Army Reserve Center
Newport, Rhode Island

Technical Report Three:
Mechanical Systems Existing Conditions Evaluation

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Table of Contents

List of Figures and Tables

Executive Summary

The purpose of this report is to summarize and evaluate the Army Reserve Center's mechanical systems based on design requirements, system configuration, individual components, and operating characteristics.

The Army Reserve Center utilizes three air handling units, two of the variable air volume type and one of the constant air volume type, and unit ventilators in smaller spaces to meet the outside air requirements, heating loads, and cooling loads. The air handling units and unit ventilators have chilled water cooling coils and hot water heating coils for temperature control. The chilled water is created using two air-cooled rotary screw packaged water chillers piped in parallel and the hot water is created by two boilers.

The Army Reserve Center was designed to minimize energy consumption. It uses 30% less energy than that required by Appendix G of ASHRAE 90.1 – 2007. It will be LEED certified with at least a Silver ranking, but it may receive Gold depending on several points it may or may not obtain after construction is complete.

Design Objectives and Requirements

The main goal in designing the Army Reserve Center was to achieve a LEED Silver or Gold certification while maintaining good design practices such as following the applicable codes and following the requests of the United States Army Corps of Engineers. The codes that were followed were the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 62.1 and 90.1, the United Facilities Criteria (UFC) 4-171-05 and 3-400-02, and all applicable National Fire Protection Association (NFPA) codes and standards. To achieve this goal, a constant volume air handling unit was used for the auditorium, two variable air volume air handling units were used for the entire second floor and the core of the first floor, and smaller unit ventilators met the loads for the classrooms on the first floor and several other smaller zones on the first floor. The design met this goal because it follows the codes mentioned above and will achieve 36 to 42 LEED points, giving it a LEED Silver or Gold rating.

Energy Sources and Rates

The Army Reserve Center is heated by two boilers that use primarily natural gas although a small amount of electricity is used for heating accessories. Cooling in the Army Reserve Center is accomplished using electricity. Electricity is also used in the operation of pumps, for lighting, and for receptacles. According to the specifications, the cost for electricity is $93.15/MWH or $0.09315/Kwh. The cost of natural gas is approximately $4.00/MMBtu.

Site, Cost, and Other Design Influences

The Army Reserve Center was constructed with warehouses being the only buildings close by. Thus, the existing buildings had no architectural influence to compliment. The Naval Station Newport Installation Appearance Guide was followed throughout the design of the Army Reserve Center.

The total cost of the project was $17 million. The financing for the project was taken from the United States Army which is funded by tax payer money.

The design was administered by the United States Army Corps of Engineers Louisville District. Several other design factors required were to obtain LEED certification and to follow applicable standards from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), United Facilities Criteria (UFC), and National Fire Protection Association (NFPA).

Outdoor / Indoor Design Conditions

The design conditions of Providence, Rhode Island were used for the Army Reserve Center because they were the closet available to Newport, Rhode Island. These are:

Heating: 10.8°F (99.0% Occurrence)
Cooling: 89.7°F DB / 73.2°F WB (0.4% Occurrence)

However, because it was requested by the US Army Corps of Engineers, 0°F was used for heating. Also, because it was requested, indoor cooling design conditions shall be 74°F with 50% relative humidity and indoor heating shall be 72°F for occupied spaces and 55°F for unoccupied spaces.

Design Ventilation Requirements

As shown in table 1 below, the estimated outdoor air from AHU-1 is 1502 CFM, from AHU-2 it is 3104 CFM, and from AHU-3 it is 1074 CFM. The estimated cubic feet per minute of outside air delivered versus that designed are quite a bit different. For AHU-3, there is not a problem except that the air handing unit is oversized slightly for a margin of safety. For AHU-1 and AHU-2, the estimate performed in Technical Report 1 assumed that not all air supplied would be delivered to each zone with 100% efficiency. The ventilation calculation (Vot estimate) assumes automatically that some outside air will be lost. The designed minimum outside air assumes that all outside air will reach each zone with 100% efficiency. Thus the minimum outside air from the Vot estimate will be a greater value than actually required because it assumes that some will be lost.

	Vot Estimate (CFM)	Designed Min OA CFM	Percentage Difference
AHU-1	1502	900	40.08%
AHU-2	3104	2375	23.49%
AHU-3	1074	1345	-25.23%

Table 1

Design Heating and Cooling Loads

As mentioned in Technical Report 2, the Army Reserve Center was broken up into several blocks for the design load estimation. Each air handling unit had its own block. AHU-1 serves the first floor offices, AHU-2 serves the second floor, and AHU-3 serves the auditorium. The other blocks are the areas served by the unit ventilators. UV-1, UV-2, and UV-3 are treated as one block since they serve several classrooms that are in a row. UV-4, UV-5, and UV-6 each are treated as a separate block because they each serve a distinct group of several spaces. UV-4 and UV-5 are on the exterior while UV-6 is on the interior.

Shown in table 2 below are the designed versus the modeled cooling square foot/ton, the heating BTUH/square foot, the total supply air CFM/square foot, and the supply air CFM/square foot. Although the design documents include several Trane Trace 700 files, they do not include the system checksums so the actual numbers cannot be obtained from the Trace file. However, the numbers can be determined from the mechanical schedules.

MODELED VERSUS DESIGNED					
		COOLING FT2 / TON	HEATING BTUH/FT2	TOTAL SA CFM/FT2	VENT SUPPLY CFM/FT2
AHU-1	**MODELED**	653	11.45	0.42	0.125
	DESIGNED	544	7.32	0.45	0.11
	% DIFF	**20.04**	**56.42**	**6.67**	**13.64**
AHU-2	**MODELED**	620	11.52	0.5	0.098
	DESIGNED	561	5.81	0.53	0.096
	% DIFF	**10.52**	**98.28**	**5.66**	**2.08**
AHU-3	**MODELED**	287	27.82	0.86	0.37
	DESIGNED	235	43	0.72	0.464
	% DIFF	**22.13**	**35.30**	**19.44**	**20.26**
UV-1, UV-2, UV-3	**MODELED**	383	24.95	0.76	0.334
	DESIGNED	408	30.6	0.52	0.157
	% DIFF	**6.13**	**18.46**	**46.15**	**112.74**
UV-4	**MODELED**	330	23.51	1.54	0.1
	DESIGNED	506	26.5	0.81	0.127
	% DIFF	**34.78**	**11.28**	**90.12**	**21.26**
UV-5	**MODELED**	301	24.2	1.54	0.1
	DESIGNED	359	28.3	0.87	0.127
	% DIFF	**16.16**	**14.49**	**77.01**	**21.26**
UV-6	**MODELED**	1320	8.35	0.19	0.083
	DESIGNED	801.00	14.60	0.56	0.12
	% DIFF	**64.79**	**42.81**	**66.07**	**29.06**

Table 2

As shown table 2, most of the systems appear to be accurately modeled since the percent differences are rarely above 30%. However, there are several discrepancies. This occurs partially because the rooms were designed using the space by space method while the model created used the block method. The block method placed several smaller spaces on the air handling units when they really were not conditioned. The other reason for the differences could be that, especially for the unit ventilators, there are only so many standard sizes. The unit ventilators thus had to be oversized in order to meet the required capacities. The schedules, which had these oversized unit ventilators, were used in determining the heating, cooling, and ventilation CFM/ square foot since the Trace 700 files documenting the required capacities of the spaces which contained the unit ventilators were not given. This error was not noticeable on the larger air handling units because they are big enough that even if they are oversized, it is by a much smaller percentage.

Annual Energy Use

Energy Usage (Estimate from Tech 2)

	Electric Consumption (kWh)	Gas Consumption (kBTU)	% of Total Building Energy	Total Building Energy (mmBtu/yr)
Heating				
Primary Heating		153,112	8.00%	153
Other Htg. Accessories	13,065		2.30%	44.6
Cooling				
Cooling Compessor	62,509		11.10%	213.3
Tower/Cond Fans	9,625		1.70%	32.9
Other Clg Accessories	876		0.20%	3
Auxiliary				
Pumps	59,755		10.70%	203.9
Lighting	252,839		45.10%	862.9
Receptacles	117,384		20.90%	400.6
Total	**516053**	**153112**	**100%**	**1,914.40**

Table 3

As shown in table 3 above, the majority of the energy consumption of the Army Reserve Center is due to lighting and receptacles which make up 45.1% and 20.9% of the energy respectively. The cooling and heating loads are both relatively small percentages of the total energy used. This is due to the tight construction of the building, each of the components of the building having small U values, and the building minimizing glass (less than 10%).

Figures 1 and 2 below show the monthly usage of natural gas and electricity, respectively. As one may predict, natural gas usage is negligible (if at all) in the summer because there is hardly any heating from the boilers. However, it increases in the winter month and is a maximum at 422 therms in January.

Electricity usage is at a maximum in July at 51,618 kilowatt hours because many of the air conditioning applications need a lot of electricity to meet their capacities. It is higher also in June and August, but really is about the same for the rest of the year. One thing to consider for the re-design of the building would be to attempt to maximize day lighting. This would help because the most of the energy is due to lighting which makes up 45% of the total energy usage of the building.

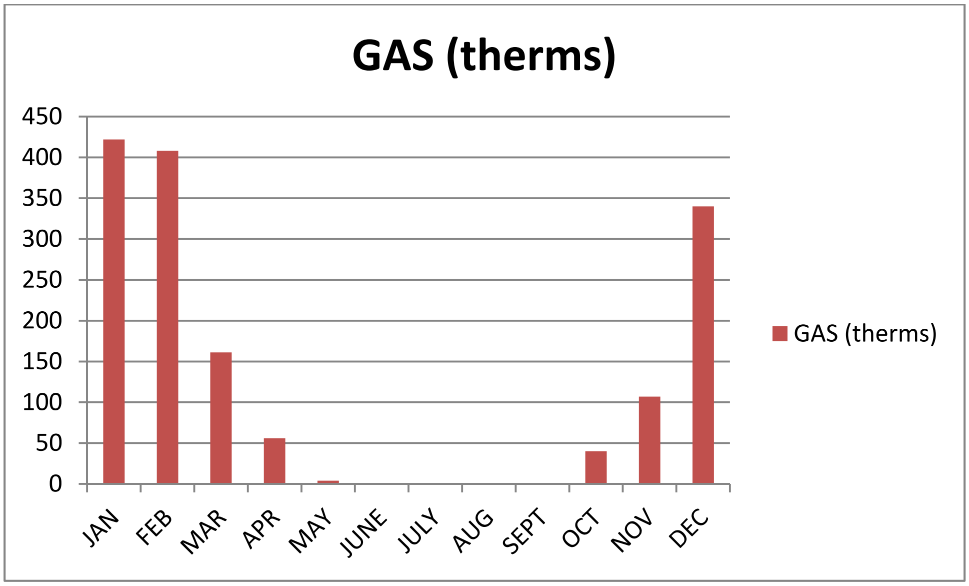

Figure 1 (above)

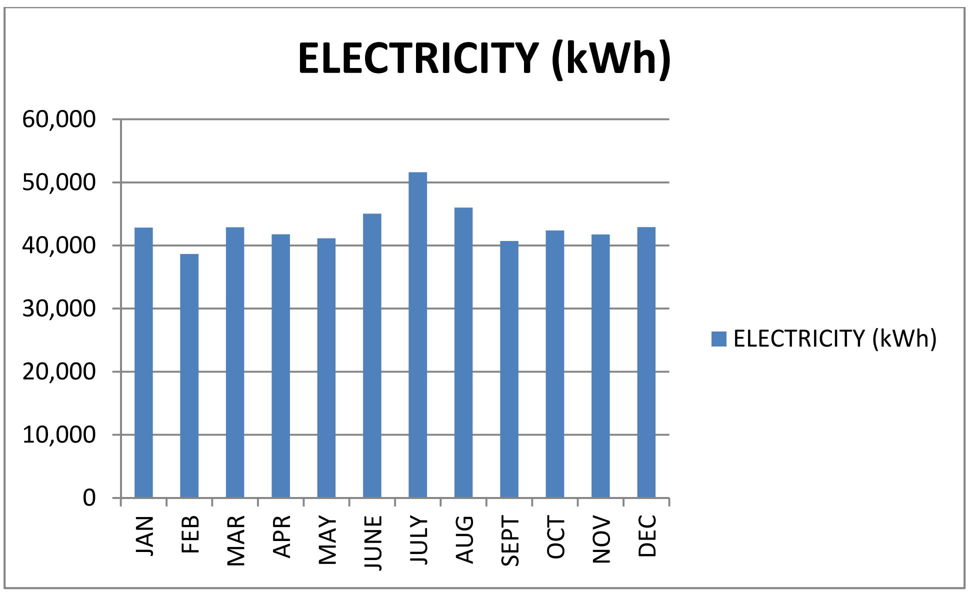

Figure 2

Compare to Actual Energy Analysis

Shown below in table 4 below are two alternatives for the building energy consumption created by the design engineer. The Army Reserve Center was designed based on Alt-1 Training Center Proposed. Although both the design engineer and the model created used Trane Trace 700 for the energy model, alternative 1 was very different than the total energy calculated. The calculated model, closer to alternative 2, used 1,914 * 10^6 BTU/yr, which is a 68% difference from alternative 1, but only an 8% difference from alternative 2. The lighting load of the model is 863 mmBTU/yr; about three times greater than alternative 1 and twice as large as alternative 2.

Part of this is because the design only takes into account conditioned spaces, while the model created is based on the block load method and thus takes the lighting load of several unconditioned spaces. Another reason for the discrepancies in lighting loads could have arisen if the design engineer took into account natural lighting and thus assumed that the lights would be off or dimmed during much of the day. The model does not take that into account because it assumes 0.71 Watts / square foot for each of the blocks.

The actual utility bills are not yet available as the Army Reserve Center is currently under construction thus no comparison of predicted and actual utility costs can be performed.

Note: The percentage displayed for the "Proposed/ Base %" column of the base case is actually the percentage of the total energy consumption. * Denotes the base alternative for the ECB study.		* Alt-2			Alt-1 Training Center Proposed		
		Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh	Energy 10^6 Btu/yr	Proposed / Base %	Peak kBtuh
Lighting - Conditioned	Electricity	405.2	23	166	280.7	69	109
Space Heating	Electricity	1.4	0	2	37.0	2,738	10
	Gas	454.4	26	712	203.1	45	510
Space Cooling	Electricity	155.0	9	310	97.9	63	220
Pumps	Electricity	0.0	0	0	1.9	0	4
Heat Rejection	Electricity	64.4	4	33	14.6	23	27
Fans - Conditioned	Electricity	99.9	6	84	67.6	68	108
Receptacles - Conditioned	Electricity	219.5	12	98	219.5	100	98
Stand-alone Base Utilities	Electricity	299.0	17	63	163.6	55	34
	Gas	60.4	3	7	50.8	84	6
Total Building Consumption		1,759.2			1,136.6		

Table 4

Schematic Drawings of Existing Mechanical Systems

Shown below in figure 3 is the chilled water flow diagram and shown below in figure 4 is the heating hot water flow diagram.

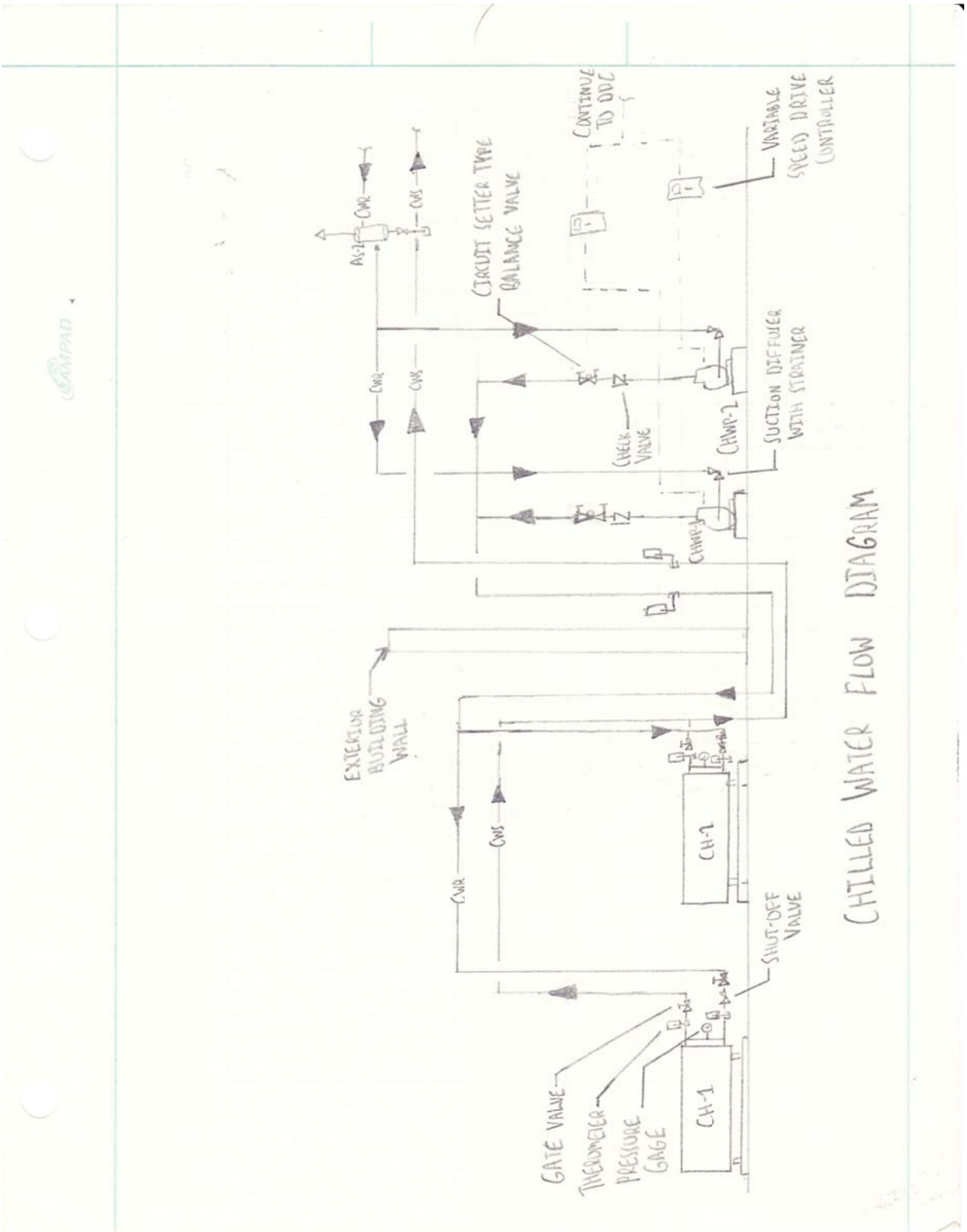
CHILLED WATER FLOW DIAGRAM
CIRCUIT SETTER TYPE BALANCE VALVE
CONTINUE TO DDC
VARIABLE SPEED DRIVE CONTROLLER
SUCTION DIFFUSER WITH STRAINER
CHECK VALVE
CHWP-1
CHWP-2
EXTERIOR BUILDING WALL
CWR
CWS
CH-1
SHUT-OFF VALVE
GATE VALVE
THERMOMETER
PRESSURE GAGE

Figure 3

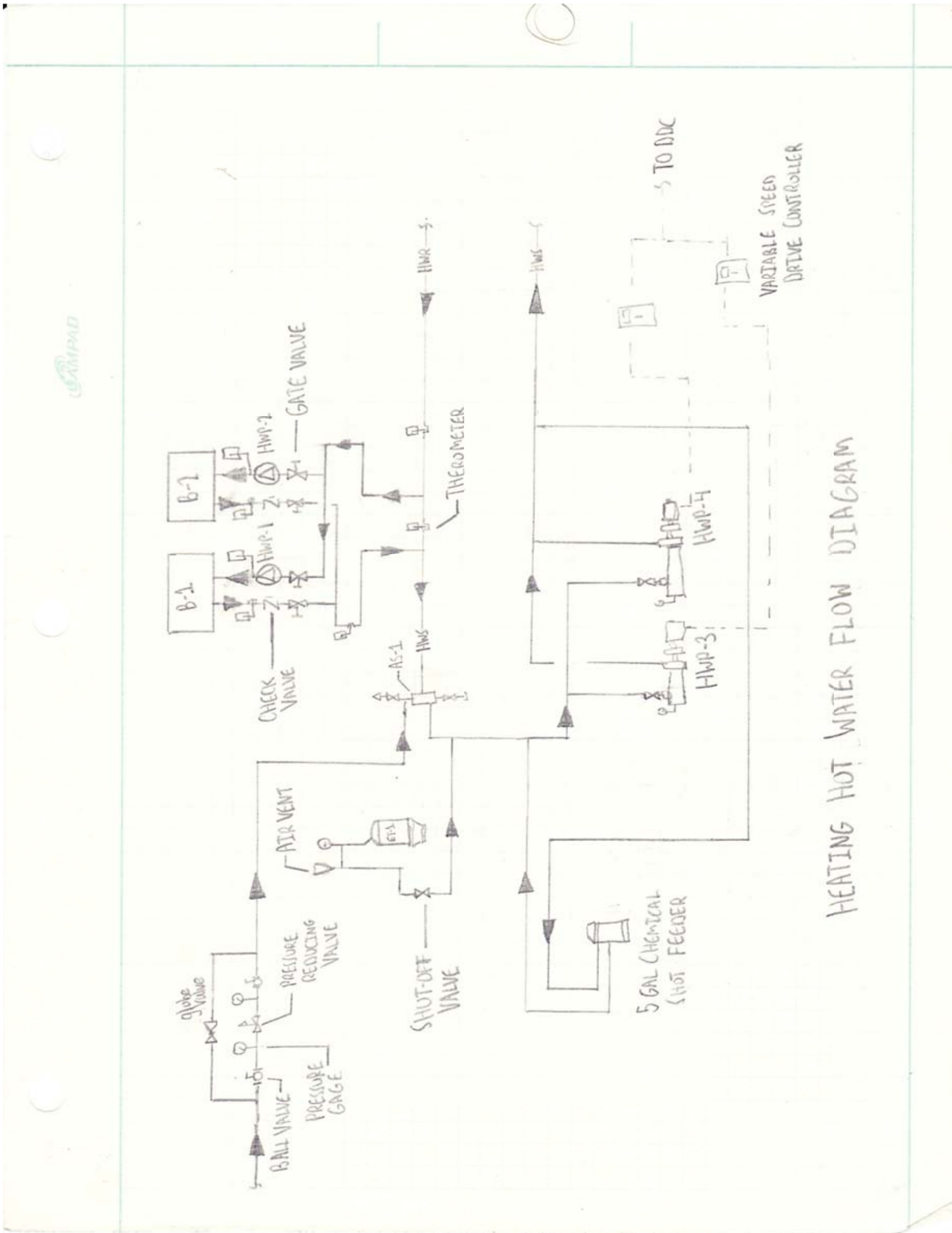
HEATING HOT WATER FLOW DIAGRAM
B-1
B-2
HWP-1
HWP-2
GATE VALVE
CHECK VALVE
THEROMETER
AS-1
HWS
HWR
TO DDC
VARIABLE SPEED DRIVE CONTROLLER
HWP-3
HWP-4
AIR VENT
ET-1
SHUT-OFF VALVE
5 GAL CHEMICAL SHOT FEEDER
globe valve
PRESSURE REDUCING VALVE
BALL VALVE
PRESSURE GAGE

Figure 4

Summary of Major Equipment

The Army Reserve Center contains three air handling units. All three air handling units are located in mechanical rooms on the second floor. Each air handling unit is manufactured by Trane and contains a supply fan, return fan, cooling coil, heating coil, filter, and enthalpy economizer. The air handling units are summarized in table 5 below.

AIR HANDLING UNIT SCHEDULE					
TAG	UNIT TYPE	AREA SERVED	MAX SA (CFM)	MIN SA (CFM)	MIN OA (CFM)
AHU-1	VAV	FIRST FLOOR OFFICE	3700	1915	900
AHU-2	VAV	SECOND FLOOR	13200	8175	2375
AHU-3	CV	ASSEMBLY AREA	2100	2100	1345

Table 5

The rest of the ventilation for several other spaces on the first floor is done using small unit ventilators. The unit ventilators are summarized in table 6 below.

FOUR PIPE UNIT VENTILATOR SCHEDULE					
TAG	AREA SERVED	SUPPLY CFM	MIN OA CFM	CHILLED WATER COOLING COIL CAPACITY (MBH) TOT/SENS	HOT WATER HEATING COIL CAPACITY (MBH)
UV-1	127-CLASSROOM	625	155	12.9 / 12.1	27
UV-2	128-CLASSROOM	440	150	20.4 / 13.3	14.4
UV-3	129-CLASSROOM	440	150	20.4 / 13.3	14.4
UV-4	SOUTH SUPPLY OFFICES	606	95	17.8 / 17.01	19.9
UV-5	WEST SUPPLY OFFICES	650	95	25.1 / 23.4	21.2
UV-6	WEAPONS SIMULATOR	975	205	26.2 / 26.2	25.5
UV-7	SIPRNET CAFÉ	1575	85	25.5 / 24.9	58.1
UV-8	MAILROOM SUITE	375	50	12.9 / 9.4	10

Table 6

To heat the Army Reserve Center, two boilers are present. They are summarized in table 7 below.

HOT WATER BOILER SCHEDULE				
TAG	TYPE	MAX INPUT (MBH)	MAX OUTPUT (MBH)	MIN GAS INPUT (MBH)
B - 1,2	MODULATING VERTICAL	999	959	50

Table 7

To cool the Army Reserve Center, two air-cooled rotary screw packaged water chillers piped in parallel are used in the building. The chillers are manufactured by Trane, and they are summarized in table 8 below.

AIR COOLED CHILLER SCHEDULE								
TAG	NOMINAL CAPACITY (TONS)	EFFICIENCY		COMPRESSOR		ELECTRICAL DATA		
		FULL LOAD EER	FULL LOAD COP	TYPE	REFRIG. TYPE	VOLTS/PHASE/HERTZ	MCA	MOCP
CH-1	40	9.9	2.9	SCROLL	R-410A	460 / 3 / 60	91.8	110.00
CH-2	52	9.9	2.9	SCROLL	R-410A	460 / 3 /60	108.2	125.00

Table 8

Pumps are used in the Army Reserve Center to send chilled and hot water throughout the building. They are summarized in table 9 below.

PUMP SCHEDULE								
TAG	PUMP TYPE	FLUID TYPE	FLUID TEMP (°F)	GPM	HEAT (FT H2O)	ELECTRICAL DATA		
						MOTOR HP	NOMINAL MOTOR RPM	VOLTS/PHASE/HERTZ
CHWP - 1,2	BASE MTD, END SUCTION	WATER	42	130	50	5	1750	480 / 3 /60
HWP - 1,2	INLINE BOOSTER	WATER	130	100	10	3 / 4	1150	460 / 3 /60
HWP - 3,4	BASE MTD, END SUCTION	WATER	130	100	55	5	1750	460 / 3 /60

Table 9

Description of System Operation

The Army Reserve Center uses a Direct Digital Control (DDC) system with electronic actuation for control of all HVAC systems and equipment. The DDC system includes controllers for all air handling units, hydronic pumping systems, VAV terminal units and lighting. It monitors electricity, natural gas, and water usage, is Johnson Control, Inc. (JCI) based, and is JCI N2 and LonWorks compatible.

Airside

The Army Reserve Center uses three air handling units in order to heat, cool, and supply outside air to the building. AHU-1 is of the variable air volume type and serves the first floor offices along with several other spaces on the first floor. The load and required outside air for the rest of the spaces on the first floor is met with unit ventilators. AHU-2, also of the variable air volume type, handles the loads and outside air required for the second floor. AHU-1 and AHU-2 have enthalpy based economizers and variable frequency drives on both the supply and return fans. Both AHU-1 and AHU-2 have a minimum and maximum amount of air. The maximum is determined by the maximum load that has to be met and the size of the system required to meet this load. The minimum, in this case, is determined by the required outside air for the zone. However, if the heating coil was electric instead of hot water, the minimum outside air across it could be the amount required for the coil to not overheat. Both AHU-1 and AHU-2 have chilled water cooling coils, hot water heating coils, and variable air volume boxes with hot water re-heat coils in each separate zone. The re-heat coils for each box contain 2-way modulating hot water control valves, are designed for an entering water temperature of 130°F with a 30°F temperature drop across the coil, and a pressure differential of 0.6 inches of water across the box. After the air reaches each zone, it is returned through a plenum until it eventually reaches the return fan of AHU-1 or AHU-2 and is sent outside.

AHU-3, a constant volume air handling unit, serves the assembly area. The assembly area contains occupancy sensors which provide information to the air handling unit in order to determine the amount of supply air required to meet the heating loads, cooling loads, and required outside air. After a constant volume of air is supplied to the auditorium, it is returned to the outside by one of two rooftop ventilators that are ducted to the auditorium from above.

Unit Ventilators one through eight (UV-1 through UV-8) are used throughout the first floor to handle the loads and outside air requirements of several smaller spaces. They each contain a chilled water cooling coil, a hot water heating coil, and motorized dampers in order to have economizer mode operation. They return air through the plenum until it reaches a relief ventilator. The spaces they serve have occupancy sensors to determine the amount of supply air required to meet the outside air and load requirements.

Waterside

In the Army Reserve Center, two boilers are present to heat the building. Each boiler, B-1 and B-2, has inline primary boiler circulation pumps and secondary pumps with variable frequency drives to send hot water throughout the building. Hot water is supplied at 130°F and returned at 100°F with automatic reset based on outdoor air temperature. Hot water minimum flows are sent through coils when the outside air temperature is below 40°F in order to prevent freezing.

In the Army Reserve Center, two air-cooled rotary screw packaged water chillers which are piped in parallel are used to cool the building. A variable flow primary pump with a variable frequency drive is used, with secondary pumps to send chilled water to the coils. The chilled water supply temperature is 42°F and the chilled water return temperature is 58°F.

Mechanical System First Cost

I have emailed the project manager, but have not yet received a response.

Lost Space Due to Mechanical System

There are three mechanical rooms in the Army Reserve Center. The mechanical room on the first floor contains the boilers, one mechanical room on the second floor contains AHU-3, and the other mechanical room on the second floor contains AHU-1 and AHU-2. Shown below in table 10 is the total area taken up by the mechanical rooms and the mechanical shaft area and the percentage of area compared to that of the total building area (the total building area is approximately 59,000 square feet).

Floor	Area	Percentage of Total Building Area
1st	1288	2.18%
2nd	1085	1.84%
Total	2373	**4.02%**

Table 10

LEED

LEED-NC is a guideline created by the United States Green Building Counsel in order to determine how environmentally friendly the construction and operation of a building is. The Army Reserve Center is designed to obtain anywhere from 36 to 42 of the possible 69 points, allowing it to obtain a silver or gold ranking. The LEED-NC Version 2.2 Registered Project Checklist shows each point and if it was or was not obtained and it can be found in Appendix A. The sections that deal with the mechanical systems of the Army Reserve Center are Energy and Atmosphere and Indoor Environmental Quality. Listed below is an explanation of the sub-categories of LEED that deal with mechanical systems that the Army Reserve Center complies with:

Energy and Atmosphere

Prerequisite 1: Fundamental Commissioning of the Building Energy Systems

The purpose of this prerequisite verify that the project's energy-related systems are installed, and calibrated to perform according to the owner's project requirements, basis of design and construction documents.

Prerequisite 2: Minimum Energy Performance

The purpose of this prerequisite is to establish the minimum level of energy efficiency for the proposed building and systems to reduce environmental and economic impacts associated with excessive energy use.

Prerequisite 3: Fundamental Refrigerant Management

The purpose of this prerequisite is to reduce stratospheric ozone depletion. To achieve this, zero use of chlorofluