272) is a single floor facility in area 2 of the camp. The facility has multiple uses with offices, a work shop, and storage areas primarily with a focus of road maintenance. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 48. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 48: Roads Shed Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of a tan plaster material most likely over concrete block walls. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof is pitched with the exterior layer consisting of dark grey asphalt shingles. Ceilings of occupied spaces primarily consist of hard gypsum board. Additional non-visible roof construction material is unknown. Most windows consists partially operable double pane glass within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by two constant volume Make-up Air Units (MAUs). These MAUs are capable of heating only and do so via force air, natural gas fired sections. A set of exhaust fans relieve air introduced by the MAUs. When ventilated air is not required, due to a lack of emissions from vehicles in the space, unit heaters are available to provide heat. These constant volume unit heaters provide heat via forced air, natural gas fired sections.

Table 49: Roads Make-up Air Unit Information

Equipment	Manufacturer	Serial #	Catalog/Model #	kBTU/hr $_{MAX}$	kBTU/hr $_{MIN}$	Horsepower	CFM
MAU-1	Titan	11918	TA-112 NG HRH AR/80	425,920	17037	3	4400
MAU-2	Titan	11919	TA-112 NG HLH AR/80	290,400	15,000	1.5	3000

As an exception, the offices are served by a single, constant volume split system. This unit is capable of heating via a forced air, natural gas fired section and capable of cooling via a direct expansion refrigerant system.

Table 50: Roads Split System Information

Manufacturer	Model #	Serial #
Lennox	C33-43C-2F-3	6007L04068

OTHER HVAC CONTROLS OBSERVATIONS:

The Roads facility has 144 observable HVAC control points on the Building Automation System (BAS) workstation. A status feedback for MAU2 is in alarm due to a mismatch with command. The reason for this is unknown.

MAUs and associated exhaust fans are controlled based off emissions gas sensors. The last time these sensors were calibrated is unknown. The unit heaters which serve the same space as the MAU are not on the BAS and utilize standalone thermostats. Overhead door lock out of the MAUs does not exist. The split system which serves the offices is also observable on the BAS workstation. Controllers utilize older N2 based communications protocol and bus.

EDUCATION CENTER (06-076)

FACILITY DESCRIPTION

The Education Center building is a two story facility in Area 6 of the Camp which was renovated in the early 1990s. The facility is primarily utilized for teaching consisting primarily of classrooms. Facility hours are based on Building Automation System (BAS) observations and are presented in Table 51. Lighting at the Education facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 51: Education Center Occupancy Schedule

Day	Start Time	End Time
Mon – Sun	4:00 AM	11:00 PM

Exterior wall façade for the facility consists primarily of a tan colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat with the exterior layer consisting of dark grey EDPM (rubber) material. A metal surface was visible in the upper most penthouse floor which is utilized as a mechanical room. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. All windows consists of non-operable double pane glass with grey tint within a black aluminum frame. A ~13'x6' skylight does exist within the main atrium of the facility

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by two, Variable Air Volume (VAV) Air Handling Units (AHUs) located in the penthouse of the facility. Each unit utilizes a chilled water coil with two way pneumatic valve control in order to cool air, and a hot water coil with three way pneumatic valve control to provide heat. Each unit consists of a supply fan and return fan each with a Variable Frequency Drive (VFD). Both VFDs displays were not operating at the time of the audit.

Both units are visible on the Metasys Building Automation System (BAS) workstation; however, the forty three VAV boxes which the unit serves are not visible and are completely controlled by pneumatic systems. Nine additional unit heaters exist within the facility with an unknown service area. Two exhaust fans serve restroom areas.

Table 52: Education Center Air Handling Units

AHU ID	Serves	Make	Model
AHU1	Offices South	Synder General	LYF137DH
AHU2	Offices North	Synder General	LYF137DH

Hot water for facility is produced by two 1,063 kBTU/hr Burnham boilers. Each boiler is served by a dedicated .75 Horse Power (HP) constant volume hot water pump. The hot water distribution system is served by two 1.5 HP constant volume hot water pumps. Pump and boiler status are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building loop.

Table 53: Education Center Boilers

Boiler ID	Boiler Location	Serves	Make	Model Number
BLR-1	Penthouse	HW Loop	Burnham	FD/30
BLR-2	Penthouse	HW Loop	Burnham	FD/30

Table 54: Education Center Hot Water Pumps

Pump ID	Pump Location	Total Discharge Pressure, ft. of Head H20	Pump Design Volumetric Flow Rate, GPM	Impeller Diameter, in.	Pump Motor, HP	Pump Motor Voltage & Phase	Pump Motor Make	Pump Motor Model	Ins. Class
BHWP-1	Penthouse	20.00	60.00	5.00	0.75	200V 3PH	Emerson	P63CZE-3022	B
BHWP-2	Penthouse	20.00	60.00	5.00	0.75	200V 3PH	Emerson	P63CZE-3022	B
HWP-1	Penthouse	30.00	75.00	6.00	1.5	200V 3PH	Emerson	P63CZC-3020	B
HWP-2	Penthouse	30.00	75.00	6.00	1.5	200V 3PH	Emerson	P63CZC-3020	B

Chilled water for the facility is produced by a single 100 ton air cooled Trane chiller unit. Name plate information for the Trane unit was erased by UV exposure. An operations manual was found designating the unit as an RTAA model. The chiller and distribution system is served by

two constant volume chilled water pumps. Chiller and pump status are visible on the Metasys BAS workstation along with return and supply chilled water temperatures for the building loop.

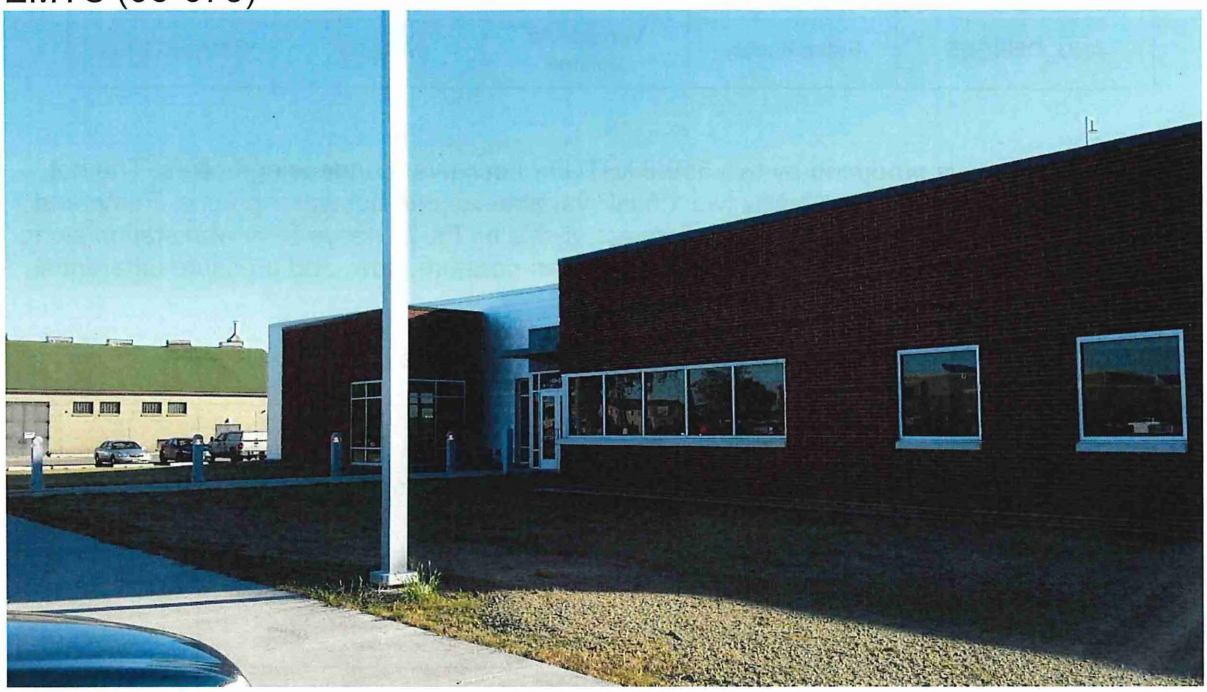
Table 55: Education Center Chilled Water Pumps

Pump ID	Pump Location	Total Discharge Pressure, ft. of Head H20	Pump Design Volumetric Flow Rate, GPM	Impeller Diameter, in.
CHWP-1	Penthouse	35.00	244.00	8.00
CHWP-2	Penthouse	16.00	244.00	5.50

OTHER HVAC CONTROLS OBSERVATIONS:

Since zone temperature are not visible on the front end and are controlled pneumatically it is assumed that zone temperatures are held constant throughout the facility. BAS observations and utility consumption observations confirm the use of lockout temperatures for both chilled water and hot water systems. This indicates that use of reheat during the cooling season is negligible. The outside air damper for the AHUs seem to control to ~20% during occupied hours. The occupancy schedule within the BAS for this facility is extended beyond the typical 8AM-5PM Monday through Friday occupancy observed throughout the camp. Reasons for this are unknown.

EMTC (06-078)



Facility Description

The EMTC building is a three year old single story facility in Area 6 of the Camp. The facility is primarily utilized for teaching management in emergency situations consisting primarily of classrooms. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the EMTC facility is presented in Table 56. Lighting at the EMTC facility is primarily provided by newer LED fixtures.

Table 56: EMTC Building Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of a light red colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat with the exterior layer consisting of EDPM (rubber) white material. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. All windows consists of non-operable double pane glass with grey tint within a aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by single, Variable Air Volume (VAV) Air Handling Unit located in the penthouse of the facility. The unit utilizes a chilled water coil with three way electronic valve control in order to cool air and a hot water coil with two way electronic valve control to provide heat. The unit consists of a supply fan and return fan each with a Variable Frequency Drive (VFD). The unit is available for observation on the Metasys Building Automation System (BAS) workstation.

Table 57: EMTC Building Air Handling Units

AHU ID	Serves	Type	Make	Model Number
AHU_OFFICES	Entire Facility	Variable Air Volume	McQuay	CAH058GDDM

Hot water for facility is produced by two 559.8 kBTU/hr Lochinvar condensing boilers. The hot water distribution system is served by two 1.5 HP variable volume hot water pumps. Pump and boiler status along with other load parameters are visible on the Metasys BAS workstation along with return hot water temperature, supply hot water temperature, flow, and pressure differential for the building loop.

Table 58: EMTC Building Boilers

Boiler ID	Boiler Location	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency	Minimum Turndown Ratio
BLR-1	Penthouse Mech Room	Lochinvar	Knight XL	559.8	93%	20%
BLR-2	Penthouse Mech Room	Lochinvar	Knight XL	559.8	93%	20%

Table 59: EMTC Building Hot Water Pumps

Pump ID	Pump Location	Pump Make	Pump Model Number	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
HWP-1	Penthouse	Bell & Gossett	1510 B	60.00	1,800.00	120.00
HWP-2	Penthouse	Bell & Gossett	1510 B	60.00	1,800.00	120.00

Table 60: EMTC Building Hot Water Motor Pumps

Pump ID	Pump Location	Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model
HWP-1	Penthouse	1.5	200	89.50%	WEG	00518OT3P184T
HWP-2	Penthouse	1.5	200	89.50%	WEG	00518OT3P184T

Chilled water for the facility is produced by a single 70 ton air cooled York chiller unit. The chiller and distribution system is served by two 6 horse power (HP) variable volume chilled water pumps. Chiller and pump status along with other load parameters are visible on the Metasys

BAS workstation along with return chilled water temperature, supply chilled water temperature, flow, and pressure differential for the building loop.

Table 61: EMTC Building Chillers

Chiller ID	Chiller Location	Serves	Make	Model Number	Type	Chiller Capacity, Tons	Refrigerator Type	Chiller Efficiency, COP
CH	North Exterior	CHW Loop	York	YLAA0070SE17	Air Cooled Scroll	70	R410A	3.04

Table 62: EMTC Building Chilled Water Pumps

Pump ID	Pump Location	Serves	Pump Make	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
CHWP-1	Penthouse	CHW Loop	Bell & Gossett	55.00	1,800.00	155.00
CHWP-2	Penthouse	CHW Loop	Bell & Gossett	55.00	1,800.00	155.00

Table 63: EMTC Building Chilled Water Pumps Motors

Pump ID	Pump Location	Serves	Pump Make	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
CHWP-1	Penthouse	CHW Loop	Bell & Gossett	55.00	1,800.00	155.00
CHWP-2	Penthouse	CHW Loop	Bell & Gossett	55.00	1,800.00	155.00

OTHER HVAC CONTROLS OBSERVATIONS:

The EMTC building is fairly new, hence, the BAS architecture and number of HVAC control points is extensive. Subsequent energy savings controls sequences such as: night setup and setback, economizing, and outside air ventilation control, have been verified as functioning based on BAS workstation observations.

PX (07-067)

Facility Description

PX (07-067) is a single floor facility in Area 7 of the Camp. The facility is utilized for multiple purposes; a large partition of the facility is utilized as a convenience store. In addition, both a small deli and barbershop exist along with other typical building features such as restrooms, lobbies, and mechanical rooms. Facility hours for the convenience store are equivalent to typical occupancy hours across the camp which are listed in Table 64. As an exception, the deli is only open during the training sessions which occur during summer. The barber shop only operates regularly three days a week. Lighting at the PX is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 64: PX Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade for the facility consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is pitched, exterior roofing material consist of dark grey asphalt shingles. Interior ceiling construction consist of gypsum board of unknown thickness. 12" of batt insulation is assumed to exist in the attic based on observations of similar facilities. Additional non-visible roof construction material is unknown. Most windows consists of operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. The convenience store is served by a constant volume, single zone Air Handling Unit (AHU). This

AHU is capable of heating via a forced air, natural gas fired section, and capable of cooling via a direct expansion system. The system is not on the BAS workstation and utilizes a standalone programmable thermostat for feedback.

Tons	Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
10	Condensing Unit	Trane	TTA120B300BB	K434K7SAH	208-230/3Ø/60
Compressor			Condenser Fan		
Qty	RLA (EA)	LRA (EA)	Qty	Horsepower (EA)	FLA (EA)
2	18.7	118	1		6

The barber shop is served by three electric radiation units which are controlled by a local thermostat.

The deli is served by a rooftop unit. This constant volume RTU is capable of heating via a forced air, natural gas fired section and capable of cooling via a direct expansion system. The system is not on the BAS workstation and utilizes a standalone programmable thermostat for feedback. This RTU also serves the facility main lobby.

The convenience store does house 15 large refrigeration units for food preservation.

OTHER HVAC CONTROLS OBSERVATIONS:
The standalone programmable thermostat for the deli was behind a refrigeration unit. This can cause issues since the refrigeration unit rejects heat to the space, this waste heat can cause erroneous warm conditions near the thermostat. In addition, this section of the building is very seasonal, the unit would make it harder for occupants to set the unit to a permanent unoccupied mode once training sessions are over.

UNIT HOUSING 7 SERIES TYPE (07-131 THROUGH 07-135)

Facility Description

The unit housing facilities 07-131 through 07-135 are two floor facilities in Area 7 of the camp. These facilities are primarily utilized as barracks or dormitories during training periods at the camp. Facility hours are not equivalent to the typical hours observed at the camp, because training sessions generally only occur between March and November. Even though reserved, the Guardsmen tend to be out training throughout most of the drill period and only return to the facility to shower, eat breakfast or dinner, and sleep at the start and end of the two-week exercises. Unit housing type 10 facilities primarily utilize 28W-32W T8 fluorescent fixtures for lighting. At some of the facilities LED exterior lighting were observed.

Exterior wall façade consists primarily of grey concrete blocks of unknown thickness and fill. Interior wall construction primarily consists of the same grey concrete blocks of unknown thickness and fil. Additional wall construction layers which are not visible are unknown. The roof for the facilities are pitched with the exterior layer consisting of dark grey asphalt shingles. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of concrete slab. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location each facility. Sleeping quarters are served by eight split systems. They are capable of heating via hot water coils with two way electronic valve control and cooling via a direct expansion systems. These units do have return and outside air dampers to regulate ventilation provided; however, these are two position dampers only and move to set position when the unit is turned on and close when the unit is off.

Latrines or shower/bathrooms are served by two constant volume units capable of heating only via hot water coils. These units have no pathway for outside air. Two exhaust fans exist serving the upstairs and downstairs latrine areas.

Hallways are served by constant volume fan coil units capable of heating only. No control valve was observable along the piping leading to the units. These units do not provide any form of ventilation.

The dining area is served by a constant volume, single zone air handler unit. This unit provides heating only via a forced air natural gas fired section. These units do have return and outside air dampers to regulate ventilation provided; however, these are two position dampers only and move to set position when the unit is turned on and close when the unit is off. The orderly room is served by an additional unit similar to the unit which serves the dining area. The unit itself doesn't provide any cooling; however, a mini split system exist to reject some heat.

The kitchen is served by a packaged constant volume Make-up Air Unit (MAU). This MAU is the only unit to entirely reside outside of the facility. The unit is capable of heating only via a forced air natural gas fired section. An outside air damper does exist, however, no form of return air is available to the unit; hence, this damper is assumed to close only when the unit is off to avoid unwanted air making its way to the space. The kitchen utilizes a single exhaust fan to relieve air.

Hot water for each facility is produced by two 856 kBTU/hr Burnham conventional hot water boilers. Two, three Horse Power (HP) constant volume pumps serve the distribution system.

Table 65: Unit Housing Type 7 Boiler Information

Equipment	Manufacturer	Model #	Btuh OUT	Btuh NET	Btuh IN
Boiler	Burnham	FD/24 34000902	856,000	744,000	1,056,000
Boiler	Burnham	FD/24 34000902	856,000	744,000	1,056,000

Table 66: Unit Housing Type 7 Hot Water Pump Information

Label	Manufacture	Model #	Horsepower	Flow Rate, gpm	Pressure Differential, ft H20
HWP-1	Bell & Gossett	3X7B 6.625 BF	3	213	32
HWP-2	Bell & Gossett	3X7B 6.625 BF	3	213	32

No chilled water is produced at the facilities. All cooling is provided by direct expansion systems.

Table 67: Unit Housing Type 7 Condensing Unit Information

Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
Condensing Unit	Lennox	SSB036H4S41Y	5807A04032	208-230/3Ø/60
Condensing Unit	Lennox	SSB036H4S41Y	5806M17126	208-230/3Ø/60
Condensing Unit	Lennox	SSB036H4S41Y	5807A04028	208-230/3Ø/60
Condensing Unit	Lennox	SSB036H4S41Y	5807A04031	208-230/3Ø/60
Condensing Unit	Lennox	SSB036H4S41Y	5807A0403-	208-230/3Ø/60

Condensing Unit	Lennox	SSB036H4S41Y	5807A46153	208-230/3Ø/60
Condensing Unit	Lennox	SSB036H4S41Y	5807A46151	208-230/3Ø/60
Condensing Unit	Carrier	38CKC036510	1200E19849	208-230/3Ø/60
Condensing Unit	Carrier	38AKS008---501--	2900G00007	208-230/3Ø/60

OTHER HVAC CONTROLS OBSERVATIONS:

HVAC equipment utilize older controllers which make use of N2 bus communications. These units are visible on the BAS workstation and can be commanded to be in an occupied or unoccupied state. However, the end user has the ability to actuate a switch on the site which overrides this signal. Most observed cases had the override forcing the facility into an occupied state even though the facility was unoccupied.

SNACK BAR (08-022)

FACILITY DESCRIPTION

Snack Bar (08-022) is a single floor facility in Area 8 of the Camp. The facility is utilized primarily as a fast food restaurant with most of the building area dedicated to kitchen functions and a dining area. Facility hours for the snack bar are equivalent to typical occupancy hours across the camp which are listed in Table 68. Lighting at the snack bar is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 68: Snack Bar Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade for the facility consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is pitched, exterior roofing material consist of dark grey asphalt shingles. Interior ceiling construction consist of gypsum board of unknown thickness. 12" of batt insulation is assumed to exist in the attic based on observations of similar facilities. Additional non-visible roof construction material is unknown. Most windows consists of operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location within the facility. The kitchen area is served by two Make-up Air Units (MAUs). These constant volume MAUs are capable of heating only via forced air, natural gas fired sections. The MAUs provide 100% outside air. Two exhaust hoods also serve the kitchen area. MAUs are controlled by standalone thermostats.

The dining area and offices are served by two constant volume Air Handling Units. These AHUs are capable of heating via forced air, natural gas sections and cooling via direct expansion systems. AHUs are controlled by standalone thermostats. These AHUs are capable of controlling return air and outside air dampers to modulate the amount of ventilation air conditioned.

Table 69: Snack Bar Make-up Air Unit Information

Equipment	Manufacturer	Model #	Serial #	BTU/hr MIN	BTU/hr IN	V/Ph/Hz
MAU	King*	DFOC 118A HPS	89-DF-5407	11,000	450,000	208-230/3Ø/60
MAU	Greenheck	-	-	-	275,000	-

Table 70: Snack Bar Air Handler Unit Information

Equipment	Manufacturer	Model #	Serial #
AHU-1 Evap Coil	Lennox	CX34-50/60C-6F	6006B82110
AHU-2 Evap Coil	Lennox	CX34-50/60C-6F	6006B82114

No hot water or steam is produced at the Snack Bar for the purpose of building heat.
No chilled water is produced at the Snack Bar. All cooling is rejected via the use of direct expansion systems.

Table 71: Snack Bar Condensing Units

Manufacturer	Model #	Serial #	V/Ph/Hz	Compressor		
				Qty	RLA (EA)	LRA (EA)
Lennox	XC13-060-230-01	5806C07263	208-230/1Ø/60	1	26.28	134
Lennox	XC13-060-230-01	5806C07266	208-230/1Ø/60	1	26.28	134

OTHER HVAC CONTROLS OBSERVATIONS:
The MAUs which serve the kitchen are not interlocked with the exhaust hoods. Hence, the MAUs can operate without the exhaust hoods running causing a large positive building pressure, or the exhaust hoods can operate without the MAUs running causing a large negative building pressure. MAUs discharge air register delivers air onto the food pre area instead of near kitchen heating elements which is more typical.

The control wiring for the AHUs which serve the dining area and offices have been modified. As such, the units no longer have an auto mode, staff must operate the units in hand to ensure the space is comfortable. Furthermore, economizer controls for the units has been disabled even though dampers are in place for free cooling to occur.

TMC (08-081)

Figure 14: Picture; TMC

Facility Description

TMC (08-081) is a single floor facility in Area 8 of the Camp. The facility is utilized primarily as an outpatient medical facility. Facility hours for the TMC are equivalent to typical occupancy hours across the camp which are listed in Table 72. Lighting at the TMC is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 72: TMC Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of tan colored brick masonry. Interior wall construction primarily consists of concrete blocks. Drawings indicate that at least 1" of fiber board insulation material exists within the exterior walls. The roof for the facility is pitched, exterior roofing material consist of a green metal material. Interior ceiling construction consist of a hanging ceiling with acoustic tiles. 12" of batt insulation exist in the attic based on drawing observations. Most windows consists of operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems is mainly provided by eight constant volume split systems. These constant volume split systems are capable of heating via forced air, natural gas fired sections and cooling via direct expansion systems. Two of these split systems are newer where the units heating sections which are capable of condensing waste heat gases; in addition, newer units are capable of economizing or free cooling with outside air when conditions are ideal. The six older units utilize conventional natural gas fired sections and utilize two position outside air dampers for ventilation.

No hot water or steam is produced at TMC for the purpose of building heat. Natural gas fired furnaces provide all building heat for the facility.

Table 73: TMC Furnace Information

Equipment	Manufacturer	Model #	Serial #	MBtuh IN	MBtuh OUT
Older Furnaces Typical of 6	Lennox	G2005/6E-125-4	5893B12755	125,000	97,500
Newer Furnaces Typical of 2	Bryant	355AAV060120FCSA	3808A04206	120,000	78,000

No chilled water is produced at TMC. All cooling is rejected via the use of direct expansion systems.

Table 74: TMC Condensing Units

Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz	Compressor		
					Qty	RLA (EA)	LRA (EA)
Condensing Unit 1	Lennox	HS14-513U-7Y	5192A20980	208-230/3Ø/60	1	15.8	85
Condensing Unit 2	Lennox	HS14-513U-7Y	5192C18118	208-230/3Ø/60	1	15.8	85
Condensing Unit 3	Lennox	HS14-653U-8Y	5192L11980	208-230/3Ø/60	1	22.6	110
Condensing Unit 4	Lennox	HS14-413U-8Y	5193C18014	208-230/3Ø/60	1	12.7	60
Condensing Unit 5	Lennox	HS14-413U-8Y	5193C18010	208-230/3Ø/60	1	12.7	60
Condensing Unit 6	Lennox	HS14-413U-8Y	5193C18012	208-230/3Ø/60	1	12.7	60
Condensing Unit 7	Bryant	187ANA060000CBAA	2506E17038	208-230/3Ø/60	1	25.7	130
Condensing Unit 8	Bryant	187ANA048000CBAA	3208E16507	208-230/3Ø/61	1	18.6	105

OTHER HVAC CONTROLS OBSERVATIONS:
All units utilize standalone programmable thermostat for zone temperature feedback.

AIR TRAFFIC CONTROL TOWER (08-192)

Figure 15: Picture; Air Traffic Control Tower

FACILITY DESCRIPTION

Air Traffic Control Tower (08-192) is a four floored facility in area 8 of the camp. The facility is primarily utilized for aircraft operation and also contains storage areas. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 77. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 75: Air Traffic Control Tower Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of grey concrete block with metal siding. Interior wall construction primarily consists of concrete masonry as well. Additional wall construction layers which are not visible are unknown. The roof for remaining sections of the facility is flat; exterior roofing construction material for flat areas consists of dark grey EPDM (rubber) material.. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

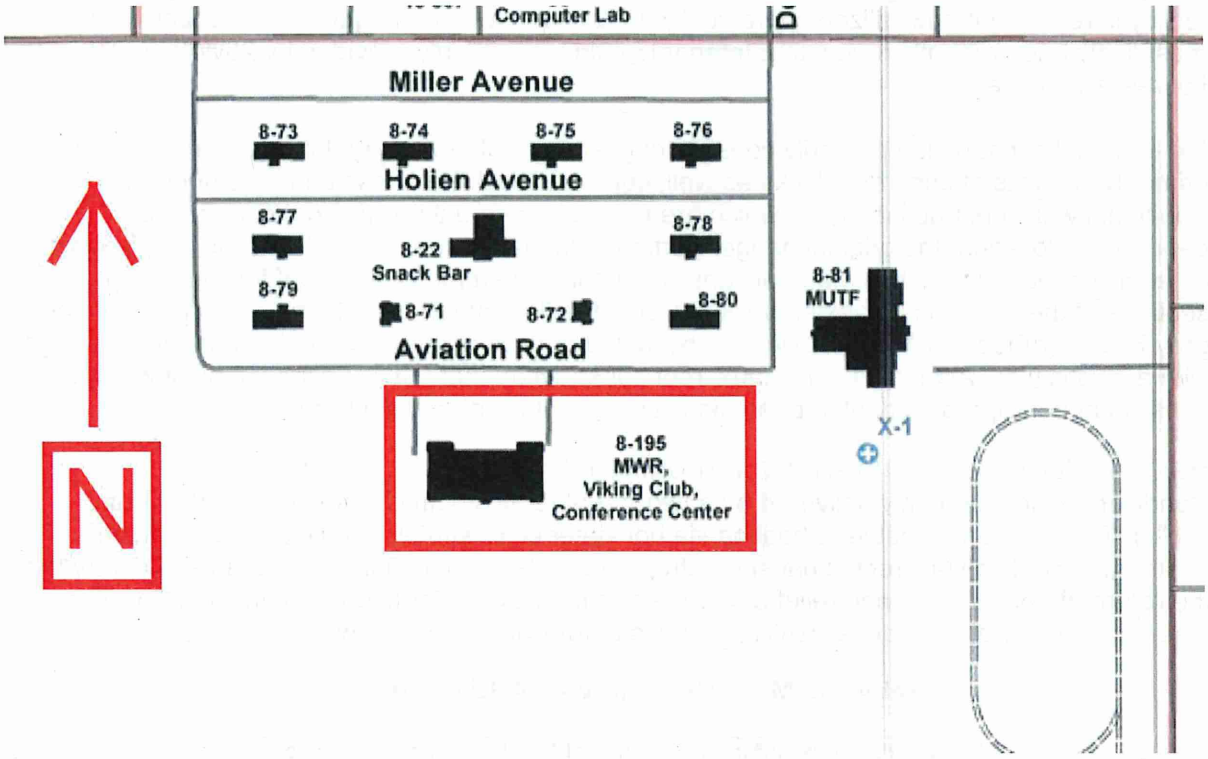
The top of the control tower is conditioned by two mini split systems that provide cooling. Heating the space are two electrical radiators. A gas fired constant volume furnace provides conditioning to the lower level of the tower.

OTHER HVAC CONTROLS OBSERVATIONS:

The Air Traffic Control Tower is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

MWR BUILDING (08-195)

Figure 16: Map; MWR Building location in Area 8



Facility Description

MWR (08-195) is a single floor facility in area 8 of the camp. The facility is primarily utilized as an event space consisting of several bars, a kitchen, and three large sitting or dining areas. The facility is rented out and utilized sporadically. Based on the age of equipment the facility has most likely been recently renovated. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Exterior wall construction primarily consists of grey concrete masonry. Interior wall construction primarily consists of concrete blocks as well; concrete block thickness and fill is unknown. Additional wall construction layers which are not visible are unknown. Roof construction depends on location, the original hanger portion of the facility has an arched roof. The hanger exterior roofing construction material consists of corrugated metal. The roof for remaining sections of the facility is flat; exterior roofing construction material for flat areas consists of dark grey EPDM (rubber) material. Ceilings of occupied spaces primarily consists of hanging ceilings with acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by a two Variable Air Volume (VAV) Air Handler Unit (AHU). The units are capable of heating via hot water coils with electronic three way valve control and cooling via direct expansion refrigerant systems. The units are capable of controlling the return air, outside air, and relief air dampers thus allowing for fine ventilation control. The type and number of VAV boxes which the units deliver air to is unknown.

Table 76: MWR Building VAV AHU Information

Unit ID	Manufacture	Model Number	Serial Number
EAST VAV	Trane	MCCB017UA0C0UA	K08L28186A
WEST VAV	Trane	MCCB017UA0C0UB	K08L28178A

Hot water is produced by two Lochinvar condensing boilers of unknown capacity. Each boiler has a dedicated constant volume hot water pump. In addition, the distribution system is served by two, variable volume, two horsepower (HP) pumps.

Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
Condensing Unit	RUUD	UAND-048JAZ	7303 M0207 06228	208-230/1Ø/60
Condensing Unit	RUUD	UAND-048JAZ	7303 M0207 06239	208-230/1Ø/60
Condensing Unit	JCI	J30YDCOOA2AAA1A	N1B2566693	208-230/3Ø/60
Condensing Unit	JCI	J25YCCOOA2ALC1A	N1B2567309	208-230/3Ø/60

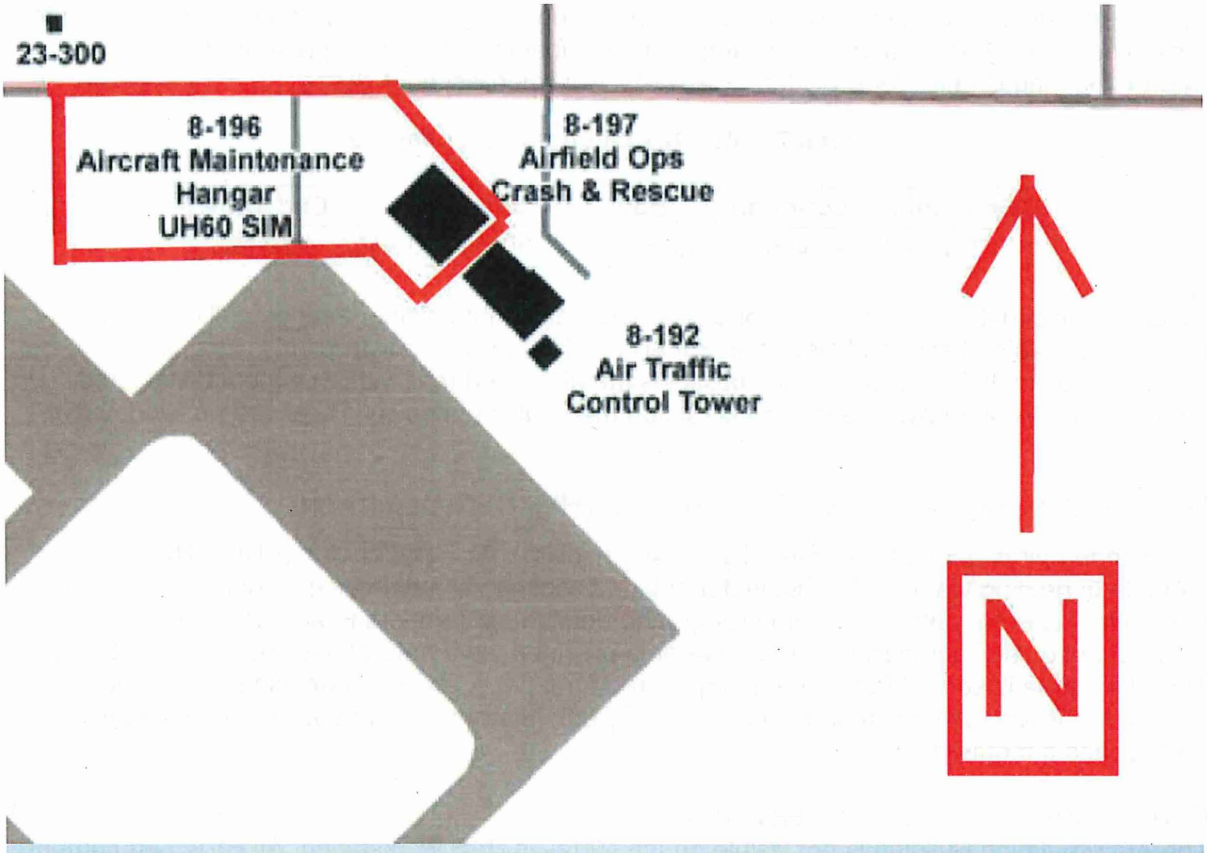
Equipment	Manufacturer	Model #	Serial #	Btuh $_{IN}$
Furnace	RUUD	UGFD-09EZCMS	FK5D701F020702502	90,000
Furnace	RUUD	UGFD-09EZCMS		90,000

Other HVAC Controls Observations:

All HVAC equipment within this facility is electronically controlled.

AIR SIMULATION BUILDING (08-196)

Figure 17: Map; Air Simulation Building location in Area 8



Facility Description

Air Ops Building (08-196) is a single floor facility in area 8 of the camp. The facility is primarily utilized as training space for aircraft operation. The space consists of a large open area that houses the aircraft simulation, office spaces, and a data center. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 77. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 77: Air Ops Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of grey aluminum siding. Interior wall construction primarily consists of exposed insulation panels. Additional wall construction layers which are not visible are unknown. The roof for the facility is metal pitched roof with an exposed insulated interior. Additional non-visible roof construction material is unknown. There are no windows in the facility.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by constant volume Air Handler Unit (AHU). This unit is capable of heating via a ducted hot water coil and cooling via a direct expansion condensing unit. This unit is capable of actuating return and outside air dampers to alter the amount of conditioned outside air introduced. Hot water is provided via a natural gas fired hanging boiler. The office area is served from a natural gas fired furnace. A single condensing unit provides cooling to the aircraft simulator. Natural gas fired unit heaters provide additional heating to the open space if required.

Other HVAC Controls Observations:

The Air Simulation Building is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

AIR OPS / CRASH RESCUE (08-197)

Figure 18: Picture; Air Ops / Crash Rescue

FACILITY DESCRIPTION

Air Ops / Crash Rescue (08-196) is a single floor facility in area 8 of the camp. The facility is primarily utilized for aircraft operation and also houses garage space for fire and emergency services. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 77. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 78: Air Traffic Control Tower Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of grey concrete block. Interior wall construction primarily consists of concrete masonry as well. Additional wall construction layers which are not visible are unknown. The roof for remaining sections of the facility is flat; exterior roofing construction material for flat areas consists of dark grey EPDM (rubber) material. Ceilings of occupied spaces primarily consists of hanging ceilings with acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air is primarily delivered by constant volume Air Handler Units (AHUs) for the office area. These units are capable of heating via forced air, natural gas fired sections and cooling via a direct expansion condensing unit. This unit is capable of actuating return and outside air

dampers to alter the amount of conditioned outside air introduced. Infrared heating serves the garage space in this facility.

OTHER HVAC CONTROLS OBSERVATIONS:
The Air Traffic Control Tower is not visible on the Metasys BAS workstation. All HVAC equipment operates on a standalone basis. Hence, it is assumed that the occupants leave the local thermostats at one position and do not set the temperature up or down upon leaving.

UNIT HOUSING 10 AND 9 SERIES TYPE (10-137 THROUGH 10-144 AND 09-131 THROUGH 09-135)

FACILITY DESCRIPTION

The unit housing facilities 10-137 through 10-133 and 09-131 through 09-135 are two floor facilities in Area 10 and 9 of the camp. These facilities are primarily utilized as barracks or dormitories during training periods at the camp. Facility hours are not equivalent to the typical hours observed at the camp; training sessions generally only occur between March and

November. Occupants tend to be out training throughout most of the two-week drill period and only return to the facility to shower, eat breakfast or dinner, and sleep at the start and completion of that exercise interval. Unit housing type 10 facilities primarily utilize 28W-32W T8 fluorescent fixtures for lighting. At some of the facilities LED exterior lighting was observed.

Exterior wall façade consists primarily of grey concrete blocks of unknown thickness and fill. Interior wall construction primarily consists of the same grey concrete blocks of unknown thickness and fil. Additional wall construction layers which are not visible are unknown. The roof for the facilities are pitched with the exterior layer consisting of dark grey asphalt shingles. Within the attic space 12" of batt insulation is assumed based on observations of other similar facilities, although not directly observed here. Ceilings of occupied spaces primarily consist of concrete slab. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location within the facility. Sleeping quarters are served by eight split systems. They are capable of heating via condensing, forced air natural gas fired sections and cooling via direct expansion systems. These units do have outside air dampers to regulate ventilation provided; however, these are two position dampers only and move to set position when the unit is turned on and close when the unit is off.

Latrines or shower/bathrooms are served by two constant volume units capable of heating only via hot water coils. These units do have return and outside air dampers to regulate ventilation provided; however, these are two position dampers only and move to set position when the unit is turned on and close when the unit is off.

Hallways are served by constant volume fan coil units capable of heating only. No control valve was observable along the piping leading to the units. These units do not provide any form of ventilation.

The dining area is served by a constant volume, single zone air handler unit. This unit provides heating only via a forced air natural gas fired section. These units do have return and outside air dampers to regulate ventilation provided; however, these are two position dampers only and move to set position when the unit is turned on and close when the unit is off.

The kitchen is served by a packaged constant volume Make-up Air Unit (MAU). This MAU is the only unit to entirely reside outside of the facility. The unit is capable of heating only via a forced air natural gas fired section. An outside air damper does exist, however, no form of return air is available to the unit; hence, this damper is assumed to close only when the unit is off to avoid unwanted air making its way to the space.

Hot water is produced at each facility by a single Lochinvar Knight condensing hot water boiler. The distribution system is served by two small constant volume hot water pumps.

No chilled water is produced at the facilities. All cooling is provided by direct expansion systems.

Table 79: Unit Housing 10 and 9 Series Type Condensing Unit Information [Typical]

Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
Condensing Unit	Lennox	SSA036H4--3Y	5807A46173	208-230/3Ø/60

Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
Condensing Unit	Lennox	SSA036H4--3Y	5807A46171	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46163	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46159	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46166	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46174	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46155	208-230/3Ø/60
Condensing Unit	Lennox	SSA036H4--3Y	5807A46169	208-230/3Ø/60
Heat Pump	Daikin	RXS09DVJU	E000432	208-230/1Ø/60

OTHER HVAC CONTROLS OBSERVATIONS:

HVAC equipment utilize older controllers which make use of N2 bus communications. These units are visible on the BAS workstation and can be commanded to be in an occupied or unoccupied state. However, the end user has the ability to actuate a switch on the site which overrides this signal. Most observed cases had the override forcing the facility into an occupied state even though the facility was unoccupied.

TACC (11-001)

Facility Description

The TACC (11-001) building is a single story facility in Area 11 of the Camp which has been recently remodeled. The facility is a multipurpose facility consisting of offices, conferences rooms, classrooms and some restricted specialized areas. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule for the TACC facility is presented in Table 80. Lighting at the TACC facility is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 80: TACC Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of tan concrete masonry. Interior wall construction primarily consists of concrete masonry as well. Additional wall construction layers which are not visible are unknown. The roof is flat with the exterior layer consisting of a dark grey EPDM (rubber) material. Ceilings of occupied spaces primarily consist of acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists of partially operable double pane glass with grey tint within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by a numerous rooftop units (RTUs). Each constant volume RTU is consists of a reversible direct expansion system, often referred to as heat pumps. These heat pumps reject or accept heat to a single water loop. This water loop is capable of rejecting or accepting heat from the earth via a series of entrenched piping runs. An

additional hot water boiler exist to supplement the loop if ground conditions cannot maintain the loop at a temperature set point.

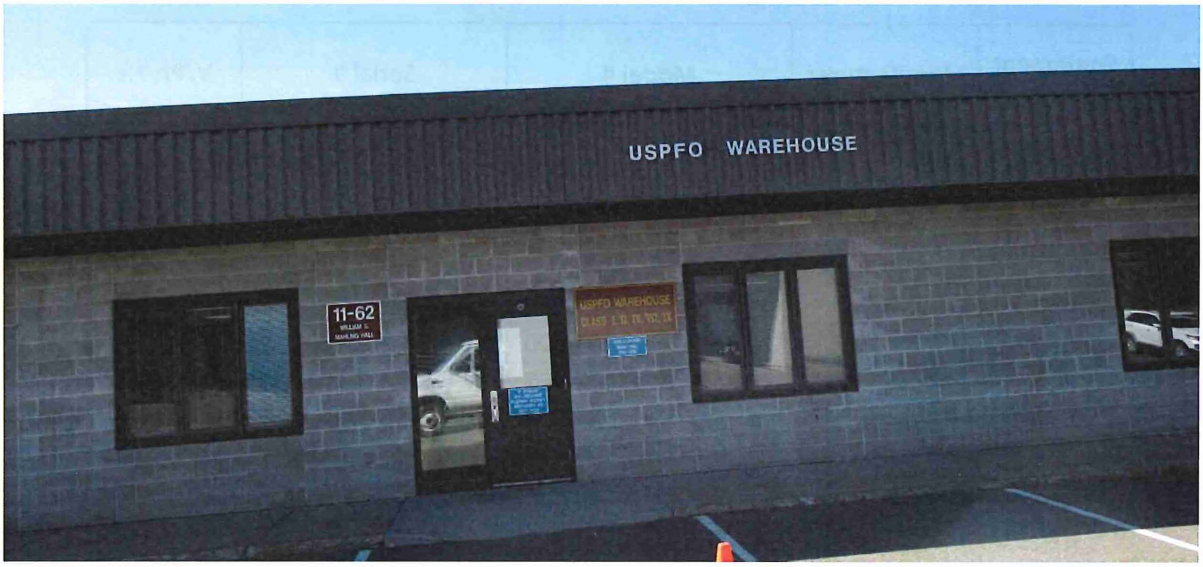
Equipment	Manufacturer	Model #	Serial #	V/Ph/Hz
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02002	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	---	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC01998	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02003	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02000	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02001	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02004	208/3Ø/60
RTU	AAON	RQ-002-8-V-G702-000	201502-AYCB02005	208/3Ø/60
RTU	AAON	RQ-002-8-V-G702-000	201502-AYCB02006	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02007	208/3Ø/60
RTU	AAON	RQ-002-8-V-G702-000	201502-AYCB02008	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02009	208/3Ø/60
RTU	AAON	RQ-006-8-V-E709-000	201502-AYCF02013	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02015	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02017	208/3Ø/60
RTU	AAON	RQ-002-8-V-G702-000	201502-AYCB02016	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02014	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02011	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02012	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02020	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02023	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02022	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02021	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02019	208/3Ø/60
RTU	AAON	RQ-003-8-V-E709-000	201502-AYCC02018	208/3Ø/60
RTU	AAON	RN-016-8-0-E709-000	201501-BNCM09124	208/3Ø/60
RTU	AAON	RQ-004-8-V-E709-000	201502-AYCD02010	208/3Ø/60
RTU	AAON	RM-004-8-0-AB01-000	200501-AMCD01601	208/3Ø/60

OTHER HVAC CONTROLS OBSERVATIONS:

The TACC facility has been recently remodeled, as such, the BAS architecture and number of controllable HVAC points is extensive. Subsequent energy savings controls sequences such as: night setup and setback, economizing, and outside air ventilation control, have been verified as functioning based on BAS workstation observations.

USPFO WAREHOUSE (11-062)

Figure 19: Picture; USPFO Warehouse



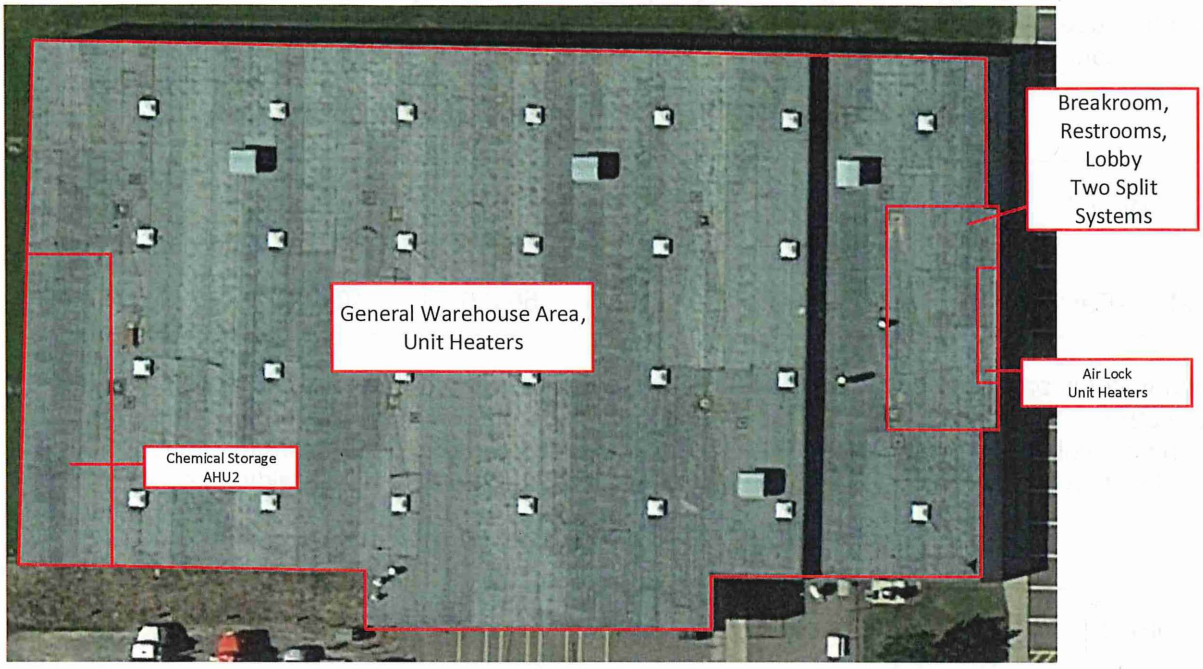
FACILITY DESCRIPTION

The USPFO Warehouse (11-062) is a single floor facility in Area 11 of the Camp. The facility is primarily dedicated to storage and distribution of mostly non-perishable and non-volatile items. Figure 20 shows a satellite image with partitions shown dependent on HVAC service area and space use type. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for the USPFO Warehouse are listed in Table 81. Lighting at the USPFO Warehouse is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown. Sky lighting does exist within the general warehouse area.

Table 81: Maintenance Shop Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Figure 20: USPFO Warehouse HVAC and Space Map



Exterior wall façade consist primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of a black EPDM (rubber) material. Interior ceiling construction depends on location: restrooms, break rooms and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consists of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. Most windows consists of operable double pane glass with grey tint within a black aluminum frame. Other major building envelope openings include: four overhead doors along the southern wall of the facility and twenty-six sky lights within the general warehouse area.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. Figure 20 is an HVAC map of the facility showing air handler equipment description and associated approximate service area. As a general summary: the general warehouse area is served by unit heaters with constant volume, downward facing fans capable of heating only via hot water coils with electronic valve control.

A partition exist where chemicals are stored, a dedicate make up air unit labeled AHU2 serves this space. This unit does not appear to have control of an outside air damper and is not capable of varying supply air volume. What appeared to be two in duct electric heaters exist. This area is also served by a dedicated exhaust fan.

The lobby, restrooms and breakroom located in the eastern portion of the facility are served by two split systems. These split systems are capable of heating via condensing, forced air natural gas fired sections and cooling via direct expansion systems.

An additional seven exhaust fans serve the facility, three of which are controlled manually.

A control valve on AHU2 appeared to utilize pneumatic controls, however, this was hard to confirm due to the height of the unit. All other HVAC controls systems makes use of older N2 based controllers.

Table 82: USPFO Warehouse Air Handling Units Information

AHU ID	Type	Make	Model Number	Serial Number	Supply Air Flow Rate, ft^3/min	Supply Fan Motor Power Input, HP
MAU_EastBay	RTU MAU	Weatherite	TOT 215 HBL	50465	10,400	5.00

Hot water is produced by two Kewanee hot water boilers; one with a capacity of 750 kBTU/hr the other with 450 kBTU/hr. The hot water distribution system for the facility is served by a two, constant volume hot water pump. Both boiler and pump status are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 83: USPFO Warehouse Boiler Information

Boiler ID	Boiler Location	Serves	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.
BLR-1	Boiler Mechanical Room	HW Loop	Kewanee	M75-KX	750
BLR-2	Boiler Mechanical Room	HW Loop	Kewanee	M45-KX	450

No chilled water is produced at the USPFO Warehouse. The only areas served by units capable of cooling are the breakrooms, restrooms, and lobby in the eastern partition of the facility.

Table 84: USPFO Warehouse Condensing Unit Information

Equipment	Manufacturer	Model #	Serial #
Condensing Unit	Lennox	CX34-62C-6F-1	6009K14221
Condensing Unit	Lennox	CX34-49C-6F-1	6009L07428

OTHER HVAC CONTROLS OBSERVATIONS:

- Audit on January 7, 2016 starting at 9:05 AM outside air conditions 34°F 404 ppm CO2. 67.3% relative humidity outside.
- Outside cinderblock surface temperature with emissivity set to .92 reads 12°F, Interior cinderblock wall color white inside surface temperature of 65°F.
- Warehouse interior ceiling temperature is 72°F with infrared gun set .77 emissivity.
- Warehouse Conditions: 74.1 °F drybulb, 20.6% RH, 528 PPM CO2
- Warehouse South wall: 70.1 °F drybulb, 26.1% RH, 576 PPM CO2
- Northeast Breakroom: 72.1°F drybulb, 26.4% RH, 673 PPM CO2
- Western Partition: 66.3°F drybulb, 26.6% RH, 528 PPM CO2

Within the existing BAS workstation there are 124 observable control points for HVAC equipment. Two of these points were overridden. One of the overridden values locked out the boiler pump until outside air temperatures were at or below 33 °F. The second override was to a zone temperature set point which didn't seem abnormal. This override may be due to an input at the local thermostat which will most likely release after a certain amount of time

The overhead doors do not lockout heating sources within the facility. However, when doors were observed to be utilized, the task was completed quickly and the doors immediately closed.

1) Unit heaters are not observable on the front end, however, some zone temperature sensors exist which may be utilized to provide a setback or setup signal to various thermostats which provide feedback to these units.
2) No CO2 sensors and associated set points observed

Relative energy use per unit building area for this facility is rather low. Staff are assumed to shut off lights often (witnessed on one occasion) and if night temperature control doesn't exist, staff are most likely manually altering the thermostats upon leaving the facility.

CIF (11-063)

Figure 21: Picture; CIF

Facility Description

CIF (11-063) is a single floor facility in Area 11 of the Camp. The facility is primarily dedicated to storage and distribution of mostly non-perishable and non-volatile items. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for CIF are listed in Table 85. Lighting at the CIF is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 85: CIF (11-063) Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of a dark grey EPDM (rubber) material. Interior ceiling construction depends on location: restrooms, break rooms, offices, conference rooms, and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consists of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with grey tint within a grey aluminum frame. Other major building envelope openings include: five overhead doors along the eastern wall of the facility and four overhead doors along the western wall.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location within the facility. The general warehouse area is served by unit heaters with constant volume, downward facing fans capable of heating only via hot water coils with electronic valve control.

Two air handler units serve other areas; they are labeled AHU1 and AHU2. They serve presumably offices, breakrooms, and a small amount of warehouse floor area. These units are constant volume units capable of heating only via hot water coils. They both have actuation control of return air and outside air dampers which allows for ventilation control and economizing sequences. AHU1 has additional cooling capabilities via a chilled water coil with electronic valve control.

An additional fan coil unit serves a second set of offices. This unit is a constant volume unit capable of providing heat via a hot water coil with electronic valve control and cooling via a direct expansion system.

Several refrigerated units exist along the northern portions of the facility. At least one of these units is a sub ~20 °F as it is used to store ice. Staff stated limited use of such spaces, however, utility consumption shows an uptick during summer months indicating that indeed refrigeration units are consuming some form of energy.

Table 86: CIF Air Handling Units Information

AHU ID	Type	Make	Model Number	Serial Number	Supply Air Flow Rate, ft^3/min	Supply Fan Motor Power Input, HP
MAU_EastBay	RTU MAU	Weatherite	TOT 215 HBL	50465	10,400	5.00

Hot water is produced by two (2) Kewanee hot water boilers; each with a capacity of 1,440 kBTU/hr. The hot water distribution system for the facility is served by two (2), constant volume, 7 ½ HP hot water pumps. Only boiler status is visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 87: CIF Boiler Information

Boiler ID	Boiler Location	Serves	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.
BLR-1	Boiler Mechanical Room	HW Loop	Kewanee	3R10-KO	1,440

BLR-2	Boiler Mechanical Room	HW Loop	Kewanee	3R10-KO	1,440

No Chilled water is produced at the USPFO Warehouse. Any cooling provided is produced by direct expansion systems.

Table 88: CIF Condensing Unit Information

OTHER HVAC CONTROLS OBSERVATIONS:

- Audit on January 5, 2016 starting at 4:08 PM
- West Warehouse: 68.6 °F drybulb, 19.5% RH, 484 PPM CO2
- West Office: 69.5 °F drybulb, 19.5% RH, 577 PPM CO2

Within the existing BAS workstation there are 107 observable control points for HVAC equipment. Two of these points were overridden. The points overridden were for boiler command which was overridden to the off condition. One point was in alarm. The point in alarm was for the of AHUS2 status. The reason for the alarm is unknown.

Other key observations made on the BAS work station are:

1) Unit heaters are not observable on the front end
2) No CO2 sensors and associated set points observed

Relative energy use per unit building area for this facility is rather low. Staff are assumed to shut off lights often and if night temperature control doesn't exist, staff are most likely manually altering the thermostats upon leaving the facility.

Table 89: CIF Condensing Unit Information

OTHER HVAC CONTROLS OBSERVATIONS:

- Audit on January 6, 2016 starting at 2:56 PM outside air conditions 33.9°F 388 ppm CO2. 55.8% relative humidity outside.
- Room 123: 71.9 °F drybulb, 16.3% RH, 426 PPM CO2
- Room 125: 67.5 °F drybulb, 19.3% RH, 503 PPM CO2
- Room 126: 66.6°F drybulb, 18.2% RH, 430 PPM CO2
- General Hallway: 71.9°F drybulb, 16% RH, 467 PPM CO2

Within the existing BAS workstation there are 227 observable control points for HVAC equipment. None of the points had a call out status of alarm, overridden, or offline.

Other key observations of HVAC operation are:

3) Titan units are not on the BAS. There is no form of infrared heating for the maintenance bays, hence, all heat is provided by MAUs.
    a. No CO2 sensors and associated set points observed
4) The global OAT being used by the BAS was observed to rapidly increase by ten degrees and the slowly return to the correct value.
5) The heat serving the shop garage is not interlocked to the overhead doors.
6) Suspended cabinet unit heater in room 104 has no coil valve control (A.K.A. runs wild)
7) In some of the labs, windows where open for cooling during the heating season. A separate thermostat exist for the baseboard heat which may be overheating the spaces.

8) Areas of the facility were overheating due to attempts to control a constant volume single zone unit to multiple zones given one of the zones is unoccupied.
9) The larger two-section warehouse area on the south side of the building are served by hot water unit heaters.
10) Exhaust fans utilize outside air intakes to provide airflow/draft during the summer season to minimize the accumulation of stagnate, warmer air.

RTSM (11-076)

Figure 22: Picture; RTSM

Facility Description

RTSM (11-076) is a single floor facility in Area 11 of the Camp. The facility is utilized for multiple purposes; the western wing is a maintenance bay and the eastern wing consists of classrooms, conference rooms, restrooms, and offices. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for RTSM are listed in Table 90. Lighting at RTSM is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 90: RTSM Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade is dependent on location, the eastern non-maintenance wing wall façade consists of red brick masonry. The western maintenance wing wall façade consists of a light beige metal material. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material is dependent on location; the majority of the facility exterior roofing consists of a dark grey EPDM (rubber) material. The exterior roof construction for a small north east portion of the facility consists of tan stones over tar. Interior ceiling construction depends on location: restrooms, break rooms, offices, conference rooms, and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consists of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. Most windows consists of operable double pane glass with grey tint within a black aluminum frame. Other major building envelope openings include: ten overhead doors along the northern and southern walls of the maintenance bay.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. As a general summary: the maintenance bay is served by two Titan Make-up Air Units (MAUs). These constant volume units are capable of providing heat only via hot water coils with electronic valve control.

Seven rooftop units (RTUs) serve the eastern wing. These constant volume RTUs are capable cooling via direct expansion systems. The RTUs appear to have the ability to actuate return air

and outside air dampers to control the amount of ventilation provided. Perimeter areas for the eastern wing have baseboard heating. Baseboard heating feedback is provided by a separate set thermostats not on the BAS.

Table 91: RTSM Air Handling Units Information

Equipment	Manufacturer	Model #	Serial #
RTU1	Lennox	LCA060SN1Y	5602D02684
RTU2	Lennox	LCA036SN1Y	5602D02629
RTU3	Lennox	LCA036SN1Y	5602D02630
RTU4	SynderGeneral	CUR085FW02	...84077-00
RTU5	SynderGeneral	RD5420603	R893900054
RTU6	AAON	RN-010-8-0-CA01-EHL	201407-ANWJ03992
RTU7	SynderGeneral	CUR085FW02	5UL84076-00

Hot water is produced by two (2) Kewanee hot water boilers boiler, with Gordon-Piatt burners. each Kewanee boiler has a capacity of 1,750 kBTU/hr. The hot water distribution system for the facility is served by a two, constant volume hot water pumps. Both boiler and pump status are visible on the Metasys BAS workstation along with hot water supply temperature for the building hot water loop.

Table 92: RTSM Boiler Information

Boiler ID	Boiler Location	Serves	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.
BLR-1& 2	Boiler Mechanical Room	HW Loop	Kewanee	M175-XX	1,750
Burner - 1 & 2	Boiler Mechanical Room	HW Loop	Gordon-Piatt	R8.3-G-15	2,495

No Chilled water is produced at RTSM. Any cooling provided is produced by direct expansion systems.

DOL Office (11-159)

Figure 23: Picture; DOL Office

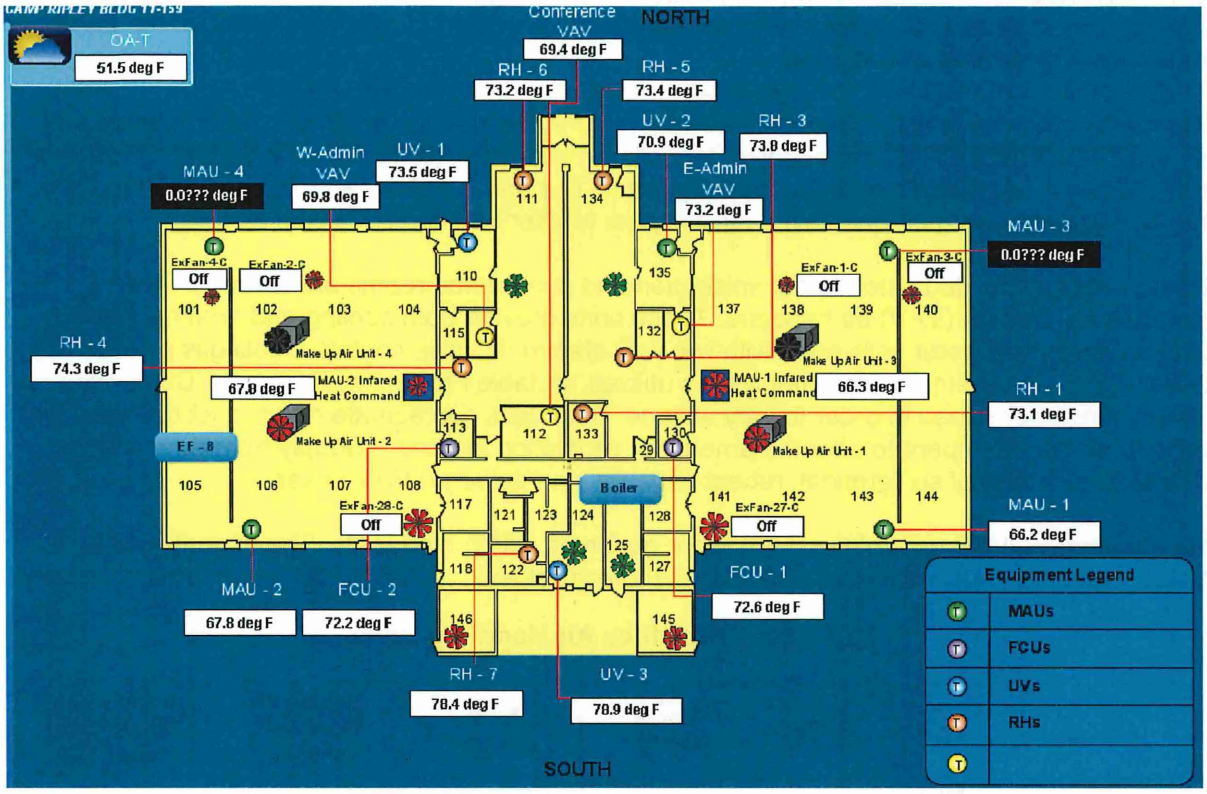
Facility Description

DOL Office (11-159) is a single floor facility in Area 11 of the Camp. The facility is considered a multipurpose facility; however, a significant portion of the occupant area is dedicated to vehicle maintenance and subsequent admin, storage, and parts. Figure 24 shows a snap shot of a graphic within the Building Automation System (BAS) with partitions shown dependent on HVAC service area and space use type. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for DOL Office are listed in Table 93. Lighting at DOL Office is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 93: DOL Office Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Figure 24: DOL Office HVAC and Space Map



Exterior wall façade consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of tan stones over a tar surface. Interior ceiling construction depends on location: offices and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consists of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. All windows consists of non-operable double pane glass with grey tint within a black aluminum frame. Other major building envelope openings include: eight overhead doors within the western maintenance bay and eight overhead doors within the eastern maintenance bay.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. Figure 29 is an HVAC map of the facility showing air handler equipment name and associated approximate service area. Table 94 list air handling unit details. As a general description, areas with high ventilation needs, such as maintenance bays, utilize constant volume dedicated make up-air units which are generally capable of heating only via natural gas fired, forced air sections. Four exhaust fans are dedicated to serving highly ventilated areas (two per bay). One exhaust fan per bay is dedicated to general area exhaust while the second is dedicated to tail pipe exhaust.

Rooms 110, 135, and 124 are served by packaged unit heaters which utilize hot water coils with two way electronic valve control for heating, and direct expansion systems for cooling. These unit heaters are not capable of varying air volume and cannot actuate outside air dampers.

Rooms 113, and 130 are served by fan coil units which utilize hot water coils with two way electronic valve control for heating, and direct expansion systems for cooling. These units are not capable of varying air volume and do not provide any form of outside air ventilation. Each room has a dedicated exhaust fan.

The boiler room is served by a dedicated roof top unit. This unit is capable of both heating and cooling; heating is provided by a hot water coil with two way electronic valve control. Cooling is provided by a two stage direct expansion system. The unit is not capable of varying air volume but can actuate return air and mixed air dampers to alter outside air ventilation rate.

Remaining spaces dedicated to administration and conference rooms are served by two Variable Air Volume (VAV) air handlers. These units provide both cooling and heating; heating is provided by hot water coils each with two way electronic valve control. Cooling is provided by direct expansion systems. The supply fans utilizes Variable Frequency Drives (VFDs) to alter supply fan motor speed in order to vary volume. Both units can actuate return duct dampers and outside air duct dampers to alter the amount of ventilation provided. Supply from each unit is delivered to a total of six terminal, reheat capable, non-powered VAV boxes.

No pneumatic HVAC controls systems were observed within the facility. The majority of the HVAC equipment makes use of older N2 based controllers.

Table 94: DOL Office Air Handling Units

AHU ID	Type	Make	Model Number	Serial Number	Supply Air Flow Rate, ft^3/min	Supply Fan Motor Power Input, HP
MAU_1 East Bay	RTU MAU	Weatherite	TOT21HHL	56179-2	6,500	3.00
MAU_2 West Bay	RTU MAU	Weatherite	TOT21HHL	56179-1	6,500	3.00
MAU_3 East Bay	RTU MAU	Weatherite	TOT218HBL	8225-2	18,000	10.00
MAU_4 West Bay	RTU MAU	Weatherite	TOT218HBL	8225-2	18,000	10.00
AHU_1 Boiler Rom	RTU AHU	Aaon	CA1057 CA-08-02	200709-CCCF07698		
VAV_East	VAV AHU					
VAV_West	VAV AHU					

Hot water is produced by two, 264 kBTU/hr hot water Burnham boilers. The hot water distribution system for the facility is served by a single constant volume hot water pump. Two additional constant volume pumps serve each boiler. Both boiler and pump status are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 95: DOL Office Boilers

Boiler ID	Boiler Location	Serves	Make	Model Number	Serial Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
BLR-1	Boiler Mech Room	Original HW Loop	Burnham	806B-W1	7731901	264	80%
BLR-2	Boiler Mech Room	Original HW Loop	Burnham	806B-W1	7731901	264	80%

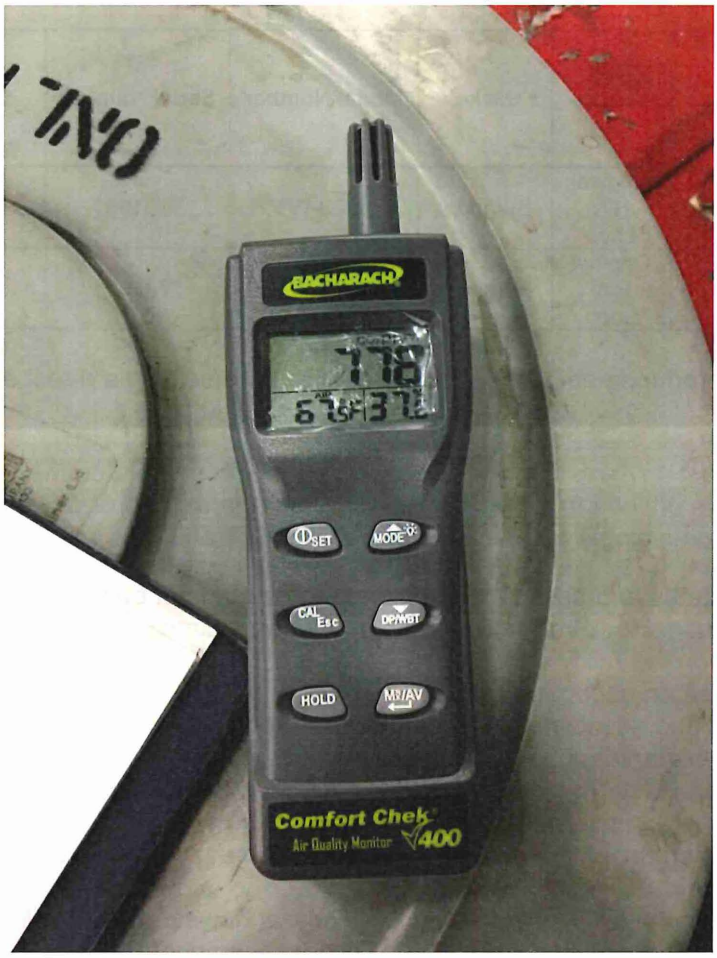
No Chilled water is produced at DOL Office. All cooling is rejected via direct expansion systems.

OTHER HVAC CONTROLS OBSERVATIONS:
The facility has at least 407 existing HVAC control points observable on the BAS workstation. A total of 40 points were offline indicating issues with communications or power. The following are observations based on a single point in time due to limited trend data availability:

1) Occupancy status and associated cooling and heating set points were observed on the BAS workstation. However, not all units had an associated unoccupied and occupied set point. Based on the utility consumption data use, most of the equipment does not alter set point based on occupancy status.
2) CO2 sensors and associated set point were observed for what is assumed to be the maintenance bays. It appears CO2 sensors have not been calibrated with the majority of the sensors providing negative readings. Control points dedicated are capable of locking out MAUs based on overhead door position also exist.
    a. Based on this, MAU operation time within the maintenance bays is very uncertain.
3) Reheat is available for VAV based AHUs. Reheat however is not utilized during the cooling season based off of natural gas utility consumption.

Vehicles were never observed operating in any bays. Given this, CO2 levels were observed at around 778 ppm CO2 without any MAU operating during occupied hours. Utility usage does indicate that the MAUs operate at some level possibly manually by the end user. Figure 25 presents a picture of the hand held sensor outputting the discussed conditions.

Figure 25: DOL Office East Maintenance Bay General Air Conditions



MAINTENANCE SHOP (11-160)

Figure 26: Picture; Maintenance Shop

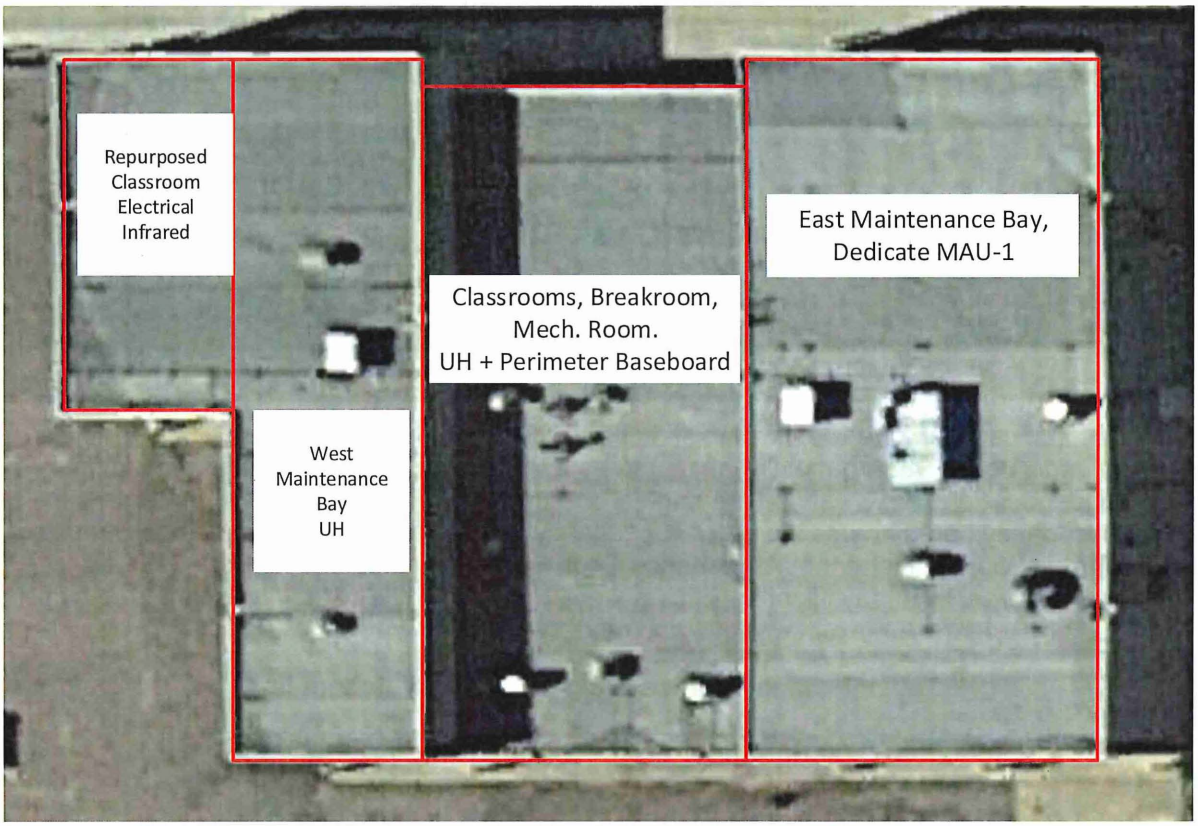
FACILITY DESCRIPTION

The Maintenance Shop (11-160) is a single floor facility in Area 11 of the Camp. The facility is primarily dedicated to vehicle maintenance. Figure 27 shows a satellite image with partitions shown dependent on HVAC service area and space use type. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for the Maintenance Shop are listed in Table 96. Lighting at the Maintenance Shop is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 96: Maintenance Shop Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Figure 27: Maintenance Shop HVAC and Space Map



Exterior wall façade consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of a dark grey EPDM (rubber) material. Interior ceiling construction depends on location: classrooms, break rooms and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consists of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. Most windows consists of operable single pane glass with light grey tint within an aluminum frame. Other major building envelope openings include: two overhead doors within the western maintenance bay and four overhead doors within the eastern maintenance bay.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. Figure 27 is an HVAC map of the facility showing air handler equipment name and associated approximate service area. The East maintenance bay is the only area with high ventilation needs. Hence, a dedicated Make-up Air Unit (MAU) serves this area and is capable of providing heating only via a natural gas fired, forced air section. This MAU is not capable of varying supplied air volume. Two exhaust fans relieve air for the bay, one is utilized for general exhaust while the other is utilized for tail pipe exhaust. Tail pipe exhaust use is activated via switches actuated by the end user. In addition, each bay has a dedicated de-stratification fan.

Six unit ventilators serve the remaining portions of the building including the west bay. The west bay has been mostly repurposed as a classroom. A small portion is still utilized to store vehicles

but the lack of tools within the space indicate that vehicle maintenance is no longer performed within this area. The six unit ventilators are capable of heating only via hot water coils. Within the BAS, hot water valve control and outside air damper control both exist. The configuration of the hot water valve is unknown. Areas in-between utilizes additional baseboard heating along the perimeter of the facility. Baseboard control points are not visible on the front end and appear to make use of standalone separate thermostats for control. The area repurposed as a classroom within the west bay also utilizes a single electric infrared heater. De-stratification air pair fans exist within each of the western bays.

No pneumatic HVAC controls systems were observed within the facility. The majority of the HVAC equipment makes use of older N2 based controllers.

Table 97: Maintenance Shop Air Handling Units

AHU ID	Type	Make	Model Number	Serial Number	Supply Air Flow Rate, ft^3/min	Supply Fan Motor Power Input, HP
MAU_EastBay	RTU MAU	Weatherite	TOT 215 HBL	50465	10,400	5.00

Hot water is produced by two, 579 kBTU/hr hot water Burnham boilers. The hot water distribution system for the facility is served by a two, two Horse Power (HP), constant volume hot water pump. Both boiler and pump status are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 98: Maintenance Shop Boiler Information

Boiler ID	Boiler Location	Serves	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
BLR-1	Boiler Mechanical Room	HW Loop	Burnham	4FW 78 45 G-1C	579	80%
BLR-2	Boiler Mechanical Room	HW Loop	Burnham	4FW 78 45 G-1C	579	80%

Table 99: Hot Water Pump Motor Information

Pump ID	Pump Location	Serves	Pump Impeller Design Rotational Velocity, RPM	Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model
HWP-1	Central Mechanical room	HW Loop	1,735.00	2	230/460 3Ph	82.50%	Marathon	KVK 145TTDR7026CCW
HWP-2	Central Mechanical room	HW Loop	1,735.00	2	230/460 3Ph	82.50%	Marathon	KVK 145TTDR7026CCW

No chilled water is produced at the Maintenance Shop. The only areas with any form of cooling are located within the northern portions of the facility between the two bays. These areas are cooled by two, window mounted, direct expansion packaged units.

OTHER HVAC CONTROLS OBSERVATIONS:

- Time of audit 10:43 AM outside air conditions 32°F with the CO2 parts per million of 393. Relative humidity of 80.3%.
- Outside surface temperature according to infrared gun 24°F. Inside surface temperature according to infrared gun 55°F.
- South Break Room: 68.4 °F dry-bulb, 24% RH, 414 PPM CO2
- East Bay: 67.5 °F dry-bulb, 37.6% RH, 778 PPM CO2
- Hallway: 67.8 °F dry-bulb, 27% RH, 849 PPM CO2

Within the existing BAS workstation there are 146 observable control points for HVAC equipment. Five of these points where in alarm, specifically, a set of exhaust fans and supply fans had an *off* status even though an *on* input command was given. Two pump interlock points where called out as *unreliable*. The following are additional observations based on a single point in time due to limited trend data availability:

11) Unit heaters are capable of setting back based on a schedule, however, multiple thermostats where observed in the space: one for the unit heaters a second for the perimeter heat. Hence, during unoccupied hours the perimeter heat most likely keeps the space at occupied levels.
12) No CO2 sensors and associated set points observed for maintenance bays. No overhead door interlock observed for maintenance bays. MAU fan was commanded *on* but status feedback was *off*. One of the switches at the facility may override the signal from the BAS.
13) No occupancy status point observed for MAU, nor associated unoccupied based set points.

CMA South (11-169)

Figure 28: Picture; CMA South

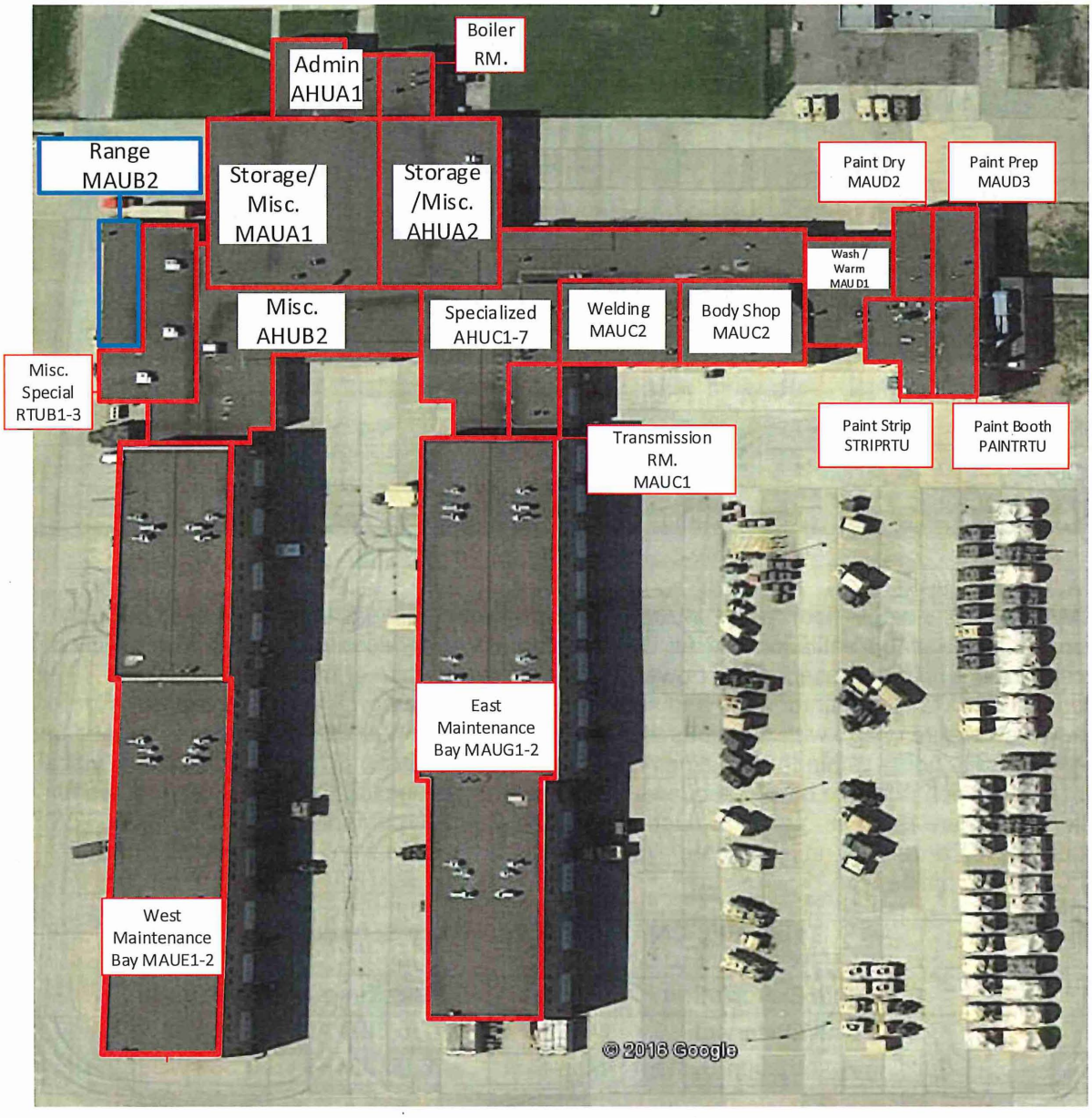
Facility Description

CMA South is a single floor facility in Area 11 of the Camp. A mezzanine does exist but only consists of Heating Ventilation and Air Conditioning (HVAC) mechanical space. The facility is considered a multipurpose facility; however, a significant portion of the occupant area is dedicated to vehicle maintenance and subsequent admin, storage, painting and parts. Figure 29 shows a satellite image with partitions shown dependent on HVAC service area and space use type. Facility hours within the Building Automation System (BAS) differ with the camps typical schedule which is based off of interviews and observations on site. Occupancy schedules for CMA South are listed in Table 116. Lighting at CMA South is primarily provided by 28W-32W T8 fluorescent fixtures. As an exception, high bays lighting fixtures were observed to be of the 400W metal halide type.

Table 100: CMA South Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM
Building Automation System	Mon-Sun	6:00 AM	6:00 PM

Figure 29: CMA North HVAC and Space Map



Exterior wall façade for the facility consists primarily of grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of tan stones over a tar surface. Interior ceiling construction depends on location: offices and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consist of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. All windows consists of non-operable double pane glass with grey tint within a black aluminum frame. Other major building envelope openings include: twenty two overhead doors within the western maintenance bay and twenty four overhead doors within the northeastern maintenance bay. Several other overhead doors exist within the other specialized sections of the facility.

HEATING VENTILATION AND AIR CONDITIONING (HVAC) DESCRIPTION

Conditioned air delivery systems vary greatly dependent on location within the facility. Figure 29 is an HVAC map of the facility showing air handler equipment name and associated approximate service area. Table 101 list air handling unit details. As a general description, areas with high ventilation needs, such as maintenance bays and paint drying or prep areas, utilize dedicated make up-air units which are generally capable of heating only via natural gas fired, forced air sections.

Administration or other areas which do not require high amounts of ventilation utilize separate air handlers. These air handlers are generally constant volume units capable of heating only via hot water coils with two way valve control. As an exception units A1, and B1 are capable of varying air flow volume by way of electronic speed control of supply fan motors. In addition, units A1, B1, and C7 also utilize direct expansion (DX) systems to provide cooling. The east and west maintenance bays make use of additional natural gas fired infrared heaters.

Roof top units (RTUs) which serve paint stripping areas and the paint booth did not have name plates on unit exteriors nor did drawings detail unit specifications. It appeared that both units are capable of only providing constant volume air and can only provide heat via forced air, natural gas fired sections.

RTUs B1 through B3 serve several specialized areas in the western portion of the facility. These RTUs are traditional single zone units which provide constant volume air, a small portion of which is purposefully ventilated outside air. They are capable of cooling via direct expansion systems and heating via hot water coils.

There are a total of 50 exhaust fans which serve the facility. Exhaust fan function is dependent on location. East and west maintenance bays have a dedicated exhaust system for general area exhaust and a second system for dedicated tail pipe exhaust.

No pneumatic HVAC controls systems were observed within the facility. The majority of the air handling units make use of older UNT or AHU controllers with a few units upgraded to newer FEC controllers. Unit labeling within the BAS workstation is not consistent with the unit labeling observed on mechanical drawings or physical labels on the units themselves. Infrared heating systems within the maintenance bays are not visible on the BAS workstation and appear to operate on a standalone electronic control system.

Table 101: CMA South Air Handling Units

AHU ID	Serves	Type	Make	Model	General Unit Control Type	Supply Fan Motor Control	Cooling Coil Transfer Medium	Heating Coil Transfer Medium	Heating Coil Load Control Valve Configuration
AHU A1	A – Offices	Variable Air Volume	McQuay	LSL10ACV	N2 Electronic DDC	Variable @28HZ during Audit	DX Cooling Coil	Hot Water	Two Way
AHU A2	A – Supply Tool / Storage	Constant Volume Single Zone	McQuay	LSL117DH	N2 Electronic DDC	Constant	N/A	Hot Water	Two Way

AHU ID	Serves	Type	Make	Model	General Unit Control Type	Supply Fan Motor Control	Cooling Coil Transfer Medium	Heating Coil Transfer Medium	Heating Coil Load Control Valve Configuration
AHU B1	B - Offices	Variable Air Volume Mixed Air	McQuay	LSL117DH	N2 Electronic DDC	Variable @34.6HZ during Audit	DX Cooling Coil	Hot Water	Two Way
MAU B1	Room 133	MAU Unknown if Mixed Air though	Titan	TA-12 NG HRV	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
AHU C1	Locker Rooms	Constant Volume Mixed Air Single Path	McQuay	LSL108CH	N2 Electronic DDC	Constant	N/A	Hot Water	Two Way
MAU C1	Engine Building Room	MAU Unknown if Mixed Air though	Titan	TA-12 NG HRV AR/80	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
AHU C2	Carpenter Shop	Constant Volume Mixed Air Single Path	McQuay	LSL108CH	N2 Electronic DDC	Constant	N/A	Hot Water	Two Way
AHU C7	Injector Test Shop	Constant Volume Mixed Air Single Path	McQuay	LSL108CH	N2 Electronic DDC	Constant	DX Cooling Coil	Hot Water	Two Way
AHU C6	Hallway	Constant Volume Mixed Air Single Path	McQuay	LSL104CH	N2 Electronic DDC	Constant *inline dampers for two separate zones*	N/A	Hot Water	Two Way
AHU C3	Canvas Shop	Constant Volume Mixed Air Single Path	McQuay	LSL104CH	N2 Electronic DDC	Constant *inline dampers for two separate zones*	N/A	Hot Water	Two Way
MAU C2	Welding Shop	MAU with mixed air	Titan	TA-15 NG HRV AR/80	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
AHU C4	Machine Shop	Constant Volume Mixed Air Single Path	McQuay	LYF106CH	N2 Electronic DDC	Constant	N/A	Hot Water	Two Way

AHU ID	Serves	Type	Make	Model	General Unit Control Type	Supply Fan Motor Control	Cooling Coil Transfer Medium	Heating Coil Transfer Medium	Heating Coil Load Control Valve Configuration
MAU C3	Body Shop	MAU with mixed air though	Titan	TA-15 NG HRV AR/80	N2 Electronic DDC	Constant *has an in line damper*	N/A	Natural Gas	Unknown
AHU C5	Radiator Shop	Constant Volume Mixed Air Single Path	McQuay	LSL108CH	N2 Electronic DDC	Constant	N/A	Hot Water	Two Way
MAU D1	RM165 and 166	MAU with mixed air	Titan	TA-12 NG HLH AR/80	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
MAU D2	171	MAU 100% OSA							
MAU D3	172	MAU with mixed air							
MAU E1	West Maintenance Bay	MAU	Titan	TA-225-NG HRV	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
MAU E2	West Maintenance Bay	MAU	Titan	TA-225-NG HRV	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
MAU G1	East Maintenance Bay	MAU	Titan	TA-225-NG HRV	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
MAU G2	East Maintenance Bay	MAU	Titan	TA-225-NG HRV	N2 Electronic DDC	Constant	N/A	Natural Gas	Unknown
RTUB1	RM 131	RTU Single Zone	Aaon	RH-05	N2 Electronic DDC	Constant	DX	Hot Water	Unknown
RTUB2	RM 128	RTU Single Zone	Aaon	RH-05	N2 Electronic DDC	Constant	DX	Hot Water	Unknown
RTUB3	RM 123,122,124,125	RTU Single Zone	Aaon	RH-05	N2 Electronic DDC	Constant	DX	Hot Water	Unknown
RTU Paint Strip	Paint Stripping Areas								
RTU Paint Shop	Paint Booth Area								

Hot water is produced by two 960 kBTU/hr Kewanee boilers. The hot water distribution system for the facility is served by two, three Horse Power (HP) constant volume hot water pumps. Two additional half HP constant volume pumps serve each boiler. Both boiler and pump status are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 102: CMA South Boilers

Boiler ID	Boiler Location	Serves	Make	Model Number	Serial Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
BLR-1	Boiler Mech Room	Original HW Loop	Bryan	AB120-W-FDG	81219	960	80%
BLR-2	Boiler Mech Room	Original HW Loop	Bryan	AB120-W-FDG	81223	960	80%

Table 103: CMA North Hot Water Pumps

Pump ID	Serves	Pump Make	Pump Model Number	System Fluid Type	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM	Pump Motor, HP
HWP-1	HW Loop: Boiler Pump 1	Bell & Gossett	Series 60 2AA	Water	14	1,750	70	.5
HWP-2	HW Loop: Boiler Pump 2	Bell & Gossett	Series 60 2AA	Water	14	1,750	70	.5
HWP-3	HW Loop: System Pump	Bell & Gossett	Series 60 2-1/2F	Water	50	1750	100	3
HWP-4	HW Loop: Standby Pump	Bell & Gossett	Series 60 2-1/2F	Water	50	1750	100	3

No chilled water is produced at CMA south. All cooling is rejected via Direct Expansion systems.

OTHER HVAC CONTROLS OBSERVATIONS:
Within the BAS workstation, EF1, 2, 3 and 4 were observed to be commanded on utilizing the override function. This indicates that fans shall not follow any schedule or sequencing unless the end user releases the command value.

At the time of the audit units the following units were observed operating during occupied hours:

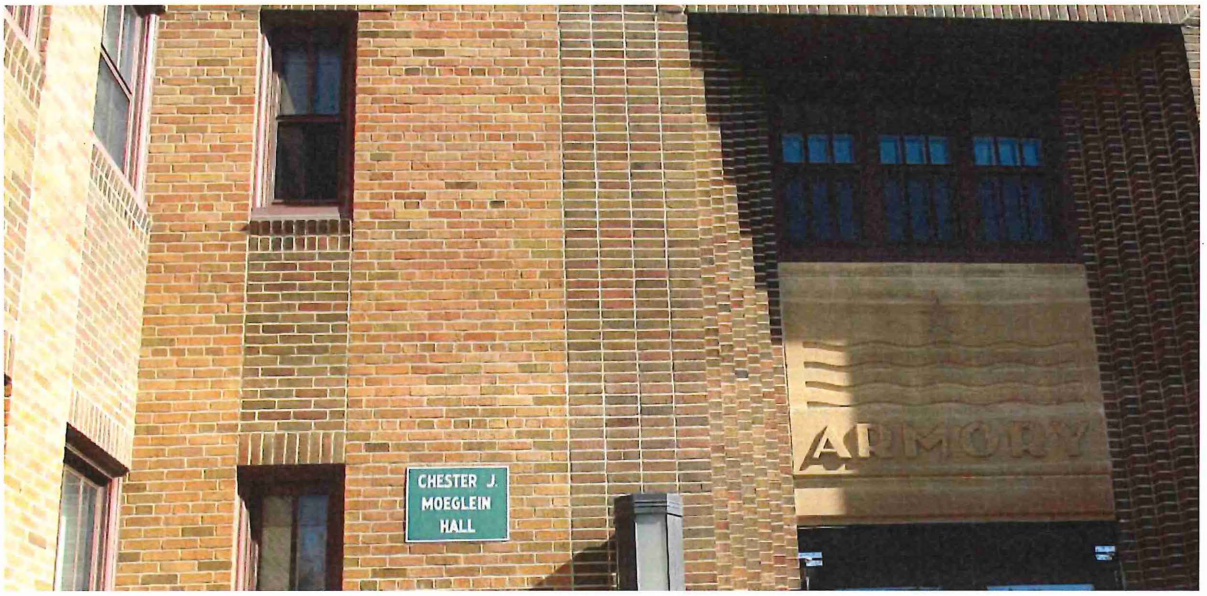
1) MAUC1
2) AHU1
3) AHUC7
4) AHUC6
5) AHU1: Malfunctioning VFD display
6) AHUB1: 34.6Hz at time of audit

At one point vehicle operation was observed within one of the bays. CO2 levels were observed to exceed 1,034 ppm CO2 without any MAU operating. Utility usage does indicate that the MAUs operate at some level possibly manually by the end user. Figure 30 presents a picture of the hand held sensor outputting the discussed conditions.

Figure 30: East Maintenance Bay General Air Conditions

MOB/DEMOB (15-001)

Figure 31: Picture; MOB/DEMOB



Facility Description

MOB/DEMOB (15-001) is a three floor facility in Area 15 of the Camp consisting of two above ground floors and a basement. The facility is utilized for multiple purposes consisting of a gymnasium, offices, classrooms, and storage. Facility hours are equivalent to typical occupancy hours across the camp. Occupancy schedules for the MOB/DEMOB are listed in Table 104. Lighting at MOB/DEMOB is primarily provided by 28W-32W T8 fluorescent fixtures. High bay lighting fixtures were observed to be of the florescent tube type within hanging troffers; the exact wattage and model are unknown.

Table 104: MOB/DEMOB Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall façade for the facility consists primarily of dark red brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior roofing material consist of a dark grey EPDM (rubber) material. Interior ceiling construction depends on location: classrooms, break rooms, offices, the gymnasium and some hallways consists of hanging ceilings with acoustic tiles. The majority of the basement ceiling, which is primarily utilized for storage, does not have a hanging ceiling where the floor construction, piping and wire conduit are visible. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with light grey tint within a brown aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

The majority of conditioned air is provided by three Variable Air Volume (VAV), Air Handling Units (AHUs). These AHUs are capable of providing heat via hot water coils with electronically actuated two-way valves and cooling via chilled water coils with electronically actuated two-way

valves. All units have full modulation electrical control of return air and outside air damper where the amount of ventilated air provided can be altered. Supply air from the units is delivered mostly to VAV boxes with no enclosed fans or reheat coil. It appears the controls system utilizes perimeter radiator coils to perform any reheat required by the thermostat. Only one major exhaust fan exist within the facility. Several relief dampers are actuated to relieve building pressure if necessary.

In addition, four unit heaters are utilized to heat the gym in conjunction with AHU-1. These constant volume units are capable of providing heating only via hot water coils with two way electronic valve control. Two pairs of ceiling fans exist which are manually switched on and off by building occupants.

A large open space in the basement appears to be utilized as a nursing staging area, this area is heated by two unit heaters. These constant volume units are capable of heating only via hot water coils with two way electronic valve control. Two freezers exist in this area for medical use; physically labeled for vaccine use.

Table 105: MOB/DEMOB Air Handling Units

Equipment	Manufacturer	Model #	Serial #
AHU-1	McQuay	CAH014GDAC	FB0U051200294
AHU-2	McQuay	CAH023GDAM	FB0U051200291
AHU-3	McQuay	CAH023GDDC	FB0U051200295

Hot water is produced by two, 2,499 kBTU/hr hot water PB boilers. The hot water distribution system for the facility is served by a two, five horsepower (HP), variable speed hot water pumps. Boiler status, pump status, and pump speed output are visible on the Metasys BAS workstation along with return and supply hot water temperatures for the building hot water loop.

Table 106: MOB/DEMOB Boiler Information

Boiler ID	Boiler Location	Serves	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
BLR-1	Boiler Mechanical Room (basement)	HW Loop	PB	TC-08-W/S	2,499	80%
BLR-2	Boiler Mechanical Room (basement)	HW Loop	PB	TC-08-W/S	2,499	80%

Table 107: Hot Water Pump Motor Information

Pump Location	Serves	Pump Make	Pump Model Number	Pump Serial Number	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
Boiler Mechanical Room	HW Loop	Bell & Gossett	1510 BF 9.5 2BC 8.25	1BF061 B60	65.00	1,760.00	130.00
Boiler Mechanical Room	HW Loop	Bell & Gossett	1510 BF 9.5 2BC 8.25	1BF061 B60	65.00	1,760.00	130.00

Table 108: Hot Water Pump Motor Information

Pump ID	Pump Location	Serves	Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model	Pump Motor Control
HWP-1	Boiler Mechanical Room	HW Loop	5	200V	87.50%	NIDEC	KVK 145TTDR7026CCW	Variable
HWP-2	Boiler Mechanical Room	HW Loop	5	200V	89.50%	Emerson	R336	Variable

Chilled water for the facility is produced by a single, 60 ton, McQuay air-cooled chiller. The distribution system is served by a single, five HP, variable speed pump. Several chiller observational and command points, pump status, pump output speed, loop pressure, and loop temperature points are observable on the BAS workstation.

Table 109: MOB/DEMOB Chiller Information

Chiller ID	Make	Model Number	Serial Number	Type	System Transfer Medium	Chiller Capacity, Tons	Refrigerator Type
CH-1	McQuay	AGZ060B512-ER11	STNU051200032	Air Cooled Chiller	Water	60	22

Table 110: MOB/DEMOB Pump Information

Pump ID	Pump Location	Serves	Pump Make	Pump Model Number	Pump Serial Number	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
CHWP-1	Boiler Mechanical Room	CHW Loop	Bell & Gossett	1510 BF 9.5 2BC 8.375	1BF061 B60	70.00	1,755.00	125.00

Table 111: MOB/DEMOB Pump Motor Information

Pump ID	Pump Location	Serves	Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model	Pump Motor Control	Starter Location
CHWP-1	Boiler Mechanical Room	CHW Loop	5	200	89.50%	Emerson	R336	Variable	@ Motor

OTHER HVAC CONTROLS OBSERVATIONS:

There are 500 existing HVAC equipment control points observable on the BAS workstation. Values for temperature resets, return air quality, boiler and chiller lockouts, and unoccupied set points all exist. At the time of the audit, AHU1 Variable Speed Drive showed an output of 100%, AHU2 VSD showed an output of 62%, and AHU3 VSD showed an output of 82%. The facility was occupied at the time of observation. The facility does make use of older controllers which communication on an N2 bus.

USPFO (15-002)

Figure 32: Picture; Roads

Facility Description

USPFO (15-002) is a single floor facility in Area 2 of the camp. The facility for offices and other administration functions but also houses a data center. Facility hours are equivalent to typical occupancy hours across the camp. The occupancy schedule is presented in Table 112. Interior Lighting is primarily provided by 28W-32W T8 fluorescent fixtures.

Table 112: USPFO Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM

Exterior wall construction primarily consists of dark red brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof is flat with the exterior layer consisting of dark grey EPDM (rubber) material. Ceilings of occupied spaces primarily of hanging ceilings with acoustic tiles. Additional non-visible roof construction material is unknown. Most windows consists partially non-operable double pane glass within a black aluminum frame.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air is primarily delivered by a single Variable Air Volume (VAV) Air Handler Unit (AHU). This unit serves the majority of the office areas and is capable of heating via a steam coil, using a small shell and tube heat exchanger and steam from the Central Steam Plant, with a face and bypass damper and cooling via a direct expansion refrigerant system. In addition, the unit is capable of humidifying the air stream utilizing steam. Supply air from this unit is delivered to both non-fan powered VAV boxes and fan powered VAV boxes, both forms of VAV boxes are capable of reheating the air stream.

Table 113: USPFO VAV AHU Information

Unit ID	Manufacture	Model Number	Serial Number
Office VAV AHU	Carrier	39EB21	780186981

An additional Liebert unit serves the data center room. This unit is designed specifically to cool data centers; often these units are labeled Computer Room Air Conditioning (CRAC) units. However, due to issues with keeping the room to set point, three additional mini split systems have been installed. All units which serve the data center are constant volume units which utilize direct expansion refrigerant systems to provide cooling.

Table 114: USPFO CRAC Unit Information

Unit ID	Manufacture	Model Number	Serial Number	Number of Stages	Refrigerant
Data Center Main Conditioning Unit	Liebert	FH199A-C01	101493A	3	R-22

Table 115: USPFO Condenser Unit Information

Unit ID	Manufacture	Model Number	Serial Number	Refrigerant
VAV Office Condenser Unit	Carrier	38AKS034-500	4301f19424	R22
Data Center Mini-Split Typical of 3	Friedrich	MR30C3F	LHBT 02017	R410A

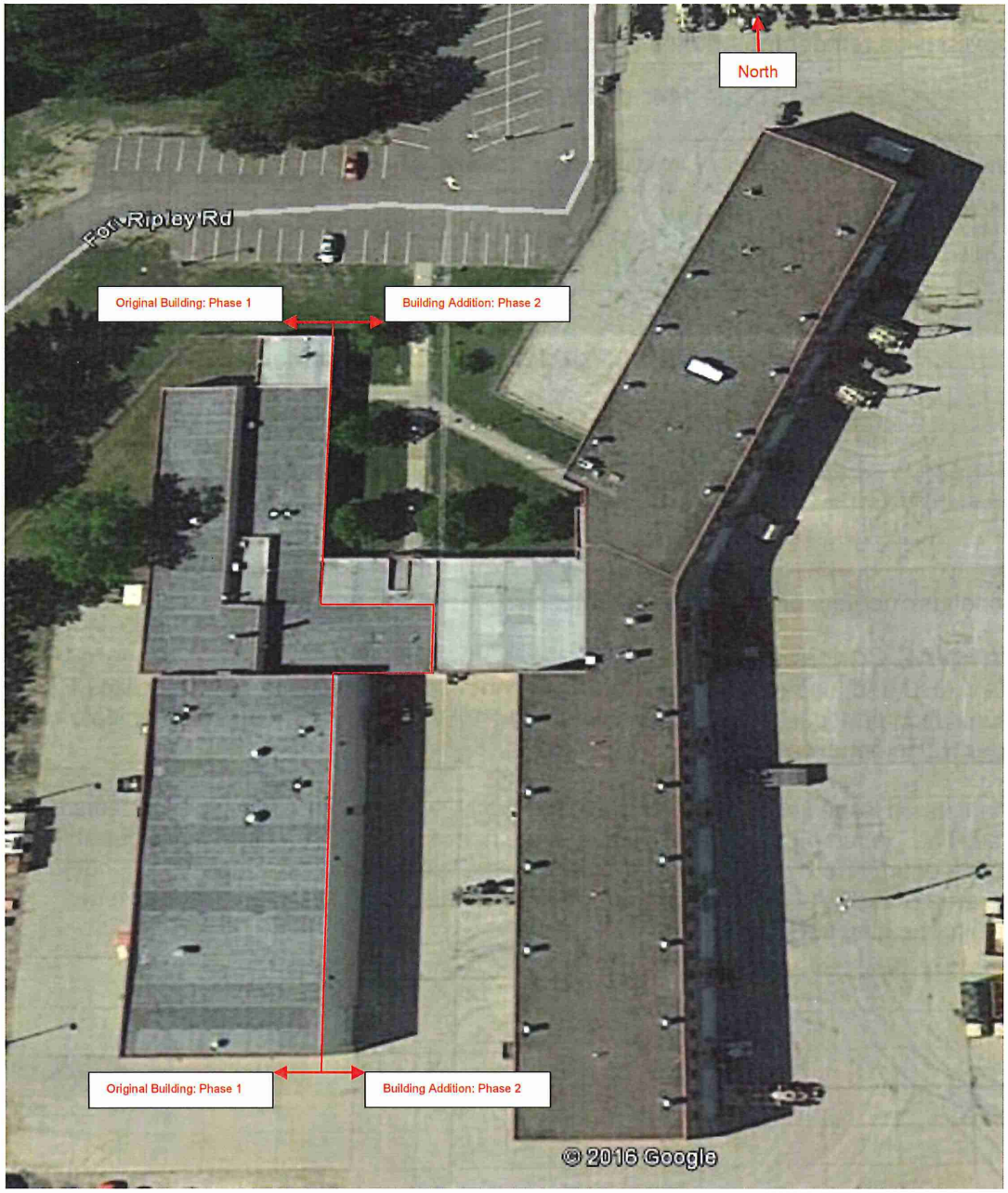
Additional unit heaters provide supplemental heat at building entrances.

OTHER HVAC CONTROLS OBSERVATIONS:
The VAV AHU and Liebert CRAC unit are both controlled by equipment which utilizes BACnet communication protocol and bus. The VAV and FPVAV boxes, however, communicate utilizing the older N2 communication protocol and bus.

Staff has stated issues cooling the data center, hence why the three mini split systems were installed. The Liebert unit may be replaced in the near future with a unit which is capable of recovering energy from the exhaust air stream. Other additional plans, include extending the service area of the VAV AHU to northern portions of the facility which are having issues maintaining heating set point.

CMA North (17-001)

Figure 33: Picture; CMA North Satellite



Facility Description

CMA North is a single floor facility in Area 17 of the Camp. The building was constructed in two phases: the original construction primarily resides in the western wing of the facility, additions are primarily located in the eastern wing (see Figure 33). The facility is considered a multipurpose facility; however, a significant portion of the facility is dedicated to vehicle maintenance and subsequent admin, storage, and parts. The western wing consists primarily of maintenance bays. The connection between the wings consists of offices and a receiving bay. The eastern wing consists of storage areas, a locker room, a physical training room, and

mechanical rooms. Facility hours within the Building Automation System (BAS) differ with the camps typical schedule which is based off of interviews and observations on site. Occupancy schedules for CMA North are listed in Table 116. Lighting at CMA North is primarily provided by 28W-32W T8 fluorescent fixtures. High bays lighting fixtures were observed to be of the florescent tube type within hanging troffers.

Table 116: CMA North Occupancy Schedule

Schedule Description	Day	Start Time	End Time
Typical/Observed	Mon – Fri	7:30 to 8:00 AM	4:30 PM
Building Automation System	Mon-Sun	6:00 AM	6:00 PM

Exterior wall façade consists primarily of tan/grey colored brick masonry. Interior wall construction primarily consists of concrete blocks of unknown thickness and fill. Additional wall construction layers which are not visible are unknown. The roof for the facility is flat, exterior material depends on the section of the facility: the original section consists of EDPM (rubber) grey material while the additions consist of tan stones over tar surface. Interior ceiling construction also depends on location: offices and some hallways consists of hanging ceilings with acoustic tiles while most high bays or storage locations consist of a visible corrugated metal surface. Additional non-visible roof construction material is unknown. Most windows consists of non-operable double pane glass with grey tint within a black aluminum frame. Other major building envelope openings include: twelve overhead doors within the southeastern maintenance bay and fourteen overhead doors within the northeastern maintenance bay. Several other overhead doors exist within the eastern wing and central section of the facility but are not operated with the same frequency as doors located in the main maintenance bays.

Heating Ventilation and Air Conditioning (HVAC) Description

Conditioned air delivery systems vary greatly dependent on location within the facility. The "BII" section of the facility is a high bay storage area located in the western wing and is primarily heated by fourteen unit heaters and a make-up air unit (MAU). The fourteen unit heaters and MAU are only capable of providing heat via hot water coils and can only cycle to provide constant volume air. Based on staff interviews, this section of the facility has been repurposed from a major maintenance staging area to parts storage. Hence, the MAU is rarely if ever utilized. The status of the fourteen unit heaters are visible on the Metasys Building Automation System (BAS) workstation while the MAU is not. Thermostat placement for unit heater feedback is rather close to exterior walls. Due to this, staff stated overheating complaints and zone temperatures were recorded as high as 75° during early January (see Figure 34).

Figure 34: Picture; CMA North BII Northern Section General Air Conditions

Remaining storage and mechanical rooms for the entire facility are served by heating only unit heaters. All unit heaters provide heat via hot water coils. Some large exhaust fans exist in the western most storage location, however, staff stated the rooms have been repurposed and exhaust fans are not required anymore; they were not observed to operate during the audit. Zone temperature feedback and unit heater fan status is visible on the BAS workstation within the western wing only.

The locker room located in the western wing is served by a constant volume single zone air handler. This air handler is capable of providing heat via a hot water coil and capable of cooling via a direct expansion coil and condenser unit. Only fan status and zone temperature feedback is visible within the Metsys BAS. The condensing unit which serves this air handler appears to be in rather poor condition and is past its useful service life. This unit is also noted to provide cooling for an ammunition storage room adjacent to the locker room and BII section.

The physical training room also located in the western wing is served by a horizontally opposed fan coil unit. The unit can only provide constant volume air and is capable of providing cooling via a direct expansion coil and condenser unit. Heating source could not be confirmed due to difficulties with unit enclosure. Neither unit status nor zone temperature feedback for this unit is visible on the Metasys BAS. The condensing unit which serves this fan coil unit appears to be in rather poor condition and is past its useful service life.

Offices located in the phase 2 section of the facility, mainly in the connection portion between the two wings, are served by a single variable air volume air handling unit designated S-5. S-5 is capable of providing heat via a hot water coil with a three way pneumatically controlled valve. In addition, air handling unit S-5 is capable of providing cooling via a direct expansion coil and condensing unit. All control actuation and feedback for this unit is performed pneumatically and is not transduced electronically for visibility on the Metasys BAS workstation. Furthermore, even though the unit is clearly labeled a variable air volume unit within control drawings, no variable frequency drive was every found. It is postulated based on control drawings and observations that an inline damper is utilized to lessen supply air flow into the space where the fan motor then alters power input based off of static pressure differential and flow due to the inline damper.

Both maintenance bays located in the eastern wing of the facility each have two dedicated Make-up Air Units (MAUs) each. Units designated S-1 and S-2 provide general make-up air for each bay and are both constant volume units capable of heating only via pneumatically controlled hot water coils. Units designated S-3 and S-4 provide make-up air based on building air pressure differential created by use of the tail pipe exhaust system. Like S-1 and S-2, S-3 and S-4 are both constant volume units and are capable of heating only via pneumatically controlled hot water coils. Each maintenance bay consist of a general exhaust system for the entire space along with a tail pipe exhaust system per individual bay. Tail pipe exhaust systems are switch operated on an as needed basis by the occupants. General exhaust is designed to operate constantly with the general MAUs S-1 and S-2. The northeast maintenance bay has an additional MAU which is no longer utilized and never observed operating during the audit. Both bays also utilize linear gas fired infrared heaters in addition to forced air systems. The infrared heaters are controlled separately from the forced air systems and have dedicated zone temperature thermostats. None of the equipment is visible on the Metasys BAS workstation and it appears that the separate systems are not capable of communicating operating conditions to each other. During the audit, one bay was observed with the forced air systems operating for heating even though occupancy was limited and no vehicle was emitting exhaust gases. The other bay had no forced air systems operating with infrared heat operating for heating purposes. In addition, MAUs were observed to operate with overhead doors open even though a lockout system with the doors appeared to be installed. The same could be said of the observed emissions control system given MAU operation with no exhaust gas being emitted. This observation is further verified by a CO2 content of the maintenance bay air of 488 parts per million (ppm); see This was a reading taken without equipment operating where any reading less than 800 ppm of CO2 is considered an over ventilated situation. It is postulated that the high Energy Utilization Intensity (EUI) value for this facility is due to the inconsistent HVAC controls within the maintenance bays.

Figure 35: CMA North Southern Maintenance Bay General Air Conditions

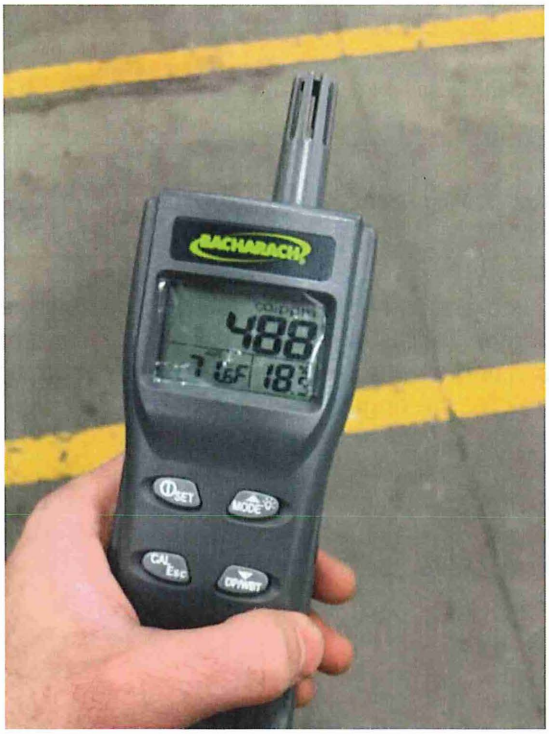


Table 117: CMA North Air Handling Units

AHU ID	Serves	Type	Make	Model Number
AHU_LKRM	Locker Room and Electrical Room	Constant Volume, Air Handler Unit	Unknown	Unknown
MAU_BII	BII Section	Constant Volume, Make-up Air Unit	McQuay	LHD217CI
AHU_S5	Offices in Center Section	Variable Air Volume Unit; Discharge Air Damper	Unknown	Unknown
MAU_S1	General Make Up Air For North Bay	Constant Volume, Make-up Air Unit	Snyder General	LHD122DH
MAU_S2	General Make Up Air South Bay	Constant Volume, Make-up Air Unit	Snyder General	LHD122DH
MAU_S3	Tail Pipe Exhaust Make Up Air North Bay	Constant Volume, Make-up Air Unit	Snyder General	LHD114DH
MAU_S4	Tail Pipe Exhaust Make Up Air South Bay	Constant Volume, Make-up Air Unit	Snyder General	LHD128DH
MAU_NGRG	Make Up Air	Abandoned Make-up Air Unit	Unknown	Unknown
AHU_PHYSTRAINING	Physical Training Room	Horizontally oriented Cabinet Unit in Space	Unknown	Unknown

Hot water for original facility is produced by two 1,750 kBTU/hr Kewanee boilers. The hot water distribution system for the original facility is served by two 5 HP constant volume hot water pumps. Only boiler status is visible on the Metasys BAS workstation along with return and supply hot water temperatures for the original building loop.

Hot water for the additions to the facility is produced by a single 4,200 kBTU/hr Burnham boiler. The hot water distribution system for the facility additions is served by two 5HP constant volume hot water pumps. Only boiler status is visible on the Metasys BAS workstation along with return and supply hot water temperatures for the facility additions.

Table 118: CMA North Boilers

Boiler ID	Boiler Location	Serves	Make	Model Number	Serial Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
BLR-1	Original Boiler Mech Room	Original HW Loop	Kewanee	M-175-KX	665801 Order #	1750	
BLR-2	Original Boiler Mech Room	Original HW Loop	Kewanee	M-175-KX	665801 Order #	1750	
BLR-3	New Addition Boiler Mech Room	New Addition HW Loop	Burnham	4FW-536A-45-G-1C	21433	4200	80%

Table 119: CMA North Hot Water Pumps

Pump ID	Serves	Pump Make	Pump Model Number	Pump Serial Number	System Fluid Type	Total Discharge Pressure, ft. of Head H20	Pump Impeller Design Rotational Velocity, RPM	Pump Design Volumetric Flow Rate, GPM
HWP-1	Original HW Loop	Bell & Gossett	2-1/287-3/8B F	815490	Water	45.00	1,750.00	200.00
HWP-2	Original HW Loop	Bell & Gossett	2-1/287-3/8B F	815490	Water	45.00	1,750.00	200.00
HWP-3	Additional HW Loop	Bell & Gossett	3X9.5B 7.75	1787084	Water	50.00	1,800.00	220.00
HWP-4	Additional HW Loop	Bell & Gossett	3X9.5B 7.75	1787084	Water	50.00	1,800.00	220.00

Table 120: CMA North Hot Water Pump Motors

Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model	Motor Type	Ins. Class	Frame
5	208-230/460V 3ph	85.50%	U.S Electrical Motors	C537A	D4	F	184JM
5	208-230/460V 3ph	85.50%	U.S Electrical Motors	C537A	D4	F	184JM

Pump Motor, HP	Pump Motor Voltage & Phase	Motor Efficiency	Pump Motor Make	Pump Motor Model	Motor Type	Ins. Class	Frame
5	230-460V/3Ph	85.50%	Magnetek	G360327-02	SCE	F	S184JM
5	230-460V/3Ph	85.50%	Magnetek	G360327-02	SCE	F	S184JM

No Chilled water is produced at CMA North. All cooling is rejected via Direct Expansion systems.

OTHER HVAC CONTROLS OBSERVATIONS:
General indoor air conditions during the time of the audit:
Monday October 5th, 2015

1. Start of Audit, OSAT = 48 °F dry bulb, 65% RH and 500 PPM of CO2
2. Storage: 71 °F drybulb, 38% RH, 685 PPM CO2
3. Office 1: 70 °F drybulb, 45% RH, 585 PPM CO2
4. Office 2: 71 °F drybulb, 23% RH, 479 PPM CO2
5. Receiving/Supply Area: 73 degF, 30% RH, 520 PPM CO2

Note: the low values of CO2 parts per million (PPM) sensed during the audit. Typically a value of 800-1000 PPM or less is considered adequate.

Other observations on Monday October 5th, 2015.

- Observed heat exhaust from flue for infrared heaters on day of audit, garage doors where open due to nice weather. Potential lock out of heat should be considered based on both OSAT and garage door position.

Wednesday January 6th, 2016

6. Start of Audit, OSAT = 28 °F with overcast skies
7. Men's Locker Room, ZNT = 68.2 °F dry bulb, 16% RH and 485 PPM of CO2
8. Original Facility Hallway, ZNT = 68.8 °F dry bulb, 15% RH and 493 PPM of CO2
9. North BII Area, ZNT = 75.5 °F dry bulb, 13% RH and 559 PPM of CO2
10. South BII Area, ZNT = 73.5 °F dry bulb, 11% RH and 508 PPM of CO2
11. North Maintenance Bay, ZNT = 67.7 °F dry bulb, 12% RH and 450 PPM of CO2

Note: the low values of CO2 parts per million (PPM) sensed during the audit. Typically a value of 800-1000 PPM or less is considered adequate.

Other observations on Wednesday January 6th, 2016

12. MAU S-3 operating during the time of the audit. No vehicles operating
13. MAU S-1 operating during the time of the audit. No vehicles operating
14. MAU S-4 off during the time of the audit. No vehicles operating
15. MAU S-2 off during the time of the audit. No vehicles operating
16. Staff states that thermostats along walls for unit heater in BII causes units to run continuously space is stated to be too warm and feels too warm (~74degF). No control of space temperature by occupants.
17. BII ceiling fans throughout area operated by switch. Two on south side are over equipment shelving and are not used. Switch for south side fans has an unknown location.

18. One of seven exhaust fans within BII area on roof were operating. Four of approximately eight or so unit heaters operating at time of audit. Make up air unit for BII area was not operating. All unit heaters eventually cycled off.

Since zone temperature for the additions to the facility are not visible on the front end and are controlled pneumatically it is assumed that zone temperatures are held constant throughout the facility. BAS observations and utility consumption observations confirm the use of lockout temperatures for both cooling and heating system. Due to the inconsistency of the operation of pneumatically controlled equipment, it is assumed that outside air dampers for these units, specifically those in the eastern wing, maintain a constant position.

DESCRIPTION OF PROPOSED ENERGY CONSERVATION MEASURES (ECMS)

ECM Description
ECM 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating
ECM 4.2A: Condensing Boiler Replacement
ECM 4.2B: RTU, and/or ACCU Replacement
ECM 3.5: Install De-stratification Fans in High Bay Spaces
ECM 3.2A: BAS: Base Controls Recommissioning and Upgrades
ECM 3.2B: BAS: Complete Pneumatic Removal
ECM 3.3: BAS: Alternate Install Standalone Programmable Thermostat
ECM 5.1: Replace Interior Lighting
ECM 5.4: Replace Exterior Lighting
ECM 6.1: Building Envelope Improvements

Energy Conservation Measure (ECM) 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating

The purpose of this ECM is to eliminate the use of the existing steam plant. Heating equipment is to be added or replaced at each facility which utilizes steam as per the scope of work for this ECM.

Existing Conditions

Currently, the Central Steam Plant provides steam to nine facilities within Area 2 of the cantonment area. This steam is primarily utilized for the purpose of building heat. The central steam plant itself utilizes produced steam to provide building heat. Table 122 list the facilities which utilizes steam produced by the Central Steam Plant. Table 121 list detailed information for existing steam boilers. Figure 36 outlines the service area of the Central Steam Plant on a map of Area 2 of the cantonment area. For details regarding the existing Heating Ventilation and Air Conditioning equipment at each facility see the *Description of Existing Facilities* section within this document.

Table 121: Existing Steam Boiler Information

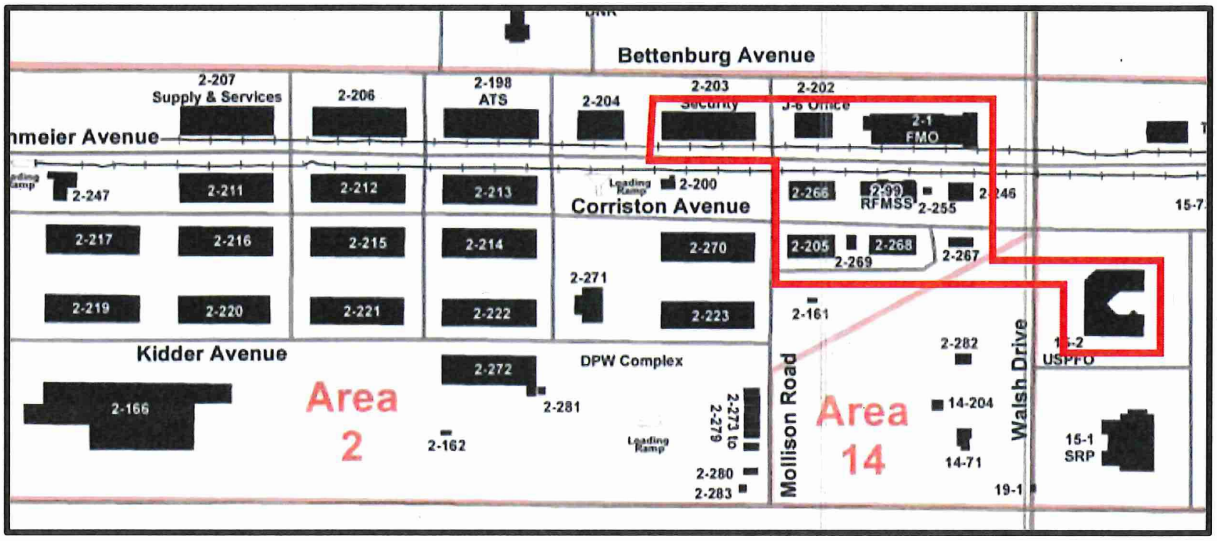
ID	Boiler Manufacture	Boiler Model Number	Individual Boiler Capacity, MMBTU/hr	Boiler Name Plate Efficiency
Boiler-1	Burnham	4FL-675A3-50-G01C	4.432	80%
Boiler-2	Burnham	4FL-675A3-50-G01C	4.432	80%

Based on the modeling calibration effort described in *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* the design existing efficiency of the steam plant is about 55% to 65%. This value represents the efficiency of the entire steam system including the boiler thermal efficiency and all losses in the distribution system.

Table 122: Facilities Served by the Central Steam Plant

Central Steam Plant (02-246)
RTI (02-001)
Storage/DPW (02-099)
J6/IT (02-202)
Security (02-203)
Carpentry (02-266)
Plumbing (02-267)
Public Works (02-268)
Paint Shop (02-269)
USPFO (15-002)

Figure 36: Central Steam Plant Service Area



PROPOSED CONDITIONS

Heating equipment shall be added or replaced according to the scope of work for this ECM. Locations where boilers shall be installed shall follow a hot water reset sequence an example of which is as follows:

When the outside air dry bulb temperature is at or above 45 degrees Fahrenheit (adjustable) the boiler shall supply 140 degree Fahrenheit hot water (adjustable). When the outside air dry bulb temperature is at or below 25 degree Fahrenheit (adjustable) the boiler shall supply 180 degree Fahrenheit hot water (adjustable). The hot water supply temperature shall vary linearly between 140 degrees Fahrenheit (adjustable) and 180 degrees Fahrenheit when the outside air temperature is between 45 degrees Fahrenheit (adjustable) and 25 degrees Fahrenheit (adjustable).

As an alternate, in locations where terminal unit and air handler unit feedback allows, the valve position output can provide a means of estimating the % load for the facility. If this is possible the hot water reset schedule presented in Table 123 shall be utilized.

Table 123: Supply Hot Water Reset Schedule

Percent Load at Maximum Supply Water Temperature	80%
Maximum Supply Water Temperature, °F	180
Percent Load at Minimum Supply Water Temperature	50%
Minimum Supply Water Temperature, °F	140

Locations to receive complete HVAC replacement in the form of natural gas unit heaters or furnaces shall supply 15% minimum outside air when the facility is occupied. This value is not yet final and shall be set by further engineering during the execution of this project.

SCOPE OF WORK
RTI (02-001)
DEMOLITION AND REMOVAL WORK
MECHANICAL

1. Disconnect, remove and properly dispose of existing Steam distribution and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of chilled water piping as required for installation of new systems and services.
4. Disconnect, remove and properly dispose of steam distribution piping in lower level of FMO building as needed for a new hot water boiler installation.

NEW INSTALLATION WORK
NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Lower Level Mechanical Room	Natural Gas	1200	2

1. New Boilers shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **AERCO** or Equal in Design, Performance, Efficiency, Options, and Installation.
     - ☒ New equipment location: Lower Level Mechanical Room
     - ☒ Natural gas service to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Furnish and install new domestic hot water loop to existing heat exchanger.
4. Supply/Connect all electrical as required.
5. Provide boiler control panel and tie-in and programming with existing boiler of same make and model as specified above.
6. The boilers shall be located in the existing lower level mechanical room. If adequate space for the new boilers cannot be achieved in the existing mechanical room, the room adjacent West to the existing mechanical room located in the lower level of the building shall be utilized. Will need to create a new "boiler room" utilizing the 8-10 feet of the back of storage room.
7. Provide and install new flue as required
8. Provide new controls and valves for new boiler system and CUHs. Disconnect and reconnect to existing controls and control valves to remain. Replace "failed" valves as needed.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
    a. DDC Panel
    b. Supply water sensor
    c. Return water sensor
    d. Boiler enable
    e. Differential pressure sensor
    f. Pump VFD command/status/output
    g. Boiler pump enable
2. CUH Controls (Typical of 5)
    a. DDC Panel
    b. Zone sensor
    c. Control valve
    d. Fan relay
    e. Transformer
3. 4 hours controls training

IT/J-6 – 02-202

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of existing steam condensate system.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Main Level Mechanical Room	Natural Gas	400	1

1. New Boiler shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **AERCO** or Equal in Design, Performance, Efficiency, Options, and Installation.

   ☒ New equipment location: Existing Mechanical Room
   ☒ New natural gas service to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Supply/Connect all electrical as required.
4. The boiler shall be located in the existing mechanical room located on the main floor of the building.
5. New HW VAVs shall have same capacity output as the current steam coil VAVs
6. New HW pumps shall be located in the existing mechanical room located on the main floor of the building.
7. Current AHU will be modified for new HW coil with same capacity output as current steam coil in AHU.
8. Route new HW piping to new HW coil in the AHU and to new HW VAVs.
9. Provide and install new flue as required
10. Provide new controls for boiler and VAV boxes. Recommissioning any existing controls that remain.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)

   g. Differential pressure sensor
   h. Pump VFD command/status/output (2)
   i. Boiler pump enable(2)
2. VAV Boxes w/Reheat (6)
   a. Discharge air temperature
   b. Heating valve output
   c. Damper actuator/controller
   d. Zone temperature
   e. Transformer
   f. Air flow sensor
3. 4 hours controls training.

FORCE PROTECTION – 02-203

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution and conversion system (steam to hot water) at point of entry, including controls.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of steam distribution piping

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Main Level Mechanical Room	Natural Gas	400	2

1. New Boilers shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **AERCO** or Equal in Design, Performance, Efficiency, Options, and Installation.

   ☒ New equipment location: Existing Main level mechanical room
   ☒ New natural gas service to be routed
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Supply/Connect all electrical as required.
4. The new boilers shall be located in the existing mechanical room located on the main floor of the building adjacent to the garage.
5. Provide and install new flue as required.
6. Provide new boiler controls.
7. Contractor to flush all new water pipe and bleed air from the system.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)
   g. Differential pressure sensor
   h. Pump VFD command/status/output (2)
   i. Boiler pump enable(2)
2. 4 hours controls training.

CARPENTRY SHOP – 02-266

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution system at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of existing steam fan coil unit located above the shop office.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (Btuh)	Quantity of Furnaces
Above Office Ceiling	Natural Gas	50,000	1
Workshop	Natural Gas	100,000	1

1. New Furnace shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **York** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Above Office ceiling and hanging in workshop area
   - ☒ Natural gas service to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Supply/Connect all electrical as required.
4. The furnace for the office area shall be located above the ceiling in the office area.
5. The furnace for the workshop shall be hung from the ceiling.
6. Provide ductwork to provide proper distribution for the area.
7. Provide and install new flue as required.
8. Provide new network controls and furnace controls.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
2. Furnace Controls (2)
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Heating command
   f. Fan relay
   g. Transformer

3. 4 hours controls training.

STORAGE/DPW – 2-099

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing Steam distribution and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Lower Level	Nat Gas	270	2

1. New Boiler shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **Aerco** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Main Level
   - ☒ Natural gas service to be routed to building
1. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
2. Supply/Connect all electrical as required.
3. Install new boilers in the lower level of the building. Will create a new "boiler room" utilizing a room located in the Southwest lower level corner of the building.
4. Install new hot water fin tube radiation in place of the existing steam fin tube radiation and terminal units.
5. Provide and install new flue as required.
6. Provide new network controller, boiler controls, fan coil unit controls, and radiation controls.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
2. Furnace Controls (2)
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Heating command
   f. Fan relay
   g. Transformer
3. 4 hours controls training.

PUBLIC WORKS – 02-268

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution system at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of three existing steam fan coil units located above the ceiling.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (Btuh)	Quantity of Fan Coil Units
Main Level Mechanical Room	Hot Water	40,000	3

1. New Fan Coil Unit shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **York** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Above Ceiling
   - ☒ Existing DX cooling system to be reconnected to new fan coil units
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. New fan coil units shall be located above the ceiling.
4. Install new HW fin tube radiation in place of existing steam fin tube radiation.
5. Boiler supplying the new HW radiation and HW fan coil units shall be located across the street in the Storage/DWP 2-099 building, route piping underground in the existing steam tunnel.
6. New HW pumps shall be located in the new "boiler room" located in the lower level of Storage/DWP 2-099 building.
7. Provide and install new flue as required.
8. Provide new network controller, fan coil unit controls and room radiation.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Pump controls
   a. DDC Panel
   b. Differential pressure sensor
   c. Pump VFD command/status/output (2)
2. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
3. FCU Controls (Typical of 3)
   a. DDC Panel
   b. Zone sensor

   c. Discharge air temperature
   d. Filter status
   e. Cooling command
   f. Heating control valve
   g. Fan relay
   h. Transformer
4. Room Radiation Controls (Typical of 10)
   a. Zone sensor (TEC)
   b. Heat control valve
   c. Transformer
5. 4 hours controls training.

PAINT SHOP – 02-269

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution system and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of existing condensate system.
4. Disconnect, remove and properly dispose of existing electric unit heater.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (Btuh)	Quantity of Furnaces
Office Area	Natural Gas	50,000	1
Workshop	Natural Gas	120,000	1

1. New Furnaces shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **York** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Main Level
   - ☒ Natural gas to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. The furnaces shall be located on the main floor of the building, one unit to serve the office area, the other to serve the workshop area.
4. Provide and install new flue as required.
5. Provide network controller and furnace controls.
6. Provide new ductwork for proper distribution.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
2. Furnace Controls (Typical of 2)
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Cooling command
   f. Heating control valve

g. Fan relay
h. Transformer

3. 4 hours controls training

CENTRAL STEAM PLANT – 02-246

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing Steam Plant and distribution piping system.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of steam distribution piping in lower level.
4. Disconnect, remove and properly dispose all steam equipment in the main level of the building.
5. Disconnect of 1.5 ton mini split system located on north wall.
6. Disconnect, remove and properly dispose of existing electric unit heater.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (Btuh)	Quantity of Furnaces
Main Level	Nat Gas	30,000	2

1. New Furnace shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **York** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Main Level
   - ☒ Existing Natural Gas Service to be reused
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Install new furnaces hanging in the main level of the building.
4. Provide and install new flue as required.
5. Connections to existing condensing unit.
6. New controls for new equipment.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)
   g. Differential pressure sensor
   h. Pump VFD command/status/output (2)
   i. Boiler pump enable(2)
2. Network controller (NCE)
   a. NCE Panel
   b. Power to panel

   c. MSTP trunk to building controllers
3. UH Controls
   a. Zone sensor (TEC)
   b. Heat command
   c. Fan relay
   d. Transformer
4. Furnace Controls
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Heating command
   f. Fan relay
   g. Transformer
5. 4 hours controls training.

PLUMBING SHOP – 02-267

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing steam distribution and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of existing steam distribution piping to point of exit to the water tower heating system.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Main Level Mechanical Room	Natural Gas	2,250	2

1. New Boiler shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **AERCO** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: Lower level
   - ☒ Natural gas service to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. The boilers shall be located in the lower level of the building.
4. Install exterior wall HW fin tube radiation in place of existing steam fin tube.
5. Install new HW pumps in lower lever of the building.
6. Reconnect existing piping used for water tower heating to the new boilers.
7. Provide and install new flue as required.
8. Provide new boiler controls, network controller, fan coil unit controls, and radiation controls.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)
   g. Differential pressure sensor
   h. Pump VFD command/status/output (4)
   i. Boiler pump enable (2)
2. Network controller (NCE)

   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
3. FCU Controls
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Heating control valve
   f. Fan relay
   g. Transformer
4. Room Radiation Controls (Typical of 6)
   a. Zone sensor (TEC)
   b. Heat control valve
   c. Transformer
5. 4 hours controls training.

USPFO – 15-002

DEMOLITION AND REMOVAL WORK

MECHANICAL

1. Disconnect, remove and properly dispose of existing Steam distribution and conversion system (steam to hot water) at point of entry.
2. Disconnect, remove and properly dispose of existing temperature control valves as required for new installation.
3. Disconnect, remove and properly dispose of existing air handling unit located in the mechanical room.

NEW INSTALLATION WORK

NEW EQUIPMENT

Location	Type	Min Output (MBtuh)	Quantity of Boilers
Main Level Mechanical Room	Natural Gas	500	2

1. New Boiler shall be a minimum of 95% (AFUE) efficient
   - Unit shall be manufactured by: **Aerco** or Equal in Design, Performance, Efficiency, Options, and Installation.
   - ☒ New equipment location: In new building to be constructed
   - ☒ Natural gas service to be routed to building
2. Furnish and install new pipe, valves, fittings, and hydronic accessories as required.
3. Boilers shall be located in a new building located adjacent to the USPFO 15-002 or possibly the old Central Steam Plant building.
4. A new HW coil AHU with like capacity of the existing AHU will be installed in the location of the existing AHU
5. Provide HW distribution pumps.
6. Provide new piping from boiler location to new AHU in the existing mechanical room.
7. Provide new boiler controls and new AHU controls.

CONTROLS

The following control points shall be added in addition to some Customer training.

1. Boiler controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)
   g. Differential pressure sensor
   h. Pump VFD command/status/output (2)
   i. Boiler pump enable (2)

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, savings are estimated based off the performance gain between existing equipment and proposed equipment. Performance equations are utilized to represent both existing and proposed equipment performance at various conditions. Existing equipment is represented by forced draft, steam coefficients with a design efficiency 65% while proposed equipment is represented by furnaces or condensing hot water boiler coefficients with a design efficiency of 95%. In addition, existing boilers have a 10% efficiency impact if building load is less than existing boiler minimum turndown which is defined as 30%. Proposed boilers have a 5% efficiency impact if building load is less than the proposed boiler minimum turndown which is defined as 20%.

Locations which shall receive completely new HVAC equipment in the form of natural gas furnaces or unit heaters also have a savings impact due to ventilation requirements. This value is currently defined as a 15% ventilation rate impact. This value is not yet final and shall be set by further engineering during the execution of this project.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating	$2,438,782	4,956	10,173	$6,288	$17,761	$24,049	101	15-25

INCLUSIONS/EXCLUSIONS/ASSUMPTIONS

Inclusions:

- Submittals of all equipment for Customer approval.
- Equipment start up and operation training
- Engineered design and stamped drawings

Exclusions:

- Repair or replacement of defective mechanical/controls equipment, other than the equipment specifically described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the Customer.)
- Repair or upgrades required due to rectify existing code violations unless specifically described in this Scope of Work.
- Electrical work, including labor, material and equipment associated with disconnecting and reconnecting of all equipment.
- Replacement, repair or installation of water treatment system.
- Hot water system hydronic balancing, unless specified in the scope of work.
- Engineering drawings other then as stated above

ENERGY CONSERVATION MEASURE (ECM) 4.2A: CONDENSING BOILER REPLACEMENT

The purpose of this ECM is to replace existing boilers at RTSM (11-076), Maintenance Shop (11-160), and USPFO Warehouse (11-062) with high efficiency condensing boilers.

EXISTING CONDITIONS

Currently RTSM (11-076), Maintenance Shop (11-160), and USPFO Warehouse (11-062) are served by conventional, forced draft, hot water boilers. Boiler details are listed in Table 124. For additional building description and existing HVAC equipment information see the *Description of Existing Facilities* section within this document.

Table 124: ECM 4.2A Existing Boilers

Facility	Boiler ID	Make	Model Number	Total Boiler Output, 1000 BTUs/hr.	Boiler Design Efficiency
RTSM (11-076)	BLR-1& 2	Kewanee	M175-XX	1,750	*80%
Maintenance Shop (11-160)	BLR-1	Burnham	806B-W1	264	80%
Maintenance Shop (11-160)	BLR-2	Burnham	806B-W1	264	80%
USPFO Warehouse (11-062)	BLR-1	Kewanee	M75-KX	750	*80%
USPFO Warehouse (11-062)	BLR-2	Kewanee	M75-KX	450	*80%

*Estimated Efficiency

PROPOSED CONDITIONS

Existing boilers shall be replaced as per the scope of work for this ECM. In order to realize the full efficiency benefits of condensing boilers a hot water supply temperature reset sequence shall be implemented. The following is an example hot water supply temperature sequence based on outside air temperature:

When the outside air dry bulb temperature is at or above 45 degrees Fahrenheit (adjustable) the boiler shall supply 140 degree Fahrenheit hot water (adjustable). When the outside air dry bulb temperature is at or below 25 degree Fahrenheit (adjustable) the boiler shall supply 180 degree Fahrenheit hot water (adjustable). The hot water supply temperature shall vary linearly between 140 degrees Fahrenheit (adjustable) and 180 degrees Fahrenheit when the outside air temperature is between 45 degrees Fahrenheit (adjustable) and 25 degrees Fahrenheit (adjustable).

As an alternate, in locations where terminal unit and air handler unit feedback allows, the valve position output can provide a means of estimating the % load for the facility. If this is possible the hot water reset schedule presented in Table 123 shall be utilized.

SCOPE OF WORK

USPFO WAREHOUSE (11-062)

DEMOLITION AND REMOVAL WORK

1. Remove existing Heating Hot Water (HHW) Boilers
2. Remove and properly dispose of existing HHW Pumps
3. Remove HHW piping to nearest isolation valves or nearest change of direction as required for new installation.
4. Remove natural gas piping to nearest isolation valves or as required for new installation.
5. Demo gas flue as required.
6. Disconnect and secure building management system connection.
7. Disconnect and secure electrical connections for HHW Pumps
8. Disconnect and secure electrical connections to the HHW boilers.

NEW INSTALLATION WORK

Mechanical

1. Provide and install new HHW Condensing Boilers according to table above
   a. Condensing, modulating burner
   b. High Efficiency >94% @ 100% load with 80°F RWT
   c. New boilers to have factory mounted and wired operating and safety controls and boiler control panel. Multiple boiler installations will have boilers programmed to have adjustable lead/lag operation.
   d. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size.

2. Provide and install new HHW Pumps
   a. Close-coupled pump required.
   b. Reconnect piping, valves, fittings, and hydronic accessories as required.
   c. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size. If housekeeping pad does not exist, provide and install new concrete housekeeping pad (minimum 4 inches in height and minimum of 4 inches larger than boiler supporting frame on all sides).
3. Reconnect HHW Supply and Return Piping to the new Boiler. Match the existing pipe size.
4. Reconnect natural gas piping to the new boiler. Match existing pipe size.
5. Install new flue, sealing any roof and/or wall penetrations.
6. Re-insulate any newly exposed pipe to match or exceed existing, valves and fittings as required.
7. Provide new VFD's.
8. Factory authorized Start-up of new boiler.

CONTROLS

1. Boiler Controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)

f. Boiler enable(2)
g. Differential pressure sensor
h. Pump VFD command/status/output (2)
i. Boiler pump enable(2)

2. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers

ELECTRICAL

1. Connect power to HHW Pump. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace.
2. Connect power to new boiler. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace

MAINTENANCE SHOP (11-060)

DEMOLITION AND REMOVAL WORK

1. Remove existing Heating Hot Water (HHW) Boilers
2. Remove and properly dispose of existing HHW Pumps
3. Remove HHW piping to nearest isolation valves or nearest change of direction as required for new installation.
4. Remove natural gas piping to nearest isolation valves or as required for new installation.
5. Demo gas flue as required.
6. Disconnect and secure building management system connection.
7. Disconnect and secure electrical connections for HHW Pumps
8. Disconnect and secure electrical connections to the HHW boilers

NEW INSTALLATION WORK

MECHANICAL

1. Provide and install new HHW Condensing Boilers according to table above
   a. Condensing, modulating burner
   b. High Efficiency >94% @ 100% load with 80°F RWT
   c. New boilers to have factory mounted and wired operating and safety controls.
   d. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size.

2. Provide and install new HHW Pumps
   a. Close-coupled pump required.
   b. Reconnect piping, valves, fittings, and hydronic accessories as required.
   c. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size. If housekeeping pad does not exist, provide and install new concrete housekeeping pad (minimum 4 inches in height and minimum of 4 inches larger than boiler supporting frame on all sides).
3. Reconnect HHW Supply and Return Piping to the new Boiler. Match the existing pipe size.
4. Reconnect natural gas piping to the new boiler. Match existing pipe size.
5. Install new flue, sealing any roof and/or wall penetrations.

6. Re-insulate any newly exposed pipe to match or exceed existing, valves and fittings as required.
7. Factory authorized Start-up of new boiler.

CONTROLS

1. Boiler Controls
    a. DDC Panel
    b. Boiler entering temperature (2)
    c. Boiler leaving temperature (2)
    d. Supply water sensor (2)
    e. Return water sensor (2)
    f. Boiler enable(2)
    g. Differential pressure sensor
    h. Pump VFD command/status/output (2)
    i. Boiler pump enable (2)

ELECTRICAL

1. Connect power to HHW Pump. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace.
2. Connect power to new boiler. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace.

RTSM (11-076)

DEMOLITION AND REMOVAL WORK

1. Remove existing Heating Hot Water (HHW) Boilers
2. Remove and properly dispose of existing HHW Pumps
3. Remove HHW piping to nearest isolation valves or nearest change of direction as required for new installation.
4. Remove natural gas piping to nearest isolation valves or as required for new installation.
5. Demo gas flue as required.
6. Disconnect and secure building management system connection.
7. Disconnect and secure electrical connections for HHW Pumps
8. Disconnect and secure electrical connections to the HHW boilers.

NEW INSTALLATION WORK

MECHANICAL

1. Provide and install new HHW Condensing Boilers according to table above
    a. Condensing, modulating burner
    b. High Efficiency >94% @ 100% load with 80°F RWT
    c. New boilers to have factory mounted and wired operating and safety controls.
    d. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size.

2. Provide and install new HHW Pumps
    a. Close-coupled pump required.
    b. Reconnect piping, valves, fittings, and hydronic accessories as required.

   c. Reuse existing concrete housekeeping pads. If existing concrete housekeeping pads are not large enough, extend the existing pad to proper size. If housekeeping pad does not exist, provide and install new concrete housekeeping pad (minimum 4 inches in height and minimum of 4 inches larger than boiler supporting frame on all sides).
3. Reconnect HHW Supply and Return Piping to the new Boiler. Match the existing pipe size.
4. Reconnect natural gas piping to the new boiler. Match existing pipe size.
5. Install new flue, sealing any roof and/or wall penetrations.
6. Re-insulate any newly exposed pipe to match or exceed existing, valves and fittings as required.
7. Factory authorized Start-up of new boiler.

CONTROLS

1. Boiler Controls
   a. DDC Panel
   b. Boiler entering temperature (2)
   c. Boiler leaving temperature (2)
   d. Supply water sensor (2)
   e. Return water sensor (2)
   f. Boiler enable(2)
   g. Differential pressure sensor
   h. Pump VFD command/status/output (2)
   i. Boiler pump enable (2)

ELECTRICAL

1. Connect power to HHW Pump. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace.
2. Connect power to new boiler. Reuse existing electrical devices and wiring. If devices and wiring are found to be of insufficient size, insufficient length, or in poor condition, Customer is responsible to replace.

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, savings are estimated based off the performance gain between existing equipment and proposed equipment. Performance equations are utilized to represent both existing and proposed equipment performance at various conditions. Existing equipment is represented by conventional, forced draft, hot water boiler coefficients with a design efficiency of 80% while proposed equipment is represented by condensing hot water boiler coefficients with a design efficiency of 94%. In addition, existing boilers have a 5% efficiency impact if building load is less than existing boiler minimum turndown which is defined as 30%. Proposed boilers have a 5% efficiency impact if building load is less than the proposed boiler minimum turndown which is defined as 20%.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 4.2A: Condensing Boiler Replacement	$763,068	-318	2,966	$1,655	$849	$2,505	305	25

INCLUSIONS/EXCLUSIONS/ASSUMPTIONS

Inclusions:

- Submittals of all equipment for Customer approval.
- Equipment start up and operation training

Exclusions:

- Repair or replacement of defective mechanical/controls equipment, other than the equipment specifically described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the Customer.)
- Repair or upgrades required due to rectify existing code violations unless specifically described in this Scope of Work.
- Electrical work, including labor, material and equipment associated with disconnecting and reconnecting of all equipment.
- Replacement, repair or installation of water treatment system.
- Hot water system hydronic balancing, unless specified in the scope of work.
- Engineering drawings other then as stated above

ENERGY CONSERVATION MEASURE (ECM) 4.2B: RTU, AND/OR ACCU REPLACEMENT

The purpose of this ECM is to replace existing packaged Roof Top Units (RTUs) with new packaged Roof Top Units (RTUs).

EXISTING CONDITIONS

Currently, the offices in the eastern partition of RTSM are served by seven RTUs. These RTUs are reaching the end of their useful service life. Table 125 list additional details for existing equipment. For additional information regarding other existing HVAC equipment for RTSM or a general description of the facility see the *Description of Existing Facilities* section within this document.

Table 125: ECM 4.2B Existing Roof Top Unit Information

Equipment	Manufacturer	Model #	Serial #
RTU1	Lennox	LCA060SN1Y	5602D02684
RTU2	Lennox	LCA036SN1Y	5602D02629
RTU3	Lennox	LCA036SN1Y	5602D02630
RTU4	SynderGeneral	CUR085FW02	...84077-00
RTU5	SynderGeneral	RD5420603	R893900054
RTU6	AAON	RN-010-8-0-CA01-EHL	201407-ANWJ03992
RTU7	SynderGeneral	CUR085FW02	5UL84076-00

PROPOSED CONDITIONS

Existing RTUs shall be replaced with like sized RTUs with a SEER rating of 13 or greater as per the scope of work for this ECM.

SCOPE OF WORK

RTSM (11-076)

DEMOLITION AND REMOVAL WORK

- Remove and dispose of existing packaged equipment according to Table above.
- Recover and properly dispose of refrigerant.
- Remove each existing equipment electrical disconnect, and safely disconnect electrical supply.
- Disconnect equipment from existing ducting, condensate drain piping, and natural gas piping and distribution piping.
- Disconnect and secure Energy Management System (EMS) connections as necessary to perform work.
- Customer is responsible to disconnect and secure electrical connections and equipment necessary to allow for removal of RTU.
- Properly dispose of all removed equipment and waste materials.

NEW INSTALLATION WORK

- Furnish and install new packaged equipment as listed in Table above at existing locations. Equipment to have the following features:

- Minimum SEER rating of 13
- Motorized fresh air intake dampers or modulating OA dampers with economizers
- Provide new curb adapters, if required
- Provide new curb flashing and sealing of roof penetrations related to this work if required.
- Provide electrical connections, with new electrical disconnect or reuse existing disconnect.
- Modify electrical power wiring distribution panel as needed. Existing electrical wiring will be reused as much as possible.
- Provide electrical connections, with new electrical disconnect or reuse existing disconnect.
- Modify electrical power wiring distribution panel as needed. Existing electrical wiring will be reused as much as possible.
- Reconnect new equipment to existing ductwork reusing existing roof penetrations. If required, provide transition ductwork. Insulate any new ductwork.
- Reconnect new equipment to existing condensate drain and natural gas piping.

CONTROLS

1. RTU Controls
    a. DDC Panel
    b. Zone sensor
    c. Discharge air temperature
    d. Mixed air dampers actuators (Typical of 3)
    e. Supply fan status
    f. Exhaust fan start/stop/status

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, savings are estimated based off the performance gain between existing equipment and proposed equipment. Performance equations are utilized to represent both existing and proposed equipment performance at various conditions. Existing equipment is represented as a small direct expansion system with a design efficiency 1.1 kW/ton or an EER rating of about 11. Proposed equipment system type is the same, however, design efficiency is defined at .94 kW/ton or an EER rating of about 12.7 EER. In addition, existing systems have an 8.3% efficiency impact if building load is less than existing system minimum operating part load which is defined as 25%. Proposed systems are not expected to experience such a performance impact at minimum operating conditions.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 4.2B: RTU, and/or ACCU Replacement	$197,343	1,050	0	$65	$517	$582	339	15

INCLUSIONS, EXCLUSIONS AND ASSUMPTIONS:

Inclusions:

- Required cranes and rigging is included, with coordination of street or parking lot traffic control and closures.
- Installation to be performed to mechanical, fire, etc., local, state, national installation and operational codes.
- Submit Operations and Maintenance (O&M) documentation.
- Start up and Check out.

Exclusions:

- Repair or replacement of defective mechanical equipment, except the equipment described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the Customer.)
- Repair or upgrades required due to bring adjacent Electrical and Mechanical systems up to code.
- Overtime work caused by unforeseen circumstances beyond the control of Johnson Controls, such as or scheduling changes by the Customer (The cost difference between the overtime work wages and normal time work wages will be the responsibility of the Customer calculated as [(overtime rate – normal rate) x hours]).
- Asbestos abatement and removal for this project is entirely the responsibility of the Customer. Johnson Controls is continuing to work with the Customer and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that the Customer can adequately plan for this requirement. If hazardous materials are encountered during the implementation phase, Johnson Controls will immediately stop work, take measures to reduce any contamination, and notify the Customers facility manager of the possible hazardous material condition and location. Johnson Controls will then request that the Customer remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during ongoing service phase of the project will remain the property and disposal responsibility of the Customer.
- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work (In the event hazardous materials are uncovered and abatement is beyond the ability of Johnson Controls to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to the Customer.)
- Air balancing of equipment.
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the Customer during development of project) is excluded from the scope and cost of this project.
- Temporary space conditioning, unless otherwise specified.
- Engineering services, studies, or analysis associated with any exclusions or work clearly outside of the scope definition.
- Roof repairs other than that directly associated with this scope of work.
- Licenses permits, & inspections required.
- Structural support modifications for new equipment.

ENERGY CONSERVATION MEASURE (ECM) 3.5: INSTALL DE-STRATIFICATION FANS IN HIGH BAY SPACES

The purpose of this ECM is to install de-stratification fans within the maintenance bays at RTSM (11-076).

EXISTING CONDITIONS

The western partition of RTSM (11-076) consist of maintenance bays which are considered high bay spaces. This means that the floor to ceiling height is greater than or equal to 20 ft. Air stratification is phenomenon which occurs in spaces with large floor to ceiling heights where warm air raises and cold air sinks. This is caused by density differences of air density at varying temperatures. During the heating season air stratification creates a situation where HVAC equipment works harder. The temperature of the air near the thermostat is at a level impacted by the cold air sinking and the hot air escaping upwards. The hot air near the roof creates indoor conditions which are typically greater than set point. This causes a greater temperature differential between the indoor conditions and the outdoor conditions increasing the amount of heat transfer loss through the roof.

PROPOSED CONDITIONS

A de-stratification fan shall be installed at each of the ten maintenance bays at RTSM (11-076) as per the scope of work.

SAVINGS METHODOLOGY

The savings methodology for this ECM are covered in detail in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section within this document. In summary, savings are based off of a reduced overall average air temperature due to the de-stratification of air. This reduces the overall temperature differential between the interior air temperature and outside air temperature which reduces heat loss due to convection/conduction. Reduced heat loss during the heating season in turn reduces the amount of work HVAC equipment must perform thus reducing utility consumption.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 3.5: Install De-stratification Fans in High Bay Spaces	$59,962	-1,806	1,041	$475	$0	$475	126	25

INCLUSIONS, EXCLUSIONS AND ASSUMPTIONS:

Inclusions:

- Required lifts, equipment, and rigging is included as needed for a complete installation.
- Submit Operations and Maintenance (O&M) documentation.
- Start up and Check out.
- Provide new conduit, wiring, etc. as needed for installation of new fans at locations that did not have any existing fans.
- Coordinate with controls contractor for any special requirements for control of de-stratification fans.

- Clean-up of all job related debris, tools, equipment, etc. after successful installation and operational check-out.
- All permitting as required.

Exclusions:

- Repair or replacement of defective mechanical equipment, existing destrat fans, etc. except the equipment described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the Customer.)
- Repair or upgrades required due to bring adjacent Electrical and Mechanical systems up to code.
- Overtime work caused by unforeseen circumstances beyond the control of Johnson Controls, such as or scheduling changes by the Customer (The cost difference between the overtime work wages and normal time work wages will be the responsibility of the Customer calculated as [(overtime rate – normal rate) x hours]).
- Asbestos abatement and removal for this project is entirely the responsibility of the Customer. Johnson Controls is continuing to work with the Customer and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that the Customer can adequately plan for this requirement. If hazardous materials are encountered during the implementation phase, Johnson Controls will immediately stop work, take measures to reduce any contamination, and notify the Customers facility manager of the possible hazardous material condition and location. Johnson Controls will then request that the Customer remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during ongoing service phase of the project will remain the property and disposal responsibility of the Customer.
- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work (In the event hazardous materials are uncovered and abatement is beyond the ability of Johnson Controls to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to the Customer.)
- Air balancing of existing equipment.
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the Customer during development of project) is excluded from the scope and cost of this project.
- Temporary space conditioning, unless otherwise specified.
- Engineering services, studies, or analysis associated with any exclusions or work clearly outside of the scope definition.
- Roof repairs other than that directly associated with this scope of work.
- Licenses permits, & inspections required.
- Structural support modifications for new equipment.

ENERGY CONSERVATION MEASURE (ECM) 3.2A: BUILDING AUTOMATION SYSTEM (BAS): BASE CONTROLS RECOMMISSIONING AND UPGRADES

The main purpose of this ECM is to revisit and expand on the sequences programmed into the existing Building Automation System (BAS) and ensure that energy savings sequences function. Some select equipment is also required to be replaced or added; exact equipment shall be detailed in the scope of work for this ECM.

EXISTING CONDITIONS

The *Description of Existing Facilities* section within this document covers the existing conditions for the BAS in detail by building. In summary, the majority of the facilities utilize older N2 based controllers. The majority of the HVAC equipment is networked and is observable on the BAS workstation where energy savings sequences are defined. However, overtime set points, schedules, or other input points have been overridden from their original value. Often, when an input command is overridden, the sequence which utilizes said input command ceases to function as desired. Typically, due to overrides or schedule changes, the equipment being controlled operates for more hours, thus energy is wasted.

The largest energy consuming facilities included in this report are CMA North and CMA South. Both of these facilities have large maintenance bays where the HVAC equipment is sized to and required to displace any emissions produced by large vehicles. However, when there are no vehicles operating, gas sensors exist to ensure that large Make-up Air Units (MAUs) are cycled off thus saving energy. These gas sensors have a service life of ten years which the existing units have surpassed. On numerous occasions, MAUs were observed operating when there were few occupants and no vehicles operating within the space.

Table 126 list existing set points and schedules which are based on BAS workstation observations, audit observations, and the model tuning process. The tuning process is covered in detail in *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section within this document.

Table 126: ECM 3.2A Existing Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
RTI (02-001)	8AM	6PM	Mon - Fri	25%	60	55	80	63
(a) Education Center (06-076)	8AM	6PM	Mon - Fri	0%	72	55	74	65
EMTC (06-078)	8AM	6PM	Mon - Fri	0%	60	55	80	61
PX (07-067)	8AM	6PM	Mon - Fri	5%	60	55	80	57
(b) Unit Housing Area 7 (07-131 Through 07-135)	4PM	8AM	Mon - Sun	5%	70	55	74	63
Snack Bar (08-022)	8AM	6PM	Mon - Fri	50%	70	55	74	57
TMC (08-081)	8AM	6PM	Mon - Fri	0%	70	57	74	59
MWR Building (08-195)	8AM	6PM	Mon - Fri	0%	70	55	74	65

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
Aviation Simulator Building (08-196)	8AM	6PM	Mon - Fri	15%	70	55	N/A	N/A
Air Ops Building (08-196)	8AM	6PM	Mon - Fri	5%	70	55	N/A	N/A
(b) Unit Housing Area 9 (09-131 Through 09-195)	4PM	8AM	Mon - Sun	5%	70	55	74	65
(b) Unit Housing Area 10 (10-137 Through 10-144)	4PM	8AM	Mon - Sun	5%	70	55	74	65
TACC (11-001)	8AM	6PM	Mon - Fri	0%	60	55	80	65
USPFO Warehouse (11-062)	8AM	6PM	Mon - Fri	0%	60	55	80	65
CIF (11-063)	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(c) RTSM (11-076)	8AM	6PM	Mon - Fri	20%	70	55	74	61
(c) DOL Office (11-159)	8AM	6PM	Mon - Fri	15%	70	55	74	57
(c) Maintenance Shop (11-160) - Garages	8AM	6PM	Mon - Fri	0%	70	55	N/A	N/A
(c) Maintenance Shop (11-160) - Classrooms and Breakrooms	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(c) CMA South (11-169)	8AM	6PM	Mon - Fri	0%	70	55	74	61
MOB/DEMOB (15-001)	8AM	6PM	Mon - Fri	0%	60	55	80	61
(d) USPFO (15-002)	8AM	6PM	Mon - Fri	20%	70	55	74	61
(a),(c) CMA North (17-001) - Additional Facility Heating Only	8AM	6PM	Mon - Fri	0%	70	55	N/A	N/A
(a) CMA North (17-001) - AHU S5 Offices	8AM	6PM	Mon - Fri	15%	70	55	74	61
CMA North (17-001) - Original Facility	8AM	6PM	Mon - Fri	0%	64	55	72	57

(a) Most changes for this facility shall take place in ECM 3.2B
(b) Dormitories occupied between March and October only, Kitchens shall follow same schedule, however outside air shall be allowed during unoccupied hours due to natural gas fired equipment
(c) Major Maintenance shop shall follow DCV sequence
(d) Cooling equipment which serves data center shall not follow the lockout sequence

PROPOSED CONDITIONS

Table 127 list the proposed set points to be utilized. See each proposed sequence section for details as to how each proposed set point shall impact proposed sequences.

Table 127: ECM 3.2A Proposed Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
RTI (02-001)	8AM	6PM	Mon - Fri	0%	60	55	80	63
(a) Education Center (06-076)	8AM	6PM	Mon - Fri	0%	60	55	80	65
EMTC (06-078)	8AM	6PM	Mon - Fri	0%	60	55	80	61
PX (07-067)	8AM	6PM	Mon - Fri	5%	60	55	80	57
(b) Unit Housing Area 7 (07-131 Through 07-135)	4PM	8AM	Mon - Sun	5%	60	55	80	63
Snack Bar (08-022)	8AM	6PM	Mon - Fri	50%	60	55	80	57
TMC (08-081)	8AM	6PM	Mon - Fri	0%	60	57	80	59
MWR Building (08-195)	8AM	6PM	Mon - Fri	0%	60	55	80	65
Aviation Simulator Building (08-196)	8AM	6PM	Mon - Fri	15%	70	55	N/A	N/A
Air Ops Building (08-196)	8AM	6PM	Mon - Fri	5%	70	55	N/A	N/A
(b) Unit Housing Area 9 (09-131 Through 09-195)	4PM	8AM	Mon - Sun	5%	60	55	80	65
(b) Unit Housing Area 10 (10-137 Through 10-144)	4PM	8AM	Mon - Sun	5%	60	55	80	65
TACC (11-001)	8AM	6PM	Mon - Fri	0%	60	55	80	65
USPFO Warehouse (11-062)	8AM	6PM	Mon - Fri	0%	60	55	80	65
CIF (11-063)	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(c) RTSM (11-076)	8AM	6PM	Mon - Fri	0%	60	55	80	61
(c) DOL Office (11-159)	8AM	6PM	Mon - Fri	0%	60	55	80	57
(c) Maintenance Shop (11-160) - Garages	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(c) Maintenance Shop (11-160) - Classrooms and Breakrooms	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(c) CMA South (11-169)	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
MOB/DEMOB (15-001)	8AM	6PM	Mon - Fri	0%	60	55	80	61
(d) USPFO (15-002)	8AM	6PM	Mon - Fri	0%	60	55	80	61

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
(a),(c) CMA North (17-001) - Additional Facility Heating Only	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(a) CMA North (17-001) - AHU S5 Offices	8AM	6PM	Mon - Fri	15%	70	55	74	61
CMA North (17-001) - Original Facility	8AM	6PM	Mon - Fri	0%	60	55	80	57

(a) Most changes for this facility shall take place in ECM 3.2B
(b) Dormitories occupied between March and October only, Kitchens shall follow same schedule, however outside air shall be allowed during unoccupied hours due to natural gas fired equipment
(c) Major Maintenance shop shall follow DCV sequence, to be implemented by 3.2A
(d) Cooling equipment which serves data center shall not follow the lockout sequence

PROPOSED SEQUENCES

NETWORKED SCHEDULED HVAC OPERATION

For each networked facility, an occupancy schedule shall be definable within the BAS. This schedule shall provide an occupied mode or unoccupied mode output based on time. When an occupied mode is defined, the HVAC equipment shall control to maintain an occupied zone temperature set point as defined within the BAS. When the schedule defines an unoccupied mode, the HVAC equipment shall control to maintain the unoccupied zone temperature set point as defined within the BAS. When the occupancy schedule is first defined, the schedule shall be set to include a warmup or cooldown period of two hours (adjustable) prior to actual initial occupancy such that the facility can reach occupied temperatures at the initiation of true occupancy. Systems which already have an occupancy schedule defined shall have the existing schedule checked, and if necessary, correct the schedule based on information presented in Table 127. Unoccupied set points shall be checked and altered to match Table 127 as well. There are no savings attributed to occupied set points which shall not be altered unless directed otherwise by the Customer.

In addition, if HVAC equipment is required to operate during the unoccupied period zero outside air shall be provided unless a special case is defined: (e.g. kitchens, labs, etc.), or unless a call for cooling is made and economizing is available. Reduced ventilation shall continue during startup period (A.K.A. warmup period, cooldown period). Table 127 list facilities where outside air shall be cut during unoccupied hours indicated by a 0% in the *% Outside Air Unocc.* column. In conjunction, when the schedule defines an unoccupied mode, exhaust fans shall be commanded off unless a special cases exist (e.g. kitchen labs etc.). When the schedule defines an occupied mode, exhaust shall be commanded on. There are no alterations proposed for occupied ventilation rates unless directed otherwise by the Customer.

MECHANICAL COOLING AND HEATING LOCKOUT

When outside air temperatures drop below the cooling lock out temperature set point mechanical cooling shall be disabled. Conversely, when outside air temperatures rise above a heating lockout temperature set point heating equipment shall be disabled. Proposed set points for both heating and cooling lockout temperatures are listed in Table 127 by facility.

ECONOMIZING

This sequence shall reuse some sensors which already exist. If not already implemented, outside air moisture content sensors and dry bulb temperature sensors shall be utilized to calculate the heat content of the air, otherwise known as enthalpy, in BTU/lb. If the enthalpy of the outside air is at or below 25 BTU/lb (adjustable) and if there is a call for cooling then economizing shall be enabled. This indicates that the outside air damper shall be completely opened and the return air damper shall be completely closed. As a non-standard caveat, cooling lock shall still follow the sequence noted in item ***Mechanical Cooling and Heating Lockout***. Hence, a case may exist where economizing is enabled, indicating that utilizing 100% air is ideal; however, the mechanical cooling system shall be enabled and shall control to maintain the DAT to set point if needed.

OVERHEAD DOOR HVAC SYSTEM LOCKOUT CAPABILITY

Door contacts shall be repaired or added as indicated in the scope of work for this ECM. Specifically, facilities with *Overhead door switches* item(s) in the scope of work shall follow this sequence. The contacts shall provide the BAS with a signal when an overhead door is open or closed. When a signal is interpreted as a door being open, the make-up air unit and general exhaust for the garage shall be commanded off; note this does not impact tail pipe exhaust or infrared heating. If a signal is interpreted as a door being open for more than 24 hours (adjustable) an alarm shall be triggered within the BAS.

MAINTENANCE BAY DEMAND CONTROL VENTILATION (DCV)

Based on the scope of work for the ECM, select facilities with maintenance bays which are served by large Make-up Air Units (MAUs) shall have new gas sensors capable of detecting NO2, CO, and CO2 installed. Specifically, facilities with *CO / NO2 Detection / Control* item(s) in the scope of work shall follow this sequence. If NO2 is detected at levels above 100 $\mu g/m^3$, or if CO is detect at levels above 9 Parts Per Million (PPM), or if CO2 is detect at levels above 1,000 PPM then associated MAUs and general exhaust fans shall be commanded on. If any command input does not match the status output an alarm shall be triggered within the BAS. MAU discharge air temperature shall not exceed the space temperature set point for the service zone.

In addition, locations which utilize infrared heaters shall utilize infrared as the main source of heat. This is a more efficient form of heat transfer, as such, occupied heating set point shall be reduced to 60 °F for these locations. These locations are specifically called out with *Infrared Heat Controls* item(s) in the scope of work.

SCOPE OF WORK

The following list the specific scope of work proposed as a part of this ECM. If equipment and associated control point is not listed and if the equipment isn't already in the BAS then it shall not be addressed as a part of this project.

RTI (02-001)

4. Recommission existing control system.
    a. Not to exceed 40 hours of tech labor.
    b. No material is included to replace existing faulty controls.
5. 8 hours controls training

EDUCATION CENTER (06-076)

1. Recommission existing control system.
    a. Not to exceed 40 hours of tech labor.
    b. No material is included to replace existing faulty controls.
2. UH Controls (Typical of 3)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer
3. Exhaust Fans (2)
    a. Fan start/stop/status
    b. Damper Actuator
    c. 4 hours controls training.

EMTC (06-078)

1. Recommission existing control system.
    a. Not to exceed 40 hours of tech labor.
    b. No material is included to replace existing faulty controls.
2. 4 hours controls training.

PX (07-067)

1. Recommission existing control system.
    a. Not to exceed 12 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. MAU Controls / NAE
    a. NCE Panel
    b. Power to panel
    c. MSTP trunk to other building controllers
    d. Zone sensor
    e. Discharge air temperature sensor
    f. Discharge air pressure
    g. Exhaust Fan command
    h. Low temperature control
    i. Mixed air temperature sensor
    j. Return air CO2 sensor
    k. Return air temperature

l. Filter status
m. Heating command
n. Supply Fan CFD command/status/output

3. RTU Controls
    a. DDC Panel
    b. Power to panel
    c. Zone sensor
    d. Discharge air temperature sensor
    e. Exhaust Fan command
    f. Mixed air Dampers actuator (3)
    g. Return air CO2 sensor
    h. Supply Fan CFD command/status/output
4. UH Controls (Typical of 2)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
5. Transformer De-strat Fans Controls (Typical of 2 Zones)
    a. Panel
    b. Fan relay
6. 4 hours controls training.

UNIT HOUSING AREA 7 (07-131 THROUGH 07-135)

1. Recommission existing control system.
    a. Not to exceed 8 hours of tech labor per building
    b. No material is included to replace existing faulty controls
2. 1 hour controls training per building.

SNACK BAR (08-022)

1. Recommission existing control system.
    a. Not to exceed 8 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. Network controller (NCE)
    a. NCE Panel
    b. Power to panel
    c. MSTP trunk to building controllers
3. Furnace Controls (Typical of 2)
    a. Control Panel
    b. Zone sensor
    c. Discharge air temperature sensor
    d. Filter status
    e. Heat command
    f. Cooling command
    g. Fan relay
4. 4 hours controls training.

TMC (08-081)

1. Recommission existing control system.
    a. Not to exceed 8 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. UH Controls (Typical of 2)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer
3. Network controller (NCE)
    a. NCE Panel
    b. Power to panel
    c. MSTP trunk to building controllers
4. FCU Controls (Typical of 8)
    a. DDC Panel
    b. Zone sensor
    c. Discharge air temperature
    d. Filter status
    e. Cooling command
    f. Heating control valve
    g. Fan relay
    h. Transformer
5. 4 hours controls training.

MWR BUILDING (08-195)

1. Recommission existing control system.
    a. Not to exceed 32 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. 4 hours controls training.

AVIATION SIMULATOR BUILDING (08-196)

1. Recommission existing control system.
    a. Not to exceed 24 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. Furnace Controls
    a. Control Panel
    b. Zone sensor
    c. Discharge air temperature sensor
    d. Filter status
    e. Heat command
    f. Cooling command
    g. Fan relay
3. UH Controls (Typical of 2)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay

   d. Transformer
4. 4 hours controls training

AIR OPS BUILDING (08-197)

1. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers
2. Furnace Controls (Typical of 2)
   a. Control Panel
   b. Zone sensor
   c. Discharge air temperature sensor
   d. Filter status
   e. Heat command
   f. Cooling command
   g. Fan relay
3. Infrared Heat Controls
   a. Zone sensor
   b. Heat command
4. 4 hours controls training.

UNIT HOUSING AREA 9 (09-131 THROUGH 09-135)

1. Recommission existing control system.
   a. Not to exceed 8 hours of tech labor per building.
   b. No material is included to replace existing faulty controls
2. 1 hours controls training per building.

UNIT HOUSING AREA 10 (10-137 THROUGH 10-144)

1. Recommission existing control system.
   a. Not to exceed 8 hours of tech labor per building.
   b. No material is included to replace existing faulty controls
2. 1 hours controls training per building.

TACC (11-001)

1. Recommission existing control system.
   a. Not to exceed 40 hours of tech labor.
   b. No material is included to replace existing faulty controls
2. 8 hours controls training.

USPFO WAREHOUSE (11-062)

3. Recommission existing control system.
   a. Not to exceed 20 hours of tech labor.
   b. No material is included to replace existing faulty controls
4. Network controller (NCE)
   a. NCE Panel
   b. Power to panel
   c. MSTP trunk to building controllers

5. UH Controls (Typical of 15)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer
6. MAU Controls (Expl Proof)
    a. DDC Panel
    b. Zone sensor
    c. Discharge air temperature
    d. Filter status
    e. Cooling command
    f. Heating command
    g. Fan relay
    h. Transformer
7. 8 hours controls training.

CIF (11-063)

1. Recommission existing control system.
    a. Not to exceed 20 hours of tech labor.
    b. No material is included to replace existing faulty controls
2. UH Controls (Typical of 15)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer
3. AC Controls (Typical of 3)
    a. Zone sensor (TEC)
    b. Cooling relay
    c. Fan relay
    d. Transformer
4. Exhaust Fan Control (3)
    a. DDC Panel
    b. Exhaust fan start/stop/status
5. Boiler Controls
    a. DDC Panel
    b. Boiler entering temperature (2)
    c. Boiler leaving temperature (2)
    d. Supply water sensor (2)
    e. Return water sensor (2)
    f. Boiler enable(2)
    g. Differential pressure sensor
    h. Pump VFD command/status/output (2)
    i. Boiler pump enable (2)
6. 4 hours controls training.

RTSM (11-076)

2. Recommission existing control system.
    a. Not to exceed 48 hours of tech labor.
    b. No material is included to replace existing faulty controls
3. UH Controls (Typical of 8)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer
4. CO / NO2 Detection / Control
    a. CO Detector (Typical of 6)
    b. NO2 Detector (Typical of 6)
    c. EF Fan relay (Typical of 4)
    d. Overhead door switches (Typical of 10)
5. Room Radiation Controls (Typical of 12)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Transformer
6. Boiler Controls
    a. DDC Panel
    b. Boiler entering temperature (2)
    c. Boiler leaving temperature (2)
    d. Supply water sensor (2)
    e. Return water sensor (2)
    f. Boiler enable(2)
    g. Differential pressure sensor
    h. Pump VFD command/status/output (2)
    i. Boiler pump enable (2)
7. Exhaust Fan Control (4)
    a. DDC Panel
    b. Exhaust fan start/stop/status
8. 8 hours controls training

DOL OFFICE (11-159)

1. Recommission existing control system.
    a. Not to exceed 24 hours of tech labor.
    b. No material is included to replace existing faulty controls.
2. CO / NO2 Detection / Control
    a. DDC Panel (Typical of 2)
    b. CO Detector (Typical of 2)
    c. NO2 Detector (Typical of 2)
    d. EF Fan relay (Typical of 12)
    e. Overhead door switches (Typical of 16)
    f. Destrat Fan Relays (Typical of 2 zones)
    g. Low zone temperature sensor (Typical of 2)

h. High zone temperature sensor (Typical of 2)
i. Infrared heater command (Typical of 2)

3. 4 hours controls training.

MAINTENANCE SHOP (11-160)

2. Recommission existing control system.
    a. Not to exceed 32 hours of tech labor.
    b. No material is included to replace existing faulty controls.
3. CO / NO2 Detection / Control
    a. DDC Panel (Typical of 2)
    b. CO Detector (Typical of 3)
    c. NO2 Detector (Typical of 3)
    d. EF Fan relay (Typical of 6)
    e. Overhead door switches (Typical of 7)
    f. Destrat Fan Relays (Typical of 3 zones)
    g. High zone temperature sensor (Typical of 3)
4. Boiler Controls
    a. DDC Panel
    b. Boiler entering temperature (2)
    c. Boiler leaving temperature (2)
    d. Supply water sensor (2)
    e. Return water sensor (2)
    f. Boiler enable(2)
    g. Differential pressure sensor
    h. Pump VFD command/status/output (2)
    i. Boiler pump enable (2)
5. Room Radiation Controls (Typical of 6)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Transformer
6. 4 hours controls training.

CMA SOUTH (11-169)

1. Recommission existing control system.
    a. Not to exceed 120 hours of tech labor.
    b. No material is included to replace existing faulty controls.
2. CO / NO2 Detection / Control
    a. DDC Panel (Typical of 6)
    b. CO Detector (Typical of 12)
    c. NO2 Detector (Typical of 12)
    d. EF Fan relay (Typical of 24)
    e. Overhead door switches (Typical of 12)
    f. Low zone temperature sensor (Typical of 8)
    g. Infrared heater command (Typical of 8)
3. 16 hours controls training

MOB/DEMOB 15-001

1. Recommission existing control system.
    a. Not to exceed 32 hours of tech labor.
    b. No material is included to replace existing faulty controls.
2. Chiller controls
    a. DDC Panel
    b. Supply water sensor
    c. Return water sensor
    d. Chiller enable
    e. Differential pressure sensor
    f. Pump VFD command/status/output (2)
3. 8 hours controls training

USPFO (15-002)

2. Recommission existing control system.
    a. Not to exceed 24 hours of tech labor.
    b. No material is included to replace existing faulty controls.
3. 8 hours controls training.

CMA NORTH (17-001)

4. Recommission existing control system.
    a. Not to exceed 56 hours of tech labor.
    b. No material is included to replace existing faulty controls.
5. CO / NO2 Detection / Control
    a. DDC Panel (Typical of 6)
    b. CO Detector (Typical of 20)
    c. NO2 Detector (Typical of 20)
    d. EF Fan relay (Typical of 24)
    e. Overhead door switches (Typical of 25)
    f. Low zone temperature sensor (Typical of 6)
    g. Infrared heater command (Typical of 6)
6. 12 hours controls training.

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, an energy model was created for each facility based off the existing set points listed in Table 126. This existing model was then duplicated and the set points altered based on Table 127 in order to represent proposed conditions. The difference between the existing model and the proposed model then represents the estimated energy savings for this ECM.

As an exception to the set points discussed, the DCV sequence for maintenance bays presents a situation which is difficult to model. If a vehicle operates in a bay and the doors are closed, then the associated Make-up Air Unit (MAU) and exhaust fan shall cycle on to provide ventilation. Otherwise, ventilation systems shall remain off. This is a sporadic event which makes defining an exact % ventilation rate for occupied periods difficult to represent accurately. Table 128 list the estimated existing ventilation rate and estimated proposed ventilation rate

utilized for the sake of estimating savings. Unoccupied ventilation rate is expected to be close to or at 0% based off of the *Networked Scheduled HVAC Operation* sequence. Locations with infrared heat shall also have heating occupied temperature set points reduced to 60°F.

Table 128: Estimated Ventilation Rates for Maintenance Bays

Facility	Existing % Ventilation Rate Occ.	Proposed % Ventilation Rate Occ.	Existing % Ventilation Rate Warmup/Cooldown	Proposed % Ventilation Rate Warmup/Cooldown
CMA North	40%	30%	40%	10%
CMA South	50%	25%	25%	10%
RTSM	20%	30%	20%	10%
DOL Office	40%	30%	40%	10%

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 3.2A: BAS: Base Controls Recommissioning and Upgrades	$1,652,310	230,064	106,716	$74,592	$65,174	$139,766	12	*15

* Gas sensors proposed at maintenance bays have a service life of 10 years

INCLUSIONS

- Detailed documentation in a mutually acceptable format.

EXCLUSIONS

- Repair or replacement of defective mechanical and/or controls equipment, other than the equipment specifically described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the owner.)
- Repair or upgrades required to bring the HVAC and mechanical systems up to code.
- Air and water balance of the existing HVAC and mechanical systems and terminal units, unless specified in the scope of work.
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Temporary space conditioning, unless otherwise specified.
- Engineering services, studies, and analysis associated with any exclusions or work clearly outside of the scope definition. Resolution of existing HVAC design, service, and or distribution conditions known or unknown.
- Asbestos abatement and removal for this project is entirely the responsibility of the Customer. Johnson Controls is continuing to work with the Customer and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that the Customer can adequately plan for this requirement. If hazardous materials are encountered during the implementation phase, Johnson Controls will immediately stop work, take measures to reduce any contamination, and notify the Customer facility manager of the possible hazardous material condition and location. Johnson Controls will then request that the Customer remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during ongoing service phase of the project will remain the property and disposal responsibility of the Customer.

- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work (In the event hazardous materials are uncovered and abatement is beyond the ability of Johnson Controls to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to the Customer.)
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Overtime work caused by unforeseen circumstances beyond the control of Johnson Controls, such as or scheduling changes by notify the Customer (The cost difference between the overtime work wages and normal time work wages will be the responsibility of the Customer calculated as [(overtime rate – normal rate) x hours]).
- LAN drops will be furnished by the owner.

ENERGY CONSERVATION MEASURE (ECM) 3.2B: BAS: COMPLETE PNEUMATIC REMOVAL

The main purpose of this ECM is to remove pneumatic based controls within CMA North and the Education Center facilities.

EXISTING CONDITIONS

Currently, the majority of the Heating Ventilation and Air Conditioning (HVAC) equipment at the Education Center and at the addition of CMA North are controlled by pneumatic systems. Pneumatic controls were utilized prior to the advent of advanced microchips. These systems utilized a mechanism or material sensitive to temperature, or other key variable, which then altered the pressure within a compressed air circuit. Valves or dampers then actuated based off the changes in pressure within this circuit. If a leaks occur or the sensitive material or mechanism damaged, the pressure in the air system can be erroneously altered causing sequences to not function often resulting in wasted energy. Ensuring that such a system is maintained is expensive when compared to electronically actuated digital systems. Such systems are also limited in what sequences can be programmed when compared to the digital counterpart.

The existing set points of such a system is difficult to define since each zone has individual control, and the locations for leaks are numerous. Hence, the existing set points for locations served by pneumatically controlled HVAC equipment was mostly derived based off an energy modeling tuning process discussed in *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section of this document. These items are listed in Table 126 but are reiterated in Table 129 immediately below.

Table 129: ECM 3.2B Existing Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
(a) Education Center (06-076)	8AM	6PM	Mon - Fri	0%	72	55	74	65
(a),(c) CMA North (17-001) - Additional Facility Heating Only	8AM	6PM	Mon - Fri	0%	70	55	N/A	N/A
(a) CMA North (17-001) - AHU S5 Offices	8AM	6PM	Mon - Fri	15%	70	55	74	61

(a) Most changes for this facility shall take place in ECM 3.2B
(b) Dormitories occupied between March and October only, Kitchens shall follow same schedule, however outside air shall be allowed during unoccupied hours due to natural gas fired equipment
(c) Major Maintenance shop shall follow DCV sequence, to be implemented by 3.2A
(d) Cooling equipment which serves data center shall not follow the lockout sequence

PROPOSED CONDITIONS

The pneumatic systems for the HVAC equipment at CMA North and the Education Center shall be removed as detailed by the scope of work for this ECM. As such energy sequences shall be implemented. Table 130 list the proposed set points to be utilized. See each proposed

sequence section for details as to how each proposed set point shall impact proposed sequences

Table 130: ECM 3.2B Proposed Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	% Outside Air	Heating Temperatures		Cooling Temperatures	
				Unocc.	Unocc.	Lockout	Unocc.	Lockout
(a) Education Center (06-076)	8AM	6PM	Mon - Fri	0%	60	55	80	65
(a),(c) CMA North (17-001) - Additional Facility Heating Only	8AM	6PM	Mon - Fri	0%	60	55	N/A	N/A
(a) CMA North (17-001) - AHU S5 Offices	8AM	6PM	Mon - Fri	15%	70	55	74	61

(a) Most changes for this facility shall take place in ECM 3.2B
(b) Dormitories occupied between March and October only, Kitchens shall follow same schedule, however outside air shall be allowed during unoccupied hours due to natural gas fired equipment
(c) Major Maintenance shop shall follow DCV sequence
(d) Cooling equipment which serves data center shall not follow the lockout sequence

PROPOSED SEQUENCES

NETWORKED SCHEDULED HVAC OPERATION

For each networked facility, an occupancy schedule shall be definable within the BAS. This schedule shall provide an occupied mode or unoccupied mode output based on time. When an occupied mode is defined, the HVAC equipment shall control to maintain an occupied zone temperature set point as defined within the BAS. When the schedule defines an unoccupied mode, the HVAC equipment shall control to maintain the unoccupied zone temperature set point as defined within the BAS. When the occupancy schedule is first defined, the schedule shall be set to include a warmup or cooldown period of two hours (adjustable) prior to actual initial occupancy such that the facility can reach occupied temperatures at the initiation of true occupancy. Systems which already have an occupancy schedule defined shall have the existing schedule checked, and if necessary, correct the schedule based on information presented in Table 130. Unoccupied set points shall be checked and altered to match Table 130 as well. There are no savings attributed to occupied set points which shall not be altered unless directed otherwise by the Customer.

In addition, if HVAC equipment is required to operate during the unoccupied period zero outside air shall be provided unless a special case is defined: (e.g. kitchens, labs, etc.), or unless a call for cooling is made and economizing is available. Reduced ventilation shall continue during startup period (A.K.A. warmup period, cooldown period). Table 130 list facilities where outside air shall be cut during unoccupied hours indicated by a 0% in the *% Outside Air Unocc.* column. In conjunction, when the schedule defines an unoccupied mode, exhaust fans shall be commanded off unless a special cases exist (e.g. kitchen labs etc.). When the schedule defines an occupied mode, exhaust shall be commanded on. There are no alterations proposed for occupied ventilation rates unless directed otherwise by the Customer. Any changes in occupied ventilation rates will impact savings and are the responsibility of the Customer

Mechanical Cooling and Heating Lockout

When outside air temperatures drop below the cooling lock out temperature set point mechanical cooling shall be disabled. Conversely, when outside air temperatures rise above a heating lockout temperature set point heating equipment shall be disabled. Proposed set points for both heating and cooling lockout temperatures are listed in Table 130 by facility.

Economizing

This sequence shall reuse some sensors which already exist. If not already implemented, outside air moisture content sensors and dry bulb temperature sensors shall be utilized to calculate the heat content of the air, otherwise known as enthalpy, in BTU/lb. If the enthalpy of the outside air is at or below 25 BTU/lb and if there is a call for cooling then economizing shall be enabled. This indicates that the outside air damper shall be completely opened and the return air damper shall be completely closed. As a non-standard caveat, cooling lock shall still follow the sequence noted in item *Mechanical Cooling and Heating Lockout*. Hence, a case may exist where economizing is enabled, indicating that utilizing 100% air is ideal; however, the mechanical cooling system shall be enabled and shall control to maintain the DAT to set point if needed.

Scope of Work

The following list the specific scope of work proposed as a part of this ECM. If equipment and associated control point is not listed then it shall not be addressed as a part of this project.

Education Center (06-076)

1. VAV Boxes w/Reheat (38)
    a. Discharge air temperature
    b. Heating valve output
    c. Damper actuator/controller
    d. Zone temperature
    e. Transformer
    f. Air flow sensor
2. UH Controls (Typical of 8)
    a. Zone sensor (TEC)
    b. Heat control valve
    c. Fan relay
    d. Transformer

CMA North (17-001)

1. AHU S-1 through S-4
    a. FEC Panel
    b. Power to panel
    c. Trunk to and from other building controllers
    d. Zone sensor
    e. Discharge air temperature sensor
    f. Discharge air pressure
    g. Exhaust Fan command
    h. Low temperature control
    i. Mixed air temperature sensor
    j. Return air CO2 sensor
    k. Return air temperature
    l. Filter status
    m. Reheat valve command

   n. Supply Fan VFD command/status/output
   o. Cooling command (Typical of 3)
   p. Damper command (Typical of 2)
2. FCU Controls
   a. DDC Panel
   b. Zone sensor
   c. Discharge air temperature
   d. Filter status
   e. Cooling command
   f. Heating control valve
   g. Fan relay
   h. Transformer
3. UH Controls (10)
   a. Zone sensor (TEC)
   b. Heat control valve
   c. Fan relay
   d. Transformer
4. Room Radiation (12)
   a. Zone sensor (TEC)
   b. Heat control valve
   c. Transformer
   d. Maintenance Bay FEC (6)
   e. DDC Control Panel

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, an energy model was created for each facility based off the existing set points listed in Table 129. This existing model was then duplicated and the set points altered based on Table 130 in order to represent proposed conditions. The difference between the existing model and the proposed model then represents the estimated energy savings for this ECM.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 3.2B: BAS: Complete Pneumatic Removal	$238,303	88,936	17,119	$15,205	$9,741	$24,946	10	15

INCLUSIONS

- Detailed documentation in a mutually acceptable format.

EXCLUSIONS

- Repair or replacement of defective mechanical and/or controls equipment, other than the equipment specifically described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the owner.)
- Repair or upgrades required to bring the HVAC and mechanical systems up to code.
- Air and water balance of the existing HVAC and mechanical systems and terminal units, unless specified in the scope of work.

- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Temporary space conditioning, unless otherwise specified.
- Engineering services, studies, and analysis associated with any exclusions or work clearly outside of the scope definition. Resolution of existing HVAC design, service, and or distribution conditions known or unknown.
- Asbestos abatement and removal for this project is entirely the responsibility of the Customer. Johnson Controls is continuing to work with the Customer and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that the Customer can adequately plan for this requirement. If hazardous materials are encountered during the implementation phase, Johnson Controls will immediately stop work, take measures to reduce any contamination, and notify the Customer facility manager of the possible hazardous material condition and location. Johnson Controls will then request that the Customer remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during ongoing service phase of the project will remain the property and disposal responsibility of the Customer.
- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work (In the event hazardous materials are uncovered and abatement is beyond the ability of Johnson Controls to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to the Customer.)
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Overtime work caused by unforeseen circumstances beyond the control of Johnson Controls, such as or scheduling changes by notify the Customer (The cost difference between the overtime work wages and normal time work wages will be the responsibility of the Customer calculated as [(overtime rate – normal rate) x hours]).
- LAN drops will be furnished by the owner.

ENERGY CONSERVATION MEASURE (ECM) 3.3: BUILDING AUTOMATION SYSTEM (BAS): ALTERNATE INSTALL STANDALONE PROGRAMMABLE THERMOSTAT

The main purpose of this ECM is to install programmable thermostats. These thermostats shall not be networked, hence, the existing systems which are not currently visible on the Building Automation System (BAS) workstation shall continue to not be visible on the BAS workstation.

EXISTING CONDITIONS

The *Description of Existing Facilities* section within this document covers the existing conditions for Heating Ventilation and Air Conditioning (HVAC) equipment in detail by building. As a summary, the majority of the facilities impacted by this ECM utilize basic split systems or unit heaters. These systems are controlled primarily by stand-alone local thermostats. These thermostats are not capable of altering temperature set point based off an occupancy schedule. Currently each individual thermostat can be altered by the end user at any time; hence, the existing thermostat set point during unoccupied hours was mostly based off of energy model calibration to existing utility consumption. The energy modeling tuning process is discussed in *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section of this document. Table 131 list the existing unoccupied thermostat set points utilized.

Table 131: ECM 3.3 Existing Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	Heating Temperatures Unocc.	Cooling Temperatures Unocc.
Old FMS (02-166)	8AM	6PM	Mon - Fri	65	N/A
DNR Warehouse (02-204)	8AM	6PM	Mon - Fri	70	74
Warehouse (02-206)	8AM	6PM	Mon - Fri	70	N/A
S&SD Warehouse (02-207)	8AM	6PM	Mon - Fri	70	74
Warehouse (02-211)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-212)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-213)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-214)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-215)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-216)	8AM	6PM	Mon - Fri	70	N/A
Warehouse (02-217)	8AM	6PM	Mon - Fri	70	N/A
Housing Services (02-219)	8AM	6PM	Mon - Fri	70	N/A
(a) Warehouse (02-220)	8AM	6PM	Mon - Fri	70	N/A
ATS Warehouse (02-221)	8AM	6PM	Mon - Fri	70	N/A
(a) Maid Service Shop (02-222)	8AM	6PM	Mon - Fri	70	N/A
FMO Warehouse (02-223)	8AM	6PM	Mon - Fri	70	N/A
WWTP Shed (02-247)	8AM	6PM	Mon - Fri	70	N/A
Ground Maint (02-271)	8AM	6PM	Mon - Fri	70	N/A
Roads (02-272)	8AM	6PM	Mon - Fri	60	85

PROPOSED CONDITIONS

Up to four thermostats shall be installed at each facility listed in Table 132. Each installation also includes installation of a relay and a transformer. To reiterate, these thermostats shall not be networked, hence, the existing systems which are not currently visible on the Building Automation System (BAS) workstation shall continue to not be visible on the BAS workstation. Proposed unoccupied thermostat temperature set point and schedule are also listed in Table 132. Buildings with an *(a)* call out were noted to have a significant drop off of utility consumption during the cooling season, this is assumed to continue after the implementation of the project. Alterations to occupied thermostat set points is not to be altered by this ECM unless directed otherwise by the Customer. Ventilation alterations of any kind is not altered by this ECM.

Table 132: ECM 3.3 Proposed Conditions

Building	Occ. Start	Occ. Stop	Occ. Days	Heating Temperatures	Cooling Temperatures
				Unocc.	Unocc.
Old FMS (02-166)	8AM	6PM	Mon - Fri	60	N/A
DNR Warehouse (02-204)	8AM	6PM	Mon - Fri	60	80
Warehouse (02-206)	8AM	6PM	Mon - Fri	60	N/A
S&SD Warehouse (02-207)	8AM	6PM	Mon - Fri	60	80
Warehouse (02-211)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-212)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-213)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-214)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-215)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-216)	8AM	6PM	Mon - Fri	60	N/A
Warehouse (02-217)	8AM	6PM	Mon - Fri	60	N/A
Housing Services (02-219)	8AM	6PM	Mon - Fri	60	N/A
(a) Warehouse (02-220)	8AM	6PM	Mon - Fri	60	N/A
ATS Warehouse (02-221)	8AM	6PM	Mon - Fri	60	N/A
(a) Maid Service Shop (02-222)	8AM	6PM	Mon - Fri	60	N/A
FMO Warehouse (02-223)	8AM	6PM	Mon - Fri	60	N/A
WWTP Shed (02-247)	8AM	6PM	Mon - Fri	60	N/A
Ground Maint (02-271)	8AM	6PM	Mon - Fri	60	N/A
Roads (02-272)	8AM	6PM	Mon - Fri	60	85

SAVINGS METHODOLOGY

The methodology utilized to estimate savings for this ECM is presented in the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* within this document. As a summary, an energy model was created for each facility based off the existing set points listed in Table 131. This existing model was then duplicated and the set points altered based on Table 132 in order to represent proposed conditions. The difference between the existing model and the proposed model then represents the estimated energy savings for this ECM.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 3.3: BAS: Alternate Install Standalone Programmable Thermostat	$104,574	7,803	19,800	$11,667	$0	$11,667	9	15

INCLUSIONS

- Detailed documentation in a mutually acceptable format.

EXCLUSIONS

- Repair or replacement of defective mechanical and/or controls equipment, other than the equipment specifically described in the ECM description (Johnson Controls will identify the location of defective equipment and notify the owner.)
- Repair or upgrades required to bring the HVAC and mechanical systems up to code.
- Air and water balance of the existing HVAC and mechanical systems and terminal units, unless specified in the scope of work.
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Temporary space conditioning, unless otherwise specified.
- Engineering services, studies, and analysis associated with any exclusions or work clearly outside of the scope definition. Resolution of existing HVAC design, service, and or distribution conditions known or unknown.
- Asbestos abatement and removal for this project is entirely the responsibility of the Customer. Johnson Controls is continuing to work with the Customer and our subcontractors to sufficiently identify the scope, costs, and project scheduling implications of any required abatement such that the Customer can adequately plan for this requirement. If hazardous materials are encountered during the implementation phase, Johnson Controls will immediately stop work, take measures to reduce any contamination, and notify the Customer facility manager of the possible hazardous material condition and location. Johnson Controls will then request that the Customer remove and dispose of the hazardous materials prior to any continuation of work. Hazardous materials encountered during ongoing service phase of the project will remain the property and disposal responsibility of the Customer.
- The cost of hazardous material abatement or removal, such as asbestos, mold and lead paint that is not currently specified in the engineering scope of work (In the event hazardous materials are uncovered and abatement is beyond the ability of Johnson Controls to abate under this contract, the ECM will be evaluated for possible removal from the scope of work or the transfer of this responsibility to the Customer.)
- Existing building ventilation conditions, indoor air quality issues (if any, except where it is was discussed with the owner during development of project) is excluded from the scope and cost of this project.
- Overtime work caused by unforeseen circumstances beyond the control of Johnson Controls, such as or scheduling changes by notify the Customer (The cost difference between the overtime work wages and normal time work wages will be the responsibility of the Customer calculated as [(overtime rate – normal rate) x hours]).

ENERGY CONSERVATION MEASURE (ECM) 5.1: REPLACE INTERIOR LIGHTING

This ECM will install new LED technology in various forms in select areas throughout Camp Ripley. These will include retrofit kits into existing linear fluorescent fixtures, re-lamping select existing CFL fixtures with new LED lamps and replace existing fluorescent and metal halide Hi-Bay fixtures with new LED fixtures according to the *Appendix 1: Lighting line by line* which is located at the end of IGA. In doing so, Camp Ripley will likely experience an improvement in the quality of light produced while benefiting from LED technology's reduced electrical power (kW) usage, longevity and electrical energy savings.

EXISTING CONDITIONS

Camp Ripley's maintenance team has done an admirable job through the years in retrofitting existing lighting systems with energy efficient technologies that seek to maintain adequate light levels for the tasks being illuminated while reducing energy costs and maintenance issues. As a result, the majority of Camp Ripley's lighting may be categorized into groupings which are loosely described below:

1. Interior recessed can lights contain 13 watt and 26 watt Compact fluorescent lamps with magnetic and electronic ballasts. These are typically found in single and dual configurations.
2. Interior linear fluorescent lighting which are primarily 2X4 prismatic and parabolic troffers, 4 and 8 foot linear strip and industrial hood fixtures and 4 and 8 foot linear wrap fixtures. All of these styles of fixtures have configurations using 2, 3 & 4 lamps of 28 and 32 watt linear fluorescent lamps with electronic ballasts. Some areas still contain T12 lamp and ballasts configurations.
3. Interior high bay lighting found in the workshops, maintenance bays and warehouses are mostly T8 6 lamp fluorescent fixtures with some areas containing 250w and 400w Metal Halide technology.
4. Select areas have medium base Incandescent and Compact Fluorescent technologies
5. Select areas have been recently retrofitted or remodeled to LED energy efficient technology.

Please reference Table 133 for a summary of existing fixture description, codes and quantities.

PROPOSED IMPROVEMENTS

Johnson Controls' proposed overall upgrade strategy is to replace existing systems with new lower wattage LED technology retrofits and replacements.

In select areas, the existing linear fluorescent lamp and ballast systems in fixtures will be replaced with energy efficient LED retrofit kits. These kits are UL listed for the specific purpose of retrofitting an existing fluorescent luminaire. They are designed to be direct wired to the line voltage feeding the fixture and eliminate the fluorescent lamp, ballast and existing socket assemblies. This technology has been mocked up for approval at FMO and TACC buildings. LED technology re-lamping strategy will be performed around existing medium base and compact fluorescent fixtures. Existing Fluorescent and Metal Halide Hi-Bay fixtures will be replaced with new LED Hi-Bay fixtures with integral occupancy and daylighting sensors. These sensors will dim the LED fixture to preset levels when no occupancy is detected in the space immediately below the fixture. The daylighting sensor will shut off the LED fixture when a preset level of natural elimination is preset immediately below the fixture.

The benefits of our proposed improvements include the following:

- Improved overall quality of light.
- Maintaining existing light levels at the base.
- Significant electrical energy savings.
- Reduces CO2 and greenhouse gas emissions.
- Installation of longer life LED systems which results in material and labor replacement savings over term of the contract.
- No replacement costs for the term of the warranty for the linear LED systems.

Special Note: In general, our strategy calls for upgrading the majority of Camp Ripley's lighting to LED. However, the lighting associated in select areas of the camp were excluded from the project. These locations, as well as other specific spaces were excluded from our recommendations due to their long term paybacks, already energy efficient upgrades performed by Camp Ripley staff, difficult to determine lighted hours, or perceived excessive cost of implementation factors associated with those locations.

The following is the scope of work associated with our recommendations. In implementing our recommendations, Johnson Controls proposes to provide all materials and labor necessary to implement the upgrades as listed in *Appendix 1: Lighting line by line*.

The existing fluorescent luminaires will be retrofitted with greater than 80 CRI, 4000°K CCT color temperature. The retrofit involves the removal and disposal of existing lamps and ballasts, fixture cleaning, and the installation of new LED retrofit system. This ECM will improve the energy efficiency of lighting fixtures, improve the overall quality of lighting, and reduce lighting system maintenance costs in the buildings.

The proposed LED systems also have no mercury content. These systems provide superior energy efficiency with a color rendering index (CRI) of greater than 80 which is on par or better than linear fluorescent lamps. This will improve the quality and ability of the light to render true colors.

Lenses and luminaires will be inspected at the time of the retrofit. Fixture and troffer lenses will be dry wiped at the time of the retrofit by Johnson Controls.

The existing interior recessed cans will be upgraded to LED medium base screw in and plug in CFL lamps. These LED replacement lamps have a CRI of 80, 4000°K CCT color temperature, consume 13 to 18 watts depending on size and location.

The retrofit involves the removal and disposal of the existing CFL lamp and the installation of new LED lamps. This ECM will improve the energy efficiency of lighting fixtures and improve the overall quality of light while reducing lighting maintenance, energy consumption, and lighting energy cost.

The existing fluorescent and metal halide hi-bay fixtures in select areas of the base will be replaced with new high efficiency LED high bay fixtures. These 160 watt LED fixtures emit light at 4000°K color temperature.

Lighting retrofits will be installed in a thoughtful manner with careful consideration of any personal belongings and surrounding equipment. Where appropriate, tarps will be used to cover all exposed desks, computers and office equipment. Cleanup will take place at the end of each shift, with all vacuuming, dusting and trash removal being completed before leaving the

premises. Interior lighting scope of work will be performed in coordination with Camp Ripley's requirements.

Removed lamps will be boxed and ballasts containing polychlorinated biphenyls (PCBs) will be contained in a clearly marked and secured ballast drum at the end of each shift. Lamps will be recycled or disposed of according to local environmental regulations. The allowance for PCB ballast disposal is limited to 100 ballasts, since there may be a few PCB ballasts remaining at the Camp. The proposed scope of work excludes disposal of large quantities of ballasts, whether they contain PCB's or not, and may be left unconnected in lighting fixtures.

WARRANTY

Installed lighting products will be warranted in accordance with the product manufacturer's published warranty terms, conditions and duration as summarized below, and supported by a one year installation labor warranty from Johnson Controls beginning from the products installation date.

Retrofit Type	Manufacturer's Warranty
LED Retrofit kits	10 years or 50,000 hours, whichever occurs first
LED – CFL replacements	5 years
LED High Bay Fixtures	10 years
LED screw in lamps	5 years

ENVIRONMENTAL IMPACT

This ECM will create no negative environmental impacts. Materials removed will be recycled and disposed of according to local regulations. The proposed new lamps have no mercury content as opposed to the existing fluorescent lamps.

UTILITIES INTERRUPTIONS

Transitions will be performed in a manner to minimize downtime. Johnson Controls will work directly with the Camp Ripley to schedule the lighting retrofits in accordance with the bases requirements.

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 5.1: Replace Interior Lighting	$2,074,115	874,379	0	$68,675	$21,739	$90,415	23	10

INCLUSIONS, EXCLUSIONS AND ASSUMPTIONS

INCLUSIONS:

- Lighting upgrades, retrofits and replacements specifically outlined in *Appendix 1: Lighting line by line*
- The equipment specifications are in a mutually acceptable format with anticipated product performance approved by the Camp prior to installation.
- Submittals, including product data and warranty information.
- Existing lighted hours as determined by observations and interviews during the Audit process and listed in Table 141.

EXCLUSIONS:

- Items marked as FALSE in scope of work line x line document.
- Any upgrade, retrofit or replacement not specifically outlined in *Appendix 1: Lighting line by line*
- Electronic Ballasts replacement
- Repair or replacement of defective lenses. Johnson Controls will identify the location of defective equipment and notify the customer.
- Repair or replacement of failed emergency battery backup fixtures, emergency ballast, or emergency batteries. Johnson Controls will report any discovered failures to the customer.
- Any repair or upgrades required to bring adjacent electrical systems up to code.
- Any repairs or upgrades required to rectify existing code or light levels.
- Repair or replacement of light infrastructure not specially outlined in scope of work.
- Any work that would result in overtime labor rates for installers.
- Any expedited shipping charges such as air freight, special handling charges, or overnight delivery fees.
- Any work that would require trouble shooting or electrical repairs.
- Johnson Controls shall notify the Camp of any code issues discovered. Johnson Controls shall not be held responsible for the correction of the code issue(s) without a change order.
- Plastering, patching and painting are excluded from Johnson Controls scope of work.

Unless specifically agreed to in the statement/scope of work, Johnson Controls and its subcontractor(s) expressly exclude any work or service of any nature associated or connected with the identification, abatement, clean up, control, removal, or disposal of any environment Hazards or dangerous substances, to include but not be limited to asbestos, discovered in or on the premises. Any language or provision of the agreement elsewhere contained which may authorize or empower the Purchaser to change, modify, or alter the scope of work or services to be performed by Johnson Controls shall not operate to compel Johnson Controls or its subcontractors to perform any work relating to Hazards without the express written consent of Johnson Controls.

ENERGY CONSERVATION MEASURE (ECM) 5.4: REPLACE EXTERIOR LIGHTING

This ECM will install new LED technology in various forms to exterior fixtures in select areas throughout Camp Ripley. These will include re-lamping select existing CFL fixtures with new LED lamps and replacement of existing induction fluorescent, High Pressure Sodium and Metal Halide fixtures with new LED fixtures according to the *Appendix 1: Lighting line by line* which is located at the end of IGA. In doing so, Camp Ripley will likely experience an improvement in the quality of light produced while benefiting from LED technology's reduced electrical power (kW) usage, longevity and electrical energy savings.

EXISTING CONDITIONS

Camp Ripley's maintenance team has done an admirable job through the years in retrofitting and replacing existing lighting systems with energy efficient technologies that seek to maintain adequate light levels for the tasks being illuminated while reducing energy costs and maintenance issues.

Please reference Table 133 located at the end of this IGA for a summary of existing fixture description, codes and quantities.

PROPOSED IMPROVEMENTS

Johnson Controls' proposed overall upgrade strategy is to replace existing systems with new lower wattage LED technology retrofits, replacements and controls.
LED technology re-lamping strategy will be performed around existing medium base and compact fluorescent fixtures. Existing Induction Fluorescent, High Pressure Sodium and Metal Halide fixtures will be replaced with new LED fixtures. With the exception of roadway lighting, these fixtures will include an integral occupancy and daylighting sensors. These sensors will dim the LED fixture to preset levels when no occupancy is detected in the space immediately below the fixture. The daylighting sensor will shut off the LED fixture when a preset level of natural elimination is preset immediately below the fixture.

The benefits of our proposed improvements include the following:

- Improved overall quality of light.
- Maintaining existing light levels at the base.
- Significant electrical energy savings.
- Reduces CO2 and greenhouse gas emissions.
- Installation of longer life LED systems which results in material and labor replacement savings over term of the contract.
- No replacement costs for the term of the warranty for the linear LED systems.

Special Note: In general, our strategy calls for upgrading the majority of Camp Ripley's lighting to LED. However, the lighting associated in select areas of the camp were excluded from the project. These locations, as well as other specific spaces were excluded from our recommendations due to their long term paybacks, already energy efficient upgrades performed by Camp Ripley staff, difficult to determine lighted hours, or perceived excessive cost of implementation factors associated with those locations.

The following is the scope of work associated with our recommendations. In implementing our recommendations, Johnson Controls proposes to provide all materials and labor necessary to implement the upgrades as listed in *Appendix 1: Lighting line by line*.

The proposed LED systems also have no mercury content. These systems provide superior energy efficiency with a color rendering index (CRI) of greater than 80 which is on par or better than linear fluorescent lamps. This will improve the quality and ability of the light to render true colors.

The retrofit involves the removal and disposal of the existing CFL lamp and the installation of new LED lamps. This ECM will improve the energy efficiency of lighting fixtures and improve the overall quality of light while reducing lighting maintenance, energy consumption, and lighting energy cost.

The existing induction fluorescent, high pressure sodium and metal halide exterior fixtures in select areas of the base will be replaced with new high efficiency LED fixtures. These LED fixtures emit light at 4000°K color temperature.

Lighting replacements will be installed in a thoughtful manner with careful consideration of any personal belongings and surrounding equipment and property. Cleanup will take place at the end of each shift, with trash removal being completed before leaving the premises. Exterior lighting scope of work will be performed in coordination with Camp Ripley's requirements.

Removed lamps will be boxed and ballasts containing polychlorinated biphenyls (PCBs) will be contained in a clearly marked and secured ballast drum at the end of each shift. Lamps will be recycled or disposed of according to local environmental regulations. The allowance for PCB ballast disposal is limited to 100 ballasts, since there may be a few PCB ballasts remaining at the Camp. The proposed scope of work excludes disposal of large quantities of ballasts, whether they contain PCB's or not, and may be left unconnected in lighting fixtures.

WARRANTY

Installed lighting products will be warranted in accordance with the product manufacturer's published warranty terms, conditions and duration as summarized below, and supported by a one year installation labor warranty from Johnson Controls beginning from the products installation date.

Retrofit Type	Manufacturer's Warranty
LED Fixtures	10 years
LED screw in lamps	5 years

ENVIRONMENTAL IMPACT

This ECM will create no negative environmental impacts. Materials removed will be recycled and disposed of according to local regulations. The proposed new lamps have no mercury content as opposed to the existing fluorescent lamps.

UTILITIES INTERRUPTIONS

Transitions will be performed in a manner to minimize downtime. Johnson Controls will work directly with the Camp Ripley to schedule the lighting retrofits in accordance with the bases requirements.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 5.4: Replace Exterior Lighting	$803,509	541,491	0	$42,530	$8,153	$50,683	16	10

INCLUSIONS, EXCLUSIONS AND ASSUMPTIONS

INCLUSIONS:

- Lighting upgrades, retrofits and replacements specifically outlined in *Appendix 1: Lighting line by line*
- The equipment specifications are in a mutually acceptable format with anticipated product performance approved by Camp Ripley prior to installation.
- Submittals, including product data and warranty information.
- Existing lighted hours as determined by observations and interviews during the Audit process and listed in *Appendix 1: Lighting line by line*

EXCLUSIONS:

- Items marked as FALSE in scope of work line x line document.
- Any upgrade, retrofit or replacement not specifically outlined in *Appendix 1: Lighting line by line*
- Electronic Ballasts replacement
- Repair or replacement of defective lenses. Johnson Controls will identify the location of defective equipment and notify the customer.
- Repair or replacement of failed emergency battery backup fixtures, emergency ballast, or emergency batteries. Johnson Controls will report any discovered failures to the customer.
- Any repair or upgrades required to bring adjacent electrical systems up to code.
- Any repairs or upgrades required to rectify existing code or light levels.
- Repair or replacement of light infrastructure not specially outlined in scope of work.
- Any work that would result in overtime labor rates for installers.
- Any expedited shipping charges such as air freight, special handling charges, or overnight delivery fees.
- Any work that would require trouble shooting or electrical repairs.
- Johnson Controls shall notify Camp Ripley of any code issues discovered. Johnson Controls shall not be held responsible for the correction of the code issue(s) without a change order.
- Plastering, patching and painting are excluded from Johnson Controls scope of work.
- Unless specifically agreed to in the statement/scope of work, Johnson Controls and its subcontractor(s) expressly exclude any work or service of any nature associated or connected with the identification, abatement, clean up, control, removal, or disposal of any environment Hazards or dangerous substances, to include but not be limited to asbestos, discovered in or on the premises. Any language or provision of the agreement elsewhere contained which may authorize or empower the Purchaser to change, modify, or alter the scope of work or services to be performed by Johnson Controls shall not operate to compel Johnson Controls or its subcontractors to perform any work relating to Hazards without the express written consent of Johnson Controls.

Table 133: Lighting Fixture Summary

Site/Building Name	Area ID	Audit Qty	Proposed Qty	kW Saved	kWh Saved/Yr (Total)
TACC (11-001)	11-001	1,051	1,051	18.3	51,606
DOL Office (11-159)	11-159	280	280	22.4	60,341
Maintenance Shop (11-160)	11-160	89	89	5.3	17,397
CMA South (11-169)	11-169	1,158	1,158	84.0	272,468
USPFO (15-002)	15-002	221	221	12.6	35,588
MOB/DEMOB (15-001)	15-001	311	311	8.2	21,628
CMA North (17-001)	17-001	550	550	24.2	67,901
Unit Housing (09-135)	9-135	163	163	1.0	1,450
Unit Housing (09-135) Exterior Attached	9-135.1	12	12	1.3	5,624
Unit Housing (09-131)	9-131	179	179	2.3	7,039
Unit Housing (09-132)	9-132	164	164	1.0	1,442
Unit Housing (09-132) Exterior Attached	9-132.1	11	11	1.3	5,589
Unit Housing (09-133)	9-133	164	164	1.0	1,442
Unit Housing (09-133) Exterior Attached	9-133.1	11	11	1.2	5,081
Unit Housing (09-134)	9-134	167	167	1.2	1,565
Unit Housing (09-134) Exterior Attached	9-134.1	11	11	1.3	5,589
Unit Housing (10-137)	10-137	167	167	1.3	2,142
Unit Housing (10-137) Exterior Attached	10-137.1	7	7	0.2	788
Unit Housing (10-138)	10-138	186	186	1.4	2,938
Unit Housing (10-140)	10-140	189	189	1.4	2,938
Unit Housing (10-139)	10-139	185	185	1.2	2,098
Unit Housing (10-139) Exterior Attached	10-139.1	1	1	0.1	508
Unit Housing (10-141)	10-141	188	188	1.3	2,606
Unit Housing (10-142)	10-142	176	176	1.2	2,134
Unit Housing (10-143)	10-143	163	163	1.3	1,834
Unit Housing (10-143) Exterior Attached	10-143.1	13	13	0.2	1,086
Unit Housing (10-144)	10-144	162	162	1.2	1,732
Unit Housing (10-144) Exterior Attached	10-144.1	13	13	0.2	1,086
Warehouse (2-206)	2-206	80	80	3.0	8,252
Warehouse (2-206) Exterior Attached	2-206.1	3	3	0.0	0
S&SD Warehouse (02-207)	2-207	87	87	4.8	12,052

Site/Building Name	Area ID	Audit Qty	Proposed Qty	kW Saved	kWh Saved/Yr (Total)
S&SD Warehouse (02-207) Exterior Attached	2-207.1	2	2	0.3	1,524
Housing Services (2-219)	2-219	41	41	1.4	3,395
Housing Services (2-219) Exterior Attached	2-219.1	1	1	0.1	223
Warehouse (2-217)	2-217	20	20	0.0	0
Warehouse (2-217) Exterior Attached	2-217.1	2	2	0.0	0
Warehouse (2-213)	2-213	20	20	0.0	0
Warehouse (2-213) Exterior Attached	2-213.1	1	1	0.0	0
FMO Warehouse (2-223)	2-223	27	27	1.1	2,778
Warehouse (2-220)	2-220	61	61	0.8	1,463
Unit Housing (07-131)	7-131	228	228	3.0	4,850
Unit Housing (07-131) Exterior Attached	7-131.1	6	6	0.7	3,048
Unit Housing (07-132)	7-132	217	217	1.9	2,589
Unit Housing (07-132) Exterior Attached	7-132.1	9	9	1.0	4,257
Unit Housing (07-134)	7-134	217	217	1.9	2,589
Unit Housing (07-134) Exterior Attached	7-134.1	8	8	0.9	4,065
Unit Housing (07-135)	7-135	217	217	1.9	2,589
Unit Housing (07-135) Exterior Attached	7-135.1	8	8	0.9	4,065
Unit Housing (07-133)	7-133	217	217	1.9	2,589
Unit Housing (07-133) Exterior Attached	7-133.1	8	8	0.9	4,065
PX (07-067)	7-067	203	203	3.2	8,093
RTI (2-001)	2-001	549	549	14.4	36,422
RTI (2-001) Exterior Attached	2-001.1	22	22	2.0	8,883
Storage/DPW (2-099)	2-099	113	113	1.8	4,349
Storage/DPW (2-099) Exterior Attached	2-099.1	4	4	0.0	0
Old FMS (2-166)	2-166	315	315	32.5	80,651
Security (2-203)	2-203	125	125	0.4	510
Security (2-203) Exterior Attached	2-203.1	13	13	1.2	5,291
J6/IT (2-202)	2-202	67	67	0.7	1,337
J6/IT (2-202) Exterior Attached	2-202.1	5	5	0.5	2,582
DNR Warehouse (2-204)	2-204	49	49	0.0	0
Central Steam Plant (02-246)	2-246	26	26	1.9	2,030

Site/Building Name	Area ID	Audit Qty	Proposed Qty	kW Saved	kWh Saved/Yr (Total)
Central Steam Plant (02-246) Exterior Attached	2-246.1	2	2	0.0	0
Carpentry (2-266)	2-266	71	71	0.4	818
Carpentry (2-266) Exterior Attached	2-266.1	4	4	0.3	1,261
Plumbing(2-267)	2-267	24	24	0.9	2,336
Plumbing(2-267) Exterior Attached	2-267.1	1	1	0.0	0
Public Works (2-268)	2-268	63	63	0.7	1,964
Public Works (2-268) Exterior Attached	2-268.1	3	3	0.0	31
WWTP Shed (2-247)	2-247	34	34	0.0	0
WWTP Shed (2-247) Exterior Attached	2-247.1	2	2	0.3	1,415
Paint Shop (2-269)	2-269	70	70	1.7	4,208
Ground Maint (2-271)	2-271	46	46	0.9	2,451
Ground Maint (2-271) Exterior Attached	2-271.1	10	10	0.5	2,234
Roads (2-272)	2-272	115	115	2.1	5,213
Roads (2-272) Exterior Attached	2-272.1	2	2	0.2	788
Education Center (06-076)	6-076	575	575	13.5	44,682
EMTC (06-078)	6-078	360	360	4.6	8,866
EMTC (06-078) Exterior Attached	6-078.1	7	7	0.0	0
TMC (08-081)	8-081	220	220	6.5	17,086
TMC (08-081) Exterior Attached	8-081.1	13	13	0.1	420
Exterior Building Attached (Bldg Interiors NIC)	3000.1	703	703	42.5	185,969
Exterior - Street, Parking & Yard Lighting	2000.1	428	428	68.9	301,816
USPFO Warehouse (11-062)	11-062	383	383	6.3	20,224
CIF (11-063)	11-063	269	269	19.2	43,685
RTSM (11-076)	11-076	265	265	8.2	23,168
Snack Bar (08-022)	8-022	48	48	2.0	5,130
Military Museum	1-086	131	131	1.2	1,739
Military Museum Exterior Attached	1-086.1	6	4	0.3	1,419
Airfield Operations	8-197	87	102	1.8	4,455
Airfield Operations Exterior Attached	8-197.1	10	10	2.0	8,580
Air Tower	8-192	40	40	1.0	2,458
Air Simulator	8-196	53	53	3.9	8,631

Site/Building Name	Area ID	Audit Qty	Proposed Qty	kW Saved	kWh Saved/Yr (Total)
Air Simulator Exterior Attached	8-196.1	2	2	0.2	1,073
Well	17-247	2	2	0.0	0
Well Exterior Attached	17-247.1	1	1	0.1	508
Well	17-246	2	2	0.0	0
Well Exterior Attached	17-246.1	1	1	0.2	727
Well House	2-248	4	4	0.4	563
Well House Exterior Attached	2-248.1	1	1	0.1	394
MWR Facility	8-195	192	192	0.0	0
MWR Facility Exterior Attached	8-195.1	6	6	0.0	0

ECM 6.1: Building Envelope Improvements

This Energy Conservation Measure (ECM) addresses unwanted air infiltration by locating and sealing the cracks, gaps and openings where unintended air flow occurs. The greatest breaches occur through gaps where walls meet the floors and ceilings, plumbing and electrical penetrations and through gaps or openings around windows and doors. Sealing and weather-stripping are the tools through which these breaches can be repaired.

An accurate assessment of the performance of the building envelope is critical to the success of a facility energy management program, even if no envelope related improvements are warranted. Energy losses in building envelope are caused by a range of issues including air leaks, thermal bridging and wet insulation. Air leaks in the envelope of a building can cause direct energy loss. Moisture in the envelope will migrate to the interior of the system, reducing insulation values and damaging building components.

Existing Conditions

Existing as well as new buildings typically have numerous air-leak paths through the envelope in such locations as gaps at transitions between wall, floor and roof levels; structural penetrations through the wall system and at transitions in wall-system types. The buildings on this project provide significant opportunity for reducing air infiltrations, greatly improving occupant comfort as well as providing valuable energy savings with rapid payback. Leaky buildings can be drafty and uncomfortable, inefficient, and expensive to heat and cool. Air leaks allow unconditioned air to infiltrate the conditioned interior spaces, or to allow conditioned air to exit the building, drastically increasing heating and cooling loads by adding or removing heat and causing HVAC systems to run longer. These same leaks can also contribute to problems with moisture, noise, dust and even insects.

Most buildings are in good condition but could use improvements to stop air infiltration/ex-filtration and energy loss. Door systems were found to be the largest areas of air infiltration/ex-filtration within the facility. Most entrance doors needed one of the following: weather stripping, sweeps, or the closure or strike plate adjusted. In most buildings of this age the door seals are either original or have been replaced. Often the replacement seals are of poor quality and are degraded by ultraviolet solar rays. Over time they lose their flexibility and ability to function reliably. Care should be taken to replace seals with products having extensive long term testing (higher cycle count). Sealant is recommended around the perimeter of several windows. Numerous penetrations were observed that need to be sealed.

Significant quantities of air infiltration into the buildings were discovered during the envelope survey period at the Camp Ripley. The facilities were found to be in a mixed set of conditions in regard to infiltration losses, mostly due to age and maintenance issues. The source of energy savings derived from this measure is the reduction in heating and cooling load provided by tighter building envelopes.

Proposed Improvements

This Energy Conservation Measure includes locating and sealing gaps in the building envelope system to reduce infiltration/ex-filtration. Gaps will be identified by visual inspection, camera, and air flow measurements as indicated in the summary table of the scope of work:

- Doors will be fitted with new weather-stripping, sealant and door sweeps
- Exterior and interior penetrations will be sealed
- Piping and electrical penetrations will be insulated and sealed.
- Roof/wall seams will be sealed as needed

The proposed weather-stripping consists of an extruded aluminum carrier with a frame form insert. It will be installed using a compression fit that allows flexibility should minimal shifting of the door occur. The weather-stripping will be applied at the sides and across the top of the doorframe.

A sweep will be installed on the inside bottom of the door.

Astragals are the weather-stripping material used to cover the gap between two doors.

All door weather-stripping will be sealed after installation using a paintable, silicon acrylic sealant. Latches will be checked to ensure they close and lock properly and closures will be adjusted. Doors will also be checked for damage, such as old screw holes and penetrations. When found, penetrations will be sealed to minimize air infiltration/ex-filtration.

Facility areas where these measure is proposed

No. 01: RTI (2-001)
No. 04: Old FMS (2-166)
No. 05: ATS Shop (02-198)
No. 06: J6/IT (2-202)
No. 07: Security (2-203)
No. 08: DNR Warehouse (2-204)
No. 09: Warehouse (2-206)
No. 22:FMO Warehouse (2-223)
No. 21: Maid Service Shop (2-222)
No. 24: WWTP Shed (2-247)
No. 23: Central Steam Plant (02-246)
No. 26: Plumbing(2-267)
No. 25: Carpentry (2-266)
No. 28: Paint Shop (2-269)
No. 27: Public Works (2-268)
No. 36: Unit Housing (07-131)
No. 31: Education Center (06-076)
No. 38: Unit Housing (07-133)
No. 33: Multipurpose Building (06-097)
No. 40: Unit Housing (07-135)
No. 35: PX (07-067)
No. 42:TMC (08-081)
No. 37: Unit Housing (07-132)
No. 44: Unit Housing (09-132)
No. 39: Unit Housing (07-134)
No. 46: Unit Housing (09-134)
No. 41: Snack Bar (08-022)
No. 48: Unit Housing (10-137)
No. 43: Unit Housing (09-131)
No. 50: Unit Housing (10-139)
No. 45: Unit Housing (09-133)
No. 52: Unit Housing (10-141)
No. 47: Unit Housing (09-135)
No. 54: Unit Housing (10-143)
No. 49: Unit Housing (10-138)
No. 56: USPFO Warehouse (11-062)
No. 51: Unit Housing (10-140)
No. 58: RTSM (11-076)
No. 53: Unit Housing (10-142)
No. 60: Maintenance Shop (11-160)
No. 55: Unit Housing (10-144)
No. 62:MOB/DEMOB (15-001)
No. 57: CIF (11-063)
No. 64: CMA North (17-001)
No. 59: DOL Office (11-159)
No. 61: CMA South (11-169)
No. 63: USPFO (15-002)

SAVINGS METHODOLOGY

Savings methodology are presented in detail within the *Description of Savings Calculation Methodology for Proposed Energy Conservation Measures (ECMs):* section within this document. In summary, savings are based off of the residential infiltration crack methodology covered in ASHRAE Fundamentals 2009 Chapter 16. This methodology estimates infiltration volumetric flow rate based on: a set of coefficients defined by facility height and surroundings, wind speed based on weather data, and the existing opening area to be impacted by the scope of work. This infiltration rate is then related to a heat transfer rate which HVAC equipment must offset via utility consumption. Estimated savings is based on the scope of work eliminating said openings. Hence, heat transfer which would otherwise occur does not thus saving energy by reducing the work HVAC equipment would perform.

ESTIMATED COST AND SAVINGS RESULTS

	Sell Price	Electrical Consumption Savings, kWh	Natural Gas Consumption Savings, Therms	Total Utility Cost Savings, $	Year 1 Operational Savings	Total Savings	Simple Payback	Estimated Equipment Service Life
ECM 6.1: Building Envelope Improvements	$779,821	4,933	69,971	$39,822	$0	$39,822	20	10

DESCRIPTION OF SAVINGS CALCULATION METHODOLOGY FOR PROPOSED ENERGY CONSERVATION MEASURES (ECMS):

ECM Description
ECM 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating
ECM 4.2A: Condensing Boiler Replacement
ECM 4.2B: RTU, and/or ACCU Replacement
ECM 3.5: Install De-stratification Fans in High Bay Spaces
ECM 3.2A: BAS: Base Controls Recommissioning and Upgrades
ECM 3.2B: BAS: Complete Pneumatic Removal
ECM 3.3: BAS: Alternate Install Standalone Programmable Thermostat
ECM 5.1: Replace Interior Lighting
ECM 5.4: Replace Exterior Lighting
ECM 6.1: Building Envelope Improvements

ENERGY CONSERVATION MEASURE (ECM) 1.3A, 4.2A, 4.2B, 3.2A, 3.2B, AND 3.3: CHILLER REPLACEMENTS, BOILER REPLACEMENTS AND CONTROLS SCHEDULING AND OPTIMIZATION

MODELING OVERVIEW

Johnson Controls has developed a building load analysis tool that utilizes hourly weather data and building occupancy profiles to assess the current state of the building energy usage. The calculations involved are derived from multiple sources including: ASHRAE Fundamentals, basic heat transfer and thermodynamics, and specific equipment curves supplied by the various manufacturers. The tool is constructed in Microsoft Excel and has been applied on a multitude of successful performance contracts by Johnson Controls.

The main purpose of the model is to determine the amount of heat gain or loss which occurs across various weather conditions based on specific building inputs. The amount of heat gain or loss defines the amount of energy Heating, Ventilation and Air Conditioning (HVAC) equipment must remove or replace in order to maintain comfortable space temperatures within the facility. The rate at which energy must be removed or replaced, or work, can be related to HVAC equipment performance parameters and can then be used to define the amount of electricity or fuel required to satisfy the load within the facility. Using this approach, the energy impact of specific sequence changes, such as space temperature setback at night, can be quantified in conjunction with performance improvements due to replacement of HVAC equipment.

BUILDING LOAD FORMULATION

This section describes the basic methodology and equations utilized to develop building load. Note, while equations represent the basic methodology of developing building loads, they do not represent the entire methodology which is difficult to represent in a paragraph form.
For the purpose of this calculation, typical metrological data over the past 30 years (otherwise known as TMY3 data) was used. Data was obtained from the Department of Energy (DOE) based on sensor readings from Brainerd Lakes Regional Airport. This data is then organized to represent the hours of occurrence observed across two °F dry bulb temperature ranges; this is done in order to reduce the amount of iterations required for the calculation. There are several forms of heat transfer which drive heat loss or gain within a given building which are a function of outside air temperature and humidity.

CONDUCTION

Conduction load represents the heat loss or gain directly through the skin of the building. Conduction is primarily a function of the thermal resistance of the building's construction materials, commonly represented by the R value of the materials. R value is a measure of thermal resistance which when multiplied by the area of the exterior exposure, represented by A, and the difference between the exterior and interior temperatures, represented by Tout and Tin, to determine the amount of heat loss, represented by Q.

Basic Steady State Conduction Heat Transfer Equations:

Equation 5: Total Exposure Thermal Resistance

$$R_{tot} = R_{material1} + R_{material2} + R_{material2} + \cdots$$

Equation 6: Heat Transfer Coefficient

$$U_{tot}\left(\frac{BTU}{[ft^2 * °F * hr]}\right) = \frac{1}{R_{tot}\left(\frac{[ft^2 * °F * hr]}{BTU}\right)}$$

Equation 7: Conduction Thermal Heat Gain or Loss

$$Q_{conduction}\left(\frac{BTU}{hr}\right) = U\left(\frac{BTU}{hr * °\mathrm{F} * \mathrm{ft}^2}\right) * A\,(ft^2) * (T_{out}(°\mathrm{F}) - T_{in}(°\mathrm{F}))$$

FENESTRATION SOLAR HEAT GAIN

Solar heat gain is specifically driven by the amount of radiation introduced to the facility, specifically through fenestrations or windows. This is a function of both the amount of shading on a particular exterior façade, and the orientation of the exterior façade in relation to the sun. The formulation of the solar heat gain through fenestrations was developed using the methodology presented in ASHRAE Fundamentals 2009 chapter 18 and chapter 14. Formulation is not shown in this document due to complexity.

INTERNAL LOAD

Buildings usually contain interior equipment which gives off heat; these heat sources have an impact on HVAC equipment and are usually described as an internal load. Internal load is

dependent on building type and usage, usually driven by four main internal heat sources; lighting, equipment (includes computers and other lab equipment), building occupants, and fan or other motors. Each particular heat source may introduce all of the generated heat to the space or only a portion based off orientation and location. For example recessed fluorescent fixtures partially exist within the plenum, which is unconditioned, and generally introduce only a fraction of the heat generated into the HVAC air stream. In addition, any particular source may not be used to its full potential; for example, not all the lights in the facility may be turned on at any given time. The following formulae represent the general approximation for the amount of heat gain from each internal source:

Equation 8: Lighting Heat Gain

$$Lighting\ Heat\ Gain\ \left(\frac{BTU}{hr}\right) = 3.41 * LPD * A * F_{ul} * F_{sal} {}^{*}F_{sfl,r,c}$$

Where:
Lighting Heat Gain = heat gain, BTU/h
LPD = lighting power density, W/ft^2
A = Building Area, ft^2
Ful = light use factor
Fsal = Lighting special allowance factor
$F_{sfl,r,c}$ *= total heat gain fraction*
3.41 = Conversion Factor
**Modified version of ASHRAE Fundamentals 2009 18.3 (Equation 1) in order to incorporate power density, and total heat fraction.*

Equation 9: Equipment Heat Gain

$$Equipment\ Heat\ Gain\ \left(\frac{BTU}{hr}\right) = 3.41 * EPD * A * Fue * Fsae * Fsfe$$

Where:
Equipment Gain = equipment sensible heat gain, BTU/h
EPD = Equipment power density, W/ft^2
A = Building Area, ft^2
Fue = equipment use factor
Fsae = equipment special allowance factor
Fsfe = equipment space heat fraction
**Modified version of ASHRAE Fundamentals 2009 18.3 (Equation 5: Not presented here) in order to incorporate equipment power density.*

Equation 10: Fan and Motor Heat Gain

$$Fan\ and\ Pump\ Motor\ Heat\ Gain\ \left(\frac{BTU}{hr}\right) = 2545 * \left(\frac{P}{E_M}\right) * F_{UM} * F_{LM}$$

Where:
Fan and Pump Motor Gain = heat equivalent of equipment operation, BTU/h
P = motor power rating, hp
E_M *= motor efficiency, decimal fraction <1.0*
F_{UM} *= motor use factor, 1.0 or decimal fraction <1.0*
F_{LM} *= motor load factor, 1.0 or decimal fraction <1.0*
*2545 = conversion factor, BTU/ [h*hp]*

**ASHRAE Fundamentals 2009 18.6 (Equation 2)*

Equation 11: Building Occupant Heat Gain

$$Building\ Occupant\ Heat\ Gain\ \left(\frac{BTU}{hr}\right) = \left(Number\ of\ Occupants * Sensible\ Heat\ Gain\ \left(\frac{\frac{BTU}{hr}}{person}\right) + Number\ of\ Occupants * Latent\ Heat\ Gain\ \left(\frac{\frac{BTU}{hr}}{person}\right)\right) * CLF$$

Equation 12: Total Internal Heat Gain

$$Q_{internal}\left(\frac{BTU}{hr}\right) = Lighting\ Gain\ \left(\frac{BTU}{hr}\right) + Equipment\ Gain\ \left(\frac{BTU}{hr}\right) + Fan\ and\ and\ Pump\ Motor\ Gain\ \left(\frac{BTU}{hr}\right) + Building\ Occupant\ Gain\ \left(\frac{BTU}{hr}\right)$$

INFILTRATION LOAD

Infiltration represents the load on heating and ventilation equipment due to unwanted outside air entering a facility. Infiltration is difficult to measure and is a function of many variables including building pressure and exterior wind speed. For the sake of simplicity, the default assumption for infiltration presented in eQuest (an industry standard energy modeling program) was used to determine the volumetric flow rate of infiltration where:

Equation 13: Infiltration Rate

$$Infiltration\ Rate\ \left(\frac{ft^3}{\min}\right) = 3.8\% * Wall\ \&\ Window\ Exterior\ Exposure\ Area\ (ft^2) * .1\% * Total\ Building\ Area\ (ft^2)$$

During the cooling season, the air entering has a latent and sensible impact where the infiltrated air increases the humidity of the return air stream. The cooling coil in turn has to work harder to condense the water, and drop the temperature in order to provide proper temperature and humidity to the space. Both sensible and latent impacts are accounted for based on the following equation:

Equation 14: Infiltration Cooling Gain or Loss

$$Q_{infiltration-Cooling}\left(\frac{BTU}{hr}\right) = Infiltration\ Rate\left(\frac{ft^3}{min}\right) * 4.383\left(\frac{lb}{ft^3 * min/hr}\right) * (h_{out}\left(\frac{BTU}{lb}\right) - h_{in}\left(\frac{BTU}{lb}\right))$$

During the heating season the heating coil is assumed to have no latent load, in other words during the heating process no water will be condensed or boiled. Heating sensible impacts are accounted for based on the following equation:

Equation 15: Infiltration Heating Gain or Loss

$$Q_{infiltration-heating}\left(\frac{BTU}{hr}\right) = Infiltration\ Rate\left(\frac{ft^3}{min}\right) * 1.052\left(\frac{BTU}{ft^3 * °F * min/hr}\right) * (T_{out}(°F) - T_{in}(°F))$$

VENTILATION LOAD

Ventilation Load is driven by the amount of outside air brought into a facility, which is then conditioned. This value varies from building to building; as described in the Infiltration Load section, during the cooling season, additional outside air increases the sensible and latent load on the cooling coil. The impacts for both load sources are captured by the following equation:

Equation 16: Ventilation Cooling Gain or Loss

$$Q_{Ventilation-Cooling}\left(\frac{BTU}{hr}\right) = Ventilation\ Rate\left(\frac{ft^3}{min}\right) * 4.383\left(\frac{lb}{ft^3 * min/hr}\right) * (h_{out}\left(\frac{BTU}{lb}\right) - h_{in}\left(\frac{BTU}{lb}\right))$$

During the heating season the heating coil is assumed to have no latent load, in other words during the heating process no water will be condensed or boiled. Heating sensible impacts are accounted for based on the following equation:

Equation 17: Ventilation Heating Gain or Loss

$$Q_{Ventilation-heating}\left(\frac{BTU}{hr}\right) = Ventilation\ Rate\left(\frac{ft^3}{min}\right) * 1.052\left(\frac{BTU}{ft^3 * °F * min/hr}\right) * (T_{out}(°F) - T_{in}(°F))$$

All sources of load are then added up to obtain the total building load for each particular outside air temperature range.

Equation 18: Total Building Heat Gain or Loss

$$Q_{Total}\left(\frac{BTU}{hr}\right) = Q_{conduction}\left(\frac{BTU}{hr}\right) + Q_{solar}\left(\frac{BTU}{hr}\right) + Q_{internal}\left(\frac{BTU}{hr}\right) + Q_{infiltration}\left(\frac{BTU}{hr}\right) + Q_{Ventilation}\left(\frac{BTU}{hr}\right)$$

Once *QTotal* is calculated, the impact on HVAC equipment can be modeled via the use of performance curves mainly taken from eQuest, a building energy modeling program developed by the Department of Energy. Only performance curves and formulae impacted by proposed ECMs are presented in this document, additional performance curves and formulae are not included in this document due to complexity and quantity; methodology can be provided on request, in addition to an overview as presented in the appendix, with corresponding PowerPoint presentation. The addition of all forms of energy consumption (HVAC equipment, lighting, plug loads) can then be totalized and represented as utility consumption.

The resultant utility consumption can then be compared to actual utility consumption discussed in the *Summary of Annual Energy Use and Cost of Base Year Condition*. If the consumption of the base model differs from utility consumption for specific periods of a year then variables can be altered to more accurately represent existing consumption. This process is called *model calibration*.

Once the model is calibrated, the base model can be duplicated and specific variables altered to represent changes due to ECMs.

In addition, the impact to *QTotal* from one ECM can impact the results of another ECM. The potential impact between ECMs is captured by cascading the impacted variables across the various models. In short, if the lighting ECM is cascaded first and the boiler last, the impact of the load due to the lighting ECM is then passed to the boiler ECM. Boiler results are then based off the impacted load, not the original baseline. For this project, Table 134 describes how the proposed ECMs are cascaded.

Table 134: Energy Modeling ECM Cascade Order

Cascade Order	ECM Description
1	ECM 5.1: Replace Interior Lighting
2	ECM 3.3: BAS: Alternate Install Standalone Programmable Thermostat
3	ECM 3.2A: BAS: Base Controls Recommissioning and Upgrades / ECM 3.2B: BAS: Complete Pneumatic Removal
4	ECM 1.3A: Eliminate Existing Steam Plant Replace with Individual Building Heating / ECM 4.2A: Condensing Boiler Replacement
5	ECM 4.2B: RTU, and/or ACCU Replacement

ENERGY CONSERVATION MEASURE (ECM) 3.3, 3.2A AND 3.2B: CONTROLS SCHEDULING AND SEQUENCING OPTIMIZATION, SCHEDULING CHANGES

Savings from this ECM are captured based on set point alterations and the implementation of sequences discussed in the *Description of Proposed Energy Conservation Measures (ECMs)*

section for each ECM. Table 127, Table 130, and Table 132 list existing and proposed conditions for impacted set points and sequences.

As an exception to the set points discussed, the DCV sequence for maintenance bays presents a situation which is difficult to model. If a vehicle operates in a bay and the doors are closed, then the associated Make-up Air Unit (MAU) and exhaust fan shall cycle on to provide ventilation. Otherwise, ventilation systems shall remain off. This is a sporadic event which makes defining an exact % ventilation rate for occupied periods difficult to represent accurately. Table 128 list the estimated existing ventilation rate and estimated proposed ventilation rate utilized for the sake of estimating savings. Unoccupied ventilation rate is expected to be close to or at 0% based off of the *Networked Scheduled HVAC Operation* sequence. Locations with infrared heat shall also have heating occupied temperature set points reduced to 60°F.

Energy Conservation Measure (ECM) 5.1: Replace Interior Lighting

The methodology described in this section is only used as an effort to adjust building internal heat gain due to the impact of ECM5.1. This is an effort to properly represent subsequent savings for other ECMs. The methodology used to calculate savings for ECM5.1 can be found in *Energy Conservation Measure (ECM) 5.1: Replace Interior Lighting* partition within this section. The impact to heat gain is described by reducing overall *LPD (Lighting Power Density)* from .1 W/ft², which is representative of 28-32W T8s normally found to exist within the facilities, to .6 W/ft² which is representative of mainly LED type fixtures proposed as a part of ECM5.1. The energy impact of this change is described by Equation 8 where only *LPD* is altered.

Energy Conservation Measure (ECM) 1.3A and 4.2A: Eliminate Existing Steam Plant Replace with Individual Building Heating and Condensing Boiler Replacement

Savings for this ECM are due to performance gains between the existing heating systems and proposed heating systems. Performance curve equations for all heating equipment types are provided by eQuest, a building energy modeling software developed by the Department of Energy (DOE). The equations adjust design efficiency as a function of part load and return water temperature depending on the heating equipment type. The coefficients for both existing and proposed heating equipment types are shown on Table 135. Equation 19 through Equation 23 represent the methodology utilized to arrive to an adjusted boiler efficiency.

Existing equipment for ECM1.2A is defined as *Steam (Forced Draft)* with a design efficiency of 65%. A 10% impact is accounted for if part load is less than 30% as an estimate of cycling loses. For equipment sizing see the specific ECM section within the *Description of Proposed Energy Conservation Measures (ECMs)* section.

Proposed equipment for ECM1.2A is defined as *Condensing Hot Water Boiler* or *Furnace* with a design efficiency of 95%. A 5% impact is accounted for if part load is less than 20% as an estimate of equipment cycling loses. For equipment sizing see the specific ECM section within the *Description of Proposed Energy Conservation Measures (ECMs)* section

Existing equipment for ECM4.2A is defined as *Hot Water Boiler (Forced Draft)* with a design efficiency of 80%. A 5% impact is accounted for if part load is less than 30% as an estimate of cycling loses. For equipment sizing see the specific ECM section within the *Description of Proposed Energy Conservation Measures (ECMs)* section.

Proposed equipment for ECM4.2A is defined as *Condensing Hot Water Boiler* with a design efficiency of 94%. A 5% impact is accounted for if part load is less than 20% as an estimate of equipment cycling loses. For equipment sizing see the specific ECM section within the *Description of Proposed Energy Conservation Measures (ECMs)* section

For conventional forced draft hot water boilers and furnaces, the design efficiency is defined as the efficiency realized when the heating equipment is at 100% part load. Design efficiency for condensing boilers is defined as the boiler efficiency realized when the boiler is at 100% part load with a return water temperature of 80 °F.

Condensing boiler efficiency is heavily dependent on the temperature of return water. This is due to the additional heat exchanger which reduces waste heat from the boiler stack by reheating return water, when return water temperatures are low enough the heat transfer causes the stack gases to actually condense, hence the descriptor for the boiler. If return water temperatures are high, the waste heat is not utilized and is exhausted to the atmosphere, this diminishes overall efficiency. Air handling hot water coils are not being replaced as a part of this project, as such, design temperature for the coils is assumed to be 180 °F or higher.

However, when weather conditions are milder, the supply water temperature from the boiler can be reset in order to take advantage of the waste heat capturing process. As such, a supply water temperature reset sequence shall be implemented which set supply water temperature maximum and minimum values according to % load. Maximum and minimum supply temperatures and corresponding % load values are shown on Table 123. Supply water temperatures between the described maximum and minimum values shall vary linearly with % load. It is required to follow the describe hot water reset in order to realize the estimated savings.

Table 135: Heat Input Ratio (HIR) Correction Factor Coefficients

Equipment Description	a	B	c	d	e	f
Furnace	1.86E-02	1.09E+00	-1.13E-01	0.00E+00	0.00E+00	0.00E+00
Hot Water Boiler (Natural Draft)	2.70E-02	1.11E+00	-1.32E-01	0.00E+00	0.00E+00	0.00E+00
Hot Water Boiler (Forced Draft)	1.60E-02	9.45E-01	3.90E-02	0.00E+00	0.00E+00	0.00E+00
Steam Boiler (Natural Draft)	2.70E-02	1.11E+00	-1.32E-01	0.00E+00	0.00E+00	0.00E+00
Steam Boiler (Forced Draft)	1.60E-02	9.45E-01	3.90E-02	0.00E+00	0.00E+00	0.00E+00
Condensing Hot Water Boiler	-8.99E-02	8.19E-01	4.30E-02	1.57E-03	-7.04E-06	1.84E-03

Equation 19: Part Load Definition

$$\%\, PRL = \frac{\dot{Q}}{\dot{Q}_d}$$

Where:

$PRL = Part\ Load$
$\dot{Q} = Heat\ load\ for\ given\ condition, BTU/hr$
$\dot{Q}_d = Desgn\ Heat\ Output\ Capacity\ for\ Boiler, BTU/hr$

Equation 20: Heat Input Ratio Correction Factor

$$HIR_c = a + b * PRL + c * PRL^2 + d * RWT + e * RWT^2 + f * PRL * RWT$$

Where:
$HIR_c = Heat\ Input\ Ratio\ Correction\ Factor$
Coefficients a, b, c, d, e and f = Boiler based performance coefficients shown on Table 135
PRL = Part load for given condition, % Value
RWT = Return water temperature for give condition, °F

Equation 21: Definition of Heat Input Ratio

$$HIR_d = \frac{1}{Eff_d}$$

Where:
$HIR_d = Design\ Heat\ Input\ Ratio$
$Eff_d = Design\ Efficiency, \%\ Value$

Equation 22: Corrected Heat Input Ratio

$$HIR_f = \frac{HIR_d * HIR_c}{PRL}$$

Where:
$HIR_f = Final\ Heat\ Input\ Ratio$
$HIR_d = Design\ Heat\ Input\ Ratio$
PRL = Part load for given condition, % Value

Equation 23: Corrected Efficiency

$$Eff_f = \frac{1}{HIR_f}$$

Where:
$Eff_d = Final\ Efficiency, \%\ Value$
$HIR_f = Final\ Heat\ Input\ Ratio$

ENERGY CONSERVATION (ECM) 4.2B: RTU, AND/OR ACCU REPLACEMENT

Savings from this ECM are due to performance gains between existing air cooled Roof Top Units (RTUs) and proposed air cooled RTUs. Performance curve equations for chillers are provided by eQuest, a building energy modeling software developed by the Department of Energy (DOE). The equations adjust design efficiency as a function of part load, coil entering wet bulb temperature, and outside air dry bulb temperature. Coefficients utilized are presented in Table 136**Error! Reference source not found.** through Table 138. Equation 24 through Equation 29 represent the methodology utilized to arrive to an adjusted chiller efficiency.

Existing equipment is represented as a small direct expansion system with a design efficiency 1.1 kW/ton or an EER rating of about 11. Proposed equipment system type is the same, however, design efficiency is defined at .94 kW/ton or an EER rating of about 12.7 EER. In addition, existing systems have an 8.3% efficiency impact if building load is less than existing boiler minimum turndown which is defined as 25%. Proposed systems are not expected to experience such a performance impact at minimum operating conditions.

Table 136: Capacity Correction Coefficients

Equipment Description	a	b	c	d	e	f
Small DX (Air Cooled)	8.74E-01	-1.14E-03	1.71E-04	-2.96E-03	1.02E-05	-5.92E-05

Equation 24: Capacity Correction Factor

$$Cap_c = a + b * EWB + c * EWB^2 + d * DBT + e * DBT^2 + f * EWB * DBT$$

Where:
$Cap_c = Capacity\ Correction\ factor\ or\ dependent\ variable$
$EWB = Coil\ Entering\ Wet\ Bulb\ Temperature, °F$
$DBT = Outside\ Air\ Drybulb\ Temperature, °F$
$Cap_d = Chiller\ Design\ Capacity, tons$

Equation 25: RTU Corrected Capacity

$$Cap_a = Cap_d * Cap_c$$

Where
$Cap_a = Chiller\ Corrected\ Capacity,\ tons$
$Cap_c = Capacity\ Correction\ factor\ or\ dependent\ variable,\ tons$
$Cap_d = Chiller\ Design\ Capacity,\ tons$

Equation 26: Part Load

$$\%\ PRL\ (Part\ Load) = \frac{\dot{Q}}{Cap_a}$$

$PRL = Part\ Load$
$\dot{Q} = Cooling\ load\ for\ given\ condition, tons$

Table 137: Electric Input Ratio Correction Factor 1 Coefficients

Equipment Description	a	b	c	D	e	f
Small DX (Air Cooled)	-1.06E+00	3.07E-02	-1.27E-04	1.54E-02	4.97E-05	-2.10E-04

Equation 27: Electric Input Correction Factor 1

$$EIR_{c1} = a + b * EWB + c * EWB^2 + d * DBT + e * DBT^2 + f * CHWT * DBT$$

Where:
$EWB = Coil\ Entering\ Wet\ Bulb\ Temperature, °F$
$DBT = Outside\ Air\ Drybulb\ Temperature, °F$

Table 138: Electric Input Ratio Correction Factor 2 Coefficients

Equipment Description	a	b	c	d
Small DX (Air Cooled)	2.01E-01	-3.12E-02	1.95E+00	-1.12E+00

$$EIR_{c2} = a + b * PRL + c * \%PRL^2 + d * PRL^3$$

Where:
$PRL = Part\ Load$

Equation 28: Final Corrected Electric Input Ratio (EIR)

$$EIRf = \frac{EIRd * EIRc1 * EIRc2}{PRL}$$

Where:
EIR_f = Final Corrected EIR
EIR_d = Design EIR of Chiller (0.242)
EIR_{c1} = EIR Correction Factor 1
EIR_{c2} = EIR Correction Factor 2
PRL = % Part Load

Equation 29: Various Conversions for EIR to Other Efficiency Units

$$Adjusted\ or\ Final\ COP = \frac{1}{EIRf}$$

$$Adjusted\ or\ Final\ kW/ton = \frac{12}{Adjusted\ or\ Final\ COP * 3.412}$$

$$Adjusted\ or\ Final\ EER\ (Energy\ Efficiency\ Rating) = Adjusted\ or\ Final\ COP * 3.412$$

ENERGY CONSERVATION MEASURE (ECM) ECM 3.5: INSTALL DE-STRATIFICATION FANS IN HIGH BAY SPACES

Savings for this ECM are based on de-stratifying air within high bay spaces. Air stratification is a phenomenon which occurs due to air density differences of air at varying temperatures. Hot air raises away from the occupant/thermostat level and settles near the ceiling while cold air sinks and settles at the occupant/thermostat level. This causes air temperatures above the occupant/thermostat level to be greater than the space temperature set point. This increases the temperature differential between indoor conditions and outside air conditions for the wall and roof surface which increase the amount of heat loss due to conduction/convection.

Conduction/convection heat loss or gain directly through the skin of the building. Conduction is primarily a function of the thermal resistance of the building's construction materials, commonly represented by the R value of the materials. R value is a measure of thermal resistance which when multiplied by the area of the exterior exposure, represented by A, and the difference between the exterior and interior temperatures, represented by Tout and Tin, to determine the amount of heat loss, represented by Q. This is mathematically represented in *Equation 32: Conduction Thermal Heat Gain or Loss*.

Equation 30: Total Exposure Thermal Resistance

$$R_{tot} = R_{material1} + R_{material2} + R_{material2} + \cdots$$

Equation 31: Heat Transfer Coefficient

$$U_{tot}\left(\frac{BTU}{[ft^2 * °F * hr]}\right) = \frac{1}{R_{tot}\left(\frac{[ft^2 * °F * hr]}{BTU}\right)}$$

Equation 32: Conduction Thermal Heat Gain or Loss

$$Q_{conduction}\left(\frac{BTU}{hr}\right) = U\left(\frac{BTU}{hr * °\mathrm{F} * \mathrm{ft}^2}\right) * A\,(ft^2) * (T_{out}(°\mathrm{F}) - T_{in}(°\mathrm{F}))$$

The main variable impacted by this ECM is *Tin* for both wall and roof exposures. The existing average temperatures for each exposure is defined by a particular temperature increase per between the thermostat level temperature and the roof temperature. This temperature increase is reduced due to the scope of work for this ECM. Figure 37 graphically represents the pre and post temperature profile from the floor to the ceiling. Table 139 list the various temperature, thermal resistance, area, and run time variable definitions for this ECM. Table 140 represents the resulting pre and post energy model for this ECM.

Figure 37: Pre and Post Temperature Profile ECM3.5

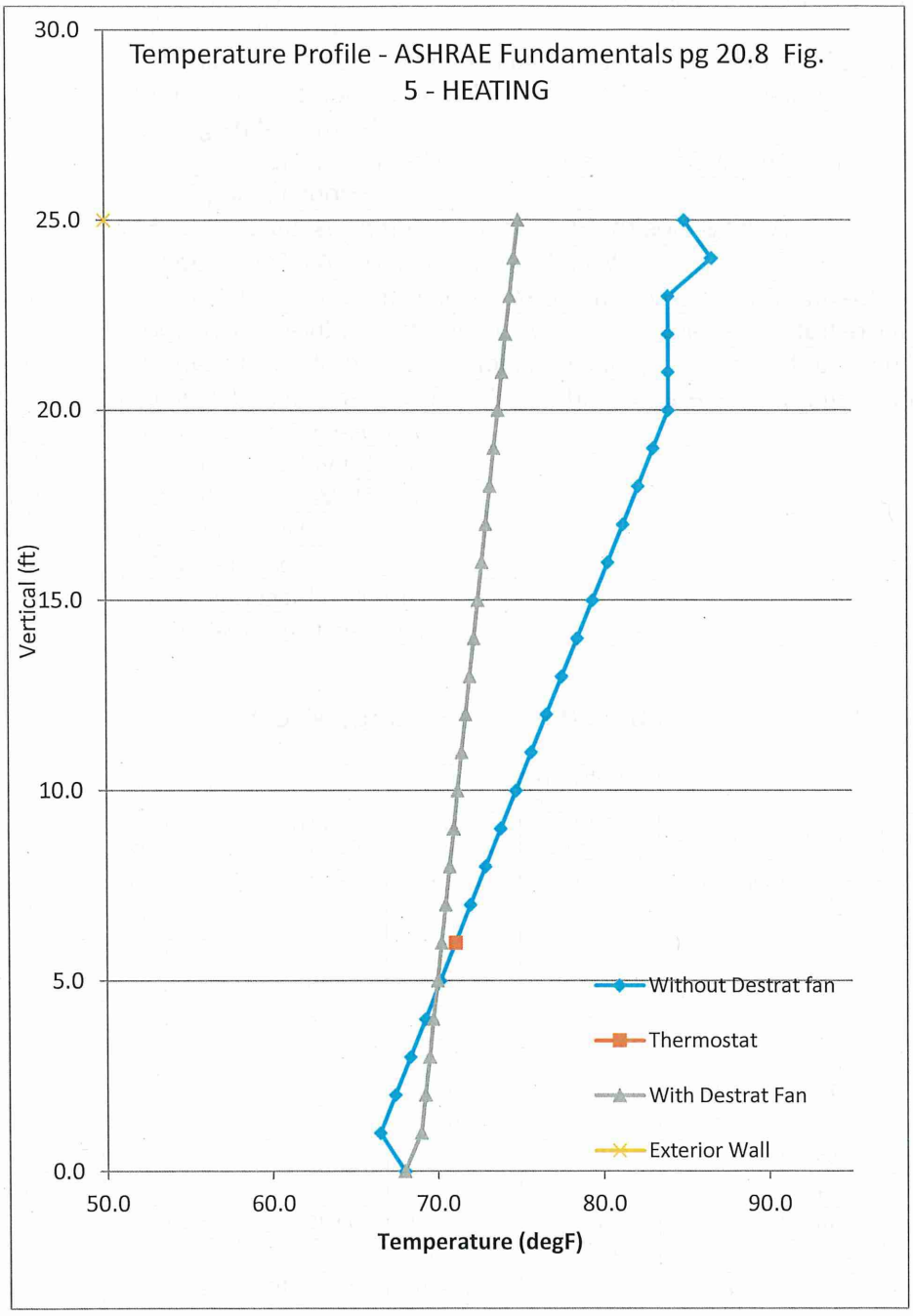


Table 139: Variable Definitions for ECM3.5

Variable Description	Variable Value
Operating When Outdoor Air Temp Less than (°F):	55
Floor to Ceiling Height (*max 40 ft*) (ft)	25.0
Equal Temp Zone height from Floor (*assumed 1 ft*)	1.0
Equal Temp Zone height from Ceiling (*2, 3, 4, 5, 6, 7, 8 ft*) or diffuser ft below roof	6.0

Variable Description	Variable Value
Average Field Observed Temperature Increase Per Vertical Foot (*assumed*) (°F/ft)	0.70
Without Destrat Fan Wall Air Temp in elevated constant region (F)	84.0
Without Destrat Fan Feet in linear temperature region (ft)	19.0
Thermostat height (ft)	6.0
Without Destrat Fan Temp at Thermostat Height (degF)	71.1
Floor Temp (degF)	68.0
Without Destrat Fan Floor Air Temp (*assumed*) (degF)	66.5
With Destrat Fan Floor Air Temp (degF)	69.0
Without Destrat Fan Average Inside Roof Air Temperature (*assumed*)	85.0
Without Destrat Fan Average Inside Wall Air Temperature (*calculated*)	85.00
With Destrat Fan Average Inside Roof Air Temperature (*assumed*)	75.0
With Destrat Fan Average Inside Wall Air Temperature (*calculated*)	75.00
# of De-stratification Fans:	10
Wall U Value (Btu/hr/ft^2)	0.310
Roof U Value (Btu/hr/ft^2)	0.150
Wall Length (ft)	450.0
Roof Area (ft^2)	10,500
Heating Plant Efficiency:	85%
Fan Operating Power (kW):	0.035

Table 140: ECM3.5 Energy Model

				Without Destratification Fans		With Destratification Fans			
Dry Bulb Temp.	Outdoor	Annual	Operating	Wall Conduction	Roof Conduction	Wall Conduction	Roof Conduction	Total	Operating
OA Range deg. F	Air Temp deg. F	BIN Hours	BIN Hours	Loss (Btu)	Loss (Btu)	Loss (Btu)	Loss (Btu)	Savings (Btu)	Cost (kWh)
			0	0	0	0	0	0	0.00
90 to 95	92.5	8	0	0	0	0	0	0	0.00
85 to 90	87.5	35	0	0	0	0	0	0	0.00
80 to 85	82.5	235	0	0	0	0	0	0	0.00
75 to 80	77.5	411	0	0	0	0	0	0	0.00
70 to 75	72.5	572	0	0	0	0	0	0	0.00
65 to 70	67.5	636	0	0	0	0	0	0	0.00
60 to 65	62.5	886	0	0	0	0	0	0	0.00
55 to 60	57.5	544	0	0	0	0	0	0	0.00
50 to 55	52.5	518	518	2,348,483	26,515,125	1,625,873	18,356,625	8,881,110	181.30
45 to 50	47.5	483	483	2,526,694	28,527,188	1,852,909	20,919,938	8,281,035	169.05
40 to 45	42.5	439	439	2,602,721	29,385,563	1,990,316	22,471,313	7,526,655	153.65
35 to 40	37.5	848	848	5,619,060	63,441,000	4,436,100	50,085,000	14,538,960	296.80
30 to 35	32.5	766	766	5,609,993	63,338,625	4,541,423	51,274,125	13,133,070	268.10
25 to 30	27.5	633	633	5,077,451	57,326,063	4,194,416	47,356,313	10,852,785	221.55
20 to 25	22.5	314	314	2,737,688	30,909,375	2,299,658	25,963,875	5,383,530	109.90
15 to 20	17.5	426	426	4,011,323	45,289,125	3,417,053	38,579,625	7,303,770	149.10
10 to 15	12.5	268	268	2,710,485	30,602,250	2,336,625	26,381,250	4,594,860	93.80
5 to 10	7.5	241	241	2,605,511	29,417,063	2,269,316	25,621,313	4,131,945	84.35
0 to 5	2.5	166	166	1,910,453	21,569,625	1,678,883	18,955,125	2,846,070	58.10

				Without Destratification Fans		With Destratification Fans			
Dry Bulb Temp.	Outdoor	Annual	Operating	Wall Conduction	Roof Conduction	Wall Conduction	Roof Conduction	Total	Operating
OA Range deg. F	Air Temp deg. F	BIN Hours	BIN Hours	Loss (Btu)	Loss (Btu)	Loss (Btu)	Loss (Btu)	Savings (Btu)	Cost (kWh)
-5 to 0	-2.5	147	147	1,794,319	20,258,438	1,589,254	17,943,188	2,520,315	51.45
-10 to -5	-7.5	110	110	1,419,413	16,025,625	1,265,963	14,293,125	1,885,950	38.50
-15 to -10	-12.5	42	42	571,253	6,449,625	512,663	5,788,125	720,090	14.70
-20 to -15	-17.5	32	32	457,560	5,166,000	412,920	4,662,000	548,640	11.20
			0	0	0	0	0	0	0.00
	Totals:	**8760.0**	**5433.0**					**93,148,785**	**1,901.55**

ENERGY CONSERVATION MEASURE (ECM) ECM 5.1 AND ECM 5.4: REPLACE INTERIOR LIGHTING AND REPLACE EXTERIOR LIGHTING

Savings for this ECM are mainly based on improvement of efficiency for lighting fixtures. In short, existing fixtures require a certain amount of electricity to provide a defined amount of light. Proposed LED fixtures require less electricity to provide existing light levels. In addition, at select few locations, occupancy sensors are proposed to reduce the number of hours lights are utilized. Table 141 list existing and proposed burn hours. *Appendix 1: Lighting line by line* details existing and proposed fixtures along with existing and expected power draw by space. The line by line detailed also associates each item with a space designation which can be associated with Table 141 in order to define burn hours. The following equations are utilized to estimate savings based off of increased efficiency and reduced hours by space.

Equations for Calculating Lighting Retrofit Savings
Demand (kW)

$$kW\ Saving = \sum_u [\ (kW/Fixture_{baseline} \times Quantity_{baseline} - kW/Fixture_{post} \times Quantity_{post})]_{t,u}$$

where:

$kW/fixture_{baseline}$ = lighting baseline demand per fixture for usage group u
$kW/fixture_{post}$ = lighting demand per fixture during post-installation period for usage group
$Quantity_{baseline}$ = quantity of affected fixtures before the lighting retrofit for usage group u
$Quantity_{post}$ = quantity of affected fixtures after the lighting retrofit for usage group u

Energy (kWh)

$$kWh\ Savings_{Lighting} = \sum_u [Connected\ kW\ Savings_u \times Burn\ Hours]_{t,u}$$

where:

$kW\ Savings_u$ = kilowatt savings realized during the post-installation time for usage group *u*

Burn Hours = number of operating hours during the time period *t* for the usage group *u*

Table 141: Lighting Hours Utilized

Master Schedule Name Per Building List	Area Specific or Hrs Type Custom Codes	Description	Existing Burn Hours Assigned	Proposed Controlled Burn Hours	% Hours Reduction
OFFICE	**au**	Auditorium/Stage	1000	700	30%
OFFICE	**br**	Break room	2500	2050	18%
OFFICE	**bras**	Break room Already Sensored	1750	1750	0%
OFFICE	**cf**	Cafeteria	2500	2050	18%
OFFICE	**cl**	Classroom	2500	1500	40%
OFFICE	**CLAS**	Classroom Already Sensored	1750	1750	0%

Master Schedule Name Per Building List	Area Specific or Hrs Type Custom Codes	Description	Existing Burn Hours Assigned	Proposed Controlled Burn Hours	% Hours Reduction
OFFICE	**cr**	Conference Room	2500	2050	18%
OFFICE	**CRAS**	Conference Room Already Sensored	1750	1750	0%
OFFICE	**E**	Exterior	4380	1621	63%
OFFICE	**gym**	Gymnasium	2500	1000	60%
OFFICE	**gymas**	Gymnasium Already Sensored	1000	1000	0%
OFFICE	**hw**	Hallway	2500	1750	30%
OFFICE	**hwas**	Hallway Already Sensored	1750	1750	0%
OFFICE	**kt**	Kitchen	2500	1750	30%
OFFICE	**LAB**	Laboratory	2500	1750	30%
OFFICE	**lo**	Lobby/Entry Vestibule	2500	1750	30%
OFFICE	**LQ**	Living Quarters/Bunk Rooms	2000	2000	0%
OFFICE	**lr**	Locker Room	2500	1750	30%
OFFICE	**LRAS**	Locker Room Already Sensored	1750	1750	0%
OFFICE	**me**	Mechanical/Electrical Rooms	625	438	30%
OFFICE	**mp**	Multipurpose	2500	1750	30%
OFFICE	**oo**	Open Office	2500	2250	10%
OFFICE	**OOAS**	Open Office Already Sensored	1750	1750	0%
OFFICE	**os**	Office Support (copy room, coffee room, etc)	2500	1750	30%
OFFICE	**OSAS**	Office Support (copy room, coffee room, etc) Already Sensored	2500	1750	30%
OFFICE	**po**	Private Office	2500	2250	10%
OFFICE	**poas**	Private Office Already Sensored	1750	1750	0%
OFFICE	**PR**	Patient Room	2500	1750	30%
OFFICE	**rr**	Restroom	2500	1750	30%
OFFICE	**rras**	Restroom Already Sensored	1750	1750	0%
OFFICE	**RT**	Retail	2500	1750	30%
OFFICE	**st**	Storage	2500	1750	30%
OFFICE	**stas**	Storage Already Sensored	1750	1750	0%
OFFICE	**sw**	Stairwell	2500	1750	30%
OFFICE	**ut**	Utility/Janitor Closets	625	438	30%
OFFICE	**wh**	Warehouse	2500	2500	0%
OFFICE	**whh**	Warehouse High Use	3000	3000	0%
OFFICE	**ws**	Workshop	2500	1000	60%
OFFICE	**WSAS**	Workshop Already Sensored	1000	1000	0%
OFFICE	**X**	Exit Signs	8760	8760	0%
OFFICE	**VEND**	Vending Machines	8760	8760	0%
OFFICE	**MUS**	Museum Display Area	1450	1015	30%
OFFICE	**MUS OO**	Museum Office	2200	1540	30%

Master Schedule Name Per Building List	Area Specific or Hrs Type Custom Codes	Description	Existing Burn Hours Assigned	Proposed Controlled Burn Hours	% Hours Reduction
OFFICE	**MUS L**	Museum Low Use	500	350	30%
WS	**au**	Auditorium/Stage	1000	700	30%
WS	**br**	Break room	2500	2050	18%
WS	**bras**	Break room Already Sensored	1750	1225	30%
WS	**cf**	Cafeteria	2500	1750	30%
WS	**cl**	Classroom	2500	1500	40%
WS	**CLAS**	Classroom Already Sensored	1750	1225	30%
WS	**cr**	Conference Room	2500	2050	18%
WS	**CRAS**	Conference Room Already Sensored	1750	1225	30%
WS	**E**	Exterior	4380	1621	63%
WS	**gym**	Gymnasium	2500	1000	60%
WS	**gymas**	Gymnasium Already Sensored	1750	1225	30%
WS	**hw**	Hallway	2500	1750	30%
WS	**hwas**	Hallway Already Sensored	1750	1225	30%
WS	**kt**	Kitchen	2500	1750	30%
WS	**LAB**	Laboratory	2500	1750	30%
WS	**lo**	Lobby/Entry Vestibule	2500	1750	30%
WS	**LQ**	Living Quarters/Bunk Rooms	2000	1400	30%
WS	**lr**	Locker Room	2500	1750	30%
WS	**LRAS**	Locker Room Already Sensored	1750	1225	30%
WS	**me**	Mechanical/Electrical Rooms	625	438	30%
WS	**mp**	Multipurpose	2500	1750	30%
WS	**oo**	Open Office	2500	2250	10%
WS	**OOAS**	Open Office Already Sensored	1750	1225	30%
WS	**os**	Office Support (copy room, coffee room, etc)	2500	1750	30%
WS	**OSAS**	Office Support (copy room, coffee room, etc) Already Sensored	1750	1225	30%
WS	**po**	Private Office	2500	2250	10%
WS	**poas**	Private Office Already Sensored	1750	1225	30%
WS	**PR**	Patient Room	2500	1750	30%
WS	**rr**	Restroom	2500	1750	30%
WS	**rras**	Restroom Already Sensored	1750	1225	30%
WS	**RT**	Retail	2500	1750	30%
WS	**st**	Storage	2500	1750	30%
WS	**stas**	Storage Already Sensored	1750	1225	30%
WS	**sw**	Stairwell	2500	1750	30%
WS	**ut**	Utility/Janitor Closets	625	438	30%
WS	**wh**	Warehouse	2500	1000	60%

Master Schedule Name Per Building List	Area Specific or Hrs Type Custom Codes	Description	Existing Burn Hours Assigned	Proposed Controlled Burn Hours	% Hours Reduction
WS	**whh**	Warehouse High Use	3000	2100	30%
WS	**ws**	Workshop	2500	1000	60%
WS	**WSAS**	Workshop Already Sensored	2500	1750	30%
WS	**X**	Exit Signs	8760	8760	0%
WS	**VEND**	Vending Machines	8760	6132	30%
RES	**au**	Auditorium/Stage	520	364	30%
RES	**br**	Break room	1300	910	30%
RES	**bras**	Break room Already Sensored	910	637	30%
RES	**cf**	Cafeteria	1456	1019	30%
RES	**cl**	Classroom	1300	910	30%
RES	**CLAS**	Classroom Already Sensored	910	637	30%
RES	**cr**	Conference Room	1300	910	30%
RES	**CRAS**	Conference Room Already Sensored	910	637	30%
RES	**E**	Exterior	4380	4380	0%
RES	**gym**	Gymnasium	1300	910	30%
RES	**gymas**	Gymnasium Already Sensored	910	637	30%
RES	**hw**	Hallway	1456	1019	30%
RES	**hwas**	Hallway Already Sensored	910	637	30%
RES	**kt**	Kitchen	1456	1019	30%
RES	**LAB**	Laboratory	1300	910	30%
RES	**lo**	Lobby/Entry Vestibule	1456	1019	30%
RES	**LQ**	Living Quarters/Bunk Rooms	1456	1019	30%
RES	**lr**	Locker Room	1300	910	30%
RES	**LRAS**	Locker Room Already Sensored	910	637	30%
RES	**me**	Mechanical/Electrical Rooms	325	228	30%
RES	**mp**	Multipurpose	1300	910	30%
RES	**oo**	Open Office	1456	1019	30%
RES	**OOAS**	Open Office Already Sensored	910	637	30%
RES	**os**	Office Support (copy room, coffee room, etc)	1300	910	30%
RES	**OSAS**	Office Support (copy room, coffee room, etc) Already Sensored	910	637	30%
RES	**po**	Private Office	1300	910	30%
RES	**poas**	Private Office Already Sensored	910	637	30%
RES	**PR**	Patient Room	1300	910	30%
RES	**rr**	Restroom	1456	1019	30%
RES	**rras**	Restroom Already Sensored	1092	764	30%
RES	**RT**	Retail	1300	910	30%
RES	**st**	Storage	1456	1019	30%

Master Schedule Name Per Building List	Area Specific or Hrs Type Custom Codes	Description	Existing Burn Hours Assigned	Proposed Controlled Burn Hours	% Hours Reduction
RES	**stas**	Storage Already Sensored	910	637	30%
RES	**sw**	Stairwell	1456	1019	30%
RES	**ut**	Utility/Janitor Closets	325	228	30%
RES	**wh**	Warehouse	1300	910	30%
RES	**whh**	Warehouse High Use	1560	1092	30%
RES	**ws**	Workshop	1300	910	30%
RES	**WSAS**	Workshop Already Sensored	1300	910	30%
RES	**X**	Exit Signs	8760	8760	0%
RES	**VEND**	Vending Machines	8760	6132	30%
EXT	**E**	Exterior	4380	4380	0%

ENERGY CONSERVATION MEASURE (ECM) ECM 6.1: BUILDING ENVELOPE IMPROVEMENTS

The following equation is based on the ASHRAE Fundamentals Chapter 16 residential crack method presented:

Heat loss per hour: $\dot{q}$ = 1.08 x Q x ΔT

Where Q represents the airflow in cubic feet per minute (CFM) and is calculated in the following manner:

$$Q = A_{crack} \times \sqrt{(C_s \Delta T + C_w V^2}$$

In this equation, *A* represents the crack area in square inches to be reduced. The other values in the equation are standard for these buildings and are based upon shelter class, height, and local wind speed.

- Cw = wind coefficient = 0.0104 average
- V = wind speed = 8.8 average mph
- Cs = stack coefficient = 0,0299 (two-story typical)
- ΔT = temperature difference = $T_{out} - T_{in}$

Table 142: Stack Coefficient Definition

Story	Stack Coefficient C_S
1	0.01500
2	0.02990
3	0.04490
4	0.06283
5	0.07858
6	0.09433
7	0.11008
8	0.12583
9	0.14158
10	0.15733

Table 143: Wind Coefficient Definition

# of Stories	Shelter Class 1	Shelter Class 2	Shelter Class 3	Shelter Class 4	Shelter Class 5
1	0.0119	0.0092	0.0065	0.0039	0.0012
2	0.0157	0.0121	0.0086	0.0051	0.0016
3	0.0184	0.0143	0.0101	0.0060	0.0018
4	0.0218	0.0170	0.0120	0.0071	0.0021
5	0.0251	0.0195	0.0138	0.0082	0.0024
6	0.0283	0.0221	0.0156	0.0092	0.0027
7	0.0316	0.0246	0.0174	0.0103	0.0030
8	0.0348	0.0272	0.0192	0.0113	0.0033
9	0.0381	0.0297	0.0210	0.0124	0.0036
10	0.0413	0.0323	0.0228	0.0134	0.0039

ΔT is calculated by subtracting the average outdoor air temperature per hour from the indoor temperature, using 24 data points per month to accurately account for weather variances, and subsequently calculating airflow and heat loss for each set of data. Therefore, 288 data points are used, and Δt is the number of hours each data point represents. The total heat loss is calculated as follows:

$$q = \sum_{x=1}^{288} 1.08 \times A_{crack} \times \sqrt{C_s (T_{out} - T_{in}) + C_w V^2} \times (T_{out} - T_{in}) \times \Delta t$$

Savings due to insulation improvements:

Steady-state, one dimensional heat flow through insulation systems is governed by Fourier's law:

q = - k·A·dT/dx * Hrs / 1MMBTU

Where:

q = rate of heat flow, Btu/hr
A = cross sectional area normal to heat flow, ft2
k = thermal conductivity of the insulation material, Btu-in/h ft2°F
dT/dx = temperature gradient, °F/in

Table 144: RTI (02-001) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	71	0.370
1/8	91	0.948
1/4	15	0.313
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.630
Penetrations		0.030
		1.660

Table 145: Old FMS (02-166) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	818	2.130
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.130
Penetrations		
		2.130

Table 146: J6/IT (02-202) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	35	0.365
1/4	7	0.146
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.510
Penetrations		
		0.510

Table 147: DNR Warehouse (02-204) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	132	0.344
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.344
Penetrations		0.010
		0.354

Table 148: Warehouse (02-206) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	118	0.307
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.307
Penetrations		
		0.307

Table 149: FMO Warehouse (02-223) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	128	1.333
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.333
Penetrations		
		1.333

Table 150: Central Steam Plant (02-246) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	53	0.552
1/4	23	0.479
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.031
Penetrations		
		1.031

Table 151: WWTP Shed (02-247) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	17	0.177
1/4	3	0.063
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.240
Penetrations		
		0.240

Table 152: Plumbing (02-267) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	56	0.583
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.583
Penetrations		0.080
		0.663

Table 153: Public Works (02-268) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	40	0.417
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.417
Penetrations		
		0.417

Table 154: Paint Shop (02-269) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	40	0.417
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.417
Penetrations		0.110
		0.527

Table 155: Education Center (06-076)

Crack area Calculation		
Width	**LF**	**ft²**
1/16	315	1.641
1/8	329	3.427
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		5.068
Penetrations		0.040
		5.108

Table 156: PX (07-067) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	170	0.885
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.885
Penetrations		0.020
		0.905

Table 157: Unit Housing (07-131) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	338	1.760
1/8	25	0.260
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.021
Penetrations		0.110
		2.131

Table 158: Unit Housing (07-132) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	1129	2.940
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.940
Penetrations		0.070
		3.010

Table 159: Unit Housing (07-133) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	1348	3.510
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		3.510
Penetrations		0.130
		3.640

Table 160: Unit Housing (07-134) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	1069	2.784
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.784
Penetrations		0.050
		2.834

Table 161: Unit Housing (07-135) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	989	2.576
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.576
Penetrations		0.070
		2.646

Table 162: Snack Bar (08-022) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	159	0.828
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.828
Penetrations		0.010
		0.838

Table 163: TMC (08-081) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	349	0.909
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.909
Penetrations		0.050
		0.959

Table 164: Unit Housing (09-131) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	996	10.375
1/4	45	0.938
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		11.313
Penetrations		0.140
		11.453

Table 165: Unit Housing (09-132) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	1026	10.688
1/4	15	0.313
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		11.000
Penetrations		0.140
		11.140

Table 166: Unit Housing (09-133) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	68	0.354
1/8	252	2.625
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.979
Penetrations		0.030
		3.009

Table 167: Unit Housing (09-134) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	34	0.177
1/8	984	10.250
1/4	24	0.500
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		10.927
Penetrations		0.140
		11.067

Table 168: Unit Housing (09-135) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	34	0.177
1/8	999	10.406
1/4	12	0.250
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		10.833
Penetrations		0.140
		10.973

Table 169: Unit Housing (10-137) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	789	8.219
1/4	211	4.396
1/2	21	0.875
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		13.490
Penetrations		0.140
		13.630

Table 170: Unit Housing (10-138) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	74	0.385
1/8	958	9.979
1/4	16	0.333
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		10.698
Penetrations		0.190
		10.888

Table 171: Unit Housing (10-139) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	755	7.865
1/4	261	5.438
1/2	39	1.625
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		14.927
Penetrations		0.110
		15.037

Table 172: Unit Housing (10-140) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	721	7.510
1/4	313	6.521
1/2	49	2.042
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		16.073
Penetrations		0.150
		16.223

Table 173: Unit Housing (10-141) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	721	7.510
1/4	307	6.396
1/2	55	2.292
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		16.198
Penetrations		0.150
		16.348

Table 174: Unit Housing (10-142) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/32	1083	2.820
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.820
Penetrations		0.130
		2.950

Table 175: Unit Housing (10-143) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	721	7.510
1/4	262	5.458
1/2	40	1.667
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		14.635
Penetrations		0.150
		14.785

Table 176: Unit Housing (10-144) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	721	7.510
1/4	262	5.458
1/2	40	1.667
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		14.635
Penetrations		0.150

Table 177: USPFO Warehouse (11-062) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	342	1.781
1/8	18	0.188
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.969
Penetrations		
		1.969

Table 178: CIF (11-063) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	484	2.521
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		2.521
Penetrations		
		2.521

Table 179: RTSM (11-076) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	1829	9.526
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		9.526
Penetrations		0.010
		9.536

Table 180: DOL Office (11-159) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	1418	7.385
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		7.385
Penetrations		
		7.385

Table 181: Maintenance Shop (11-160) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	119	1.240
1/4	21	0.438
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.677
Penetrations		
		1.677

Table 182: CMA South (11-169) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	4122	21.469
1/8	1150	11.979
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		33.448
Penetrations		0.040
		33.488

Table 183: MOB/DEMOB (15-001) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16		0.000
1/8	110	1.146
1/4	10	0.208
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		1.354
Penetrations		0.030
		1.384

Table 184: USPFO (15-002) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	55	0.286
1/8	53	0.552
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		0.839
Penetrations		0.070
		0.909

Table 185: CMA North (17-001) Crack Area Calculation

Crack area Calculation		
Width	**LF**	**ft²**
1/16	1920	10.000
1/8		0.000
1/4		0.000
1/2		0.000
3/4		0.000
1		0.000
1 1/2		0.000
2		0.000
		10.000
Penetrations		0.030
		10.030

DESCRIPTION OF PRELIMINARY MEASUREMENT AND VERIFICATION PLAN FOR PROPOSED ENERGY CONSERVATION MEASURES (ECMS):

The proposed preliminary Measurement and Verification Plan is presented in detail within *Appendix 3: Preliminary Measurement and Verification Plan*.

DISCUSSION OF MEASURES CONSIDERED BUT NOT RECOMMENDED

As a part of this study the ECMs listed in Table 186 were considered but not recommended. The column labeled *Comment Number* prescribes a number to each ECM which associates which of the following comments describe the reasoning why the ECM is not recommended as a part of this report.

1. These ECM involves a heavy capital cost with little savings. Total savings could not support proposed ECMs, some of which are capital intensive, and the ECMs defined with a *1* within Table 186. The Customer, during workshops, helped define which ECMs were of the upmost importance, ECMs recommended in this study are a result of such workshops.
2. These ECMs are based on renewable technology. The utility rates at the Camp are relatively low reducing the benefit of utilizing renewable technology. In addition, few utility rebates exist to offset the large cost of renewable technology. Ultimately the Customer decided to include ECMs which address immediate maintenance concerns.
3. This ECM is a capital item only, in other words, no savings are associated with this ECM. The Camp is required to report consumption of sub meters which the prescribed ECM would assist with. However, the Customer decided to include ECMs which address immediate maintenance concerns.

Table 186: ECMs Considered but not Recommended

ECM ID	ECM Description	Comment Number
ECM 1.3B	Eliminate Existing Steam Plant Replace with Central Heating, Hot Water Plant	1
ECM 1.6	Condensing Furnace Replacement	1
ECM 1.7	IR Heaters	1
ECM 4.2C	Chiller Replacement	1
ECM 11.1	Install Solar Hot Water Preheating	2
ECM 11.3	Geothermal Heat Pump Retrofit	2
ECM 18.1	Automatic Meter Reading	3
ECM 8.1	Retrofit Existing Well Water Pump & Trim Impellers to Match Flow	1

CONCLUSIONS AND RECOMMENDATIONS

Johnson Controls concludes that there is a great opportunity for Camp Ripley to implement the energy project outlined in this Investment Grade Audit to 1) help with the overall mission of self-sustainability and 2) address immediate maintenance concerns. It is recommended Camp Ripley engage in this energy conservation project with Johnson Controls, Inc.

APPENDIX 1: LIGHTING LINE BY LINE

This appendix contains specific detail regarding the lighting audit and proposed scope.

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APPENDIX 2: LIGHTING WARRANTY DOCUMENTATION

This appendix contains an example lighting warranty certificate for proposed equipment

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APPENDIX 3: PRELIMINARY MEASUREMENT AND VERIFICATION PLAN

This appendix covers the measurement and verification plan as per the Minnesota Department of commerce.

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APPENDIX 4: ENERGY MODELING DETAILED EXPLANATION

This appendix includes additional detail for the methodology utilized to create energy models for this study.

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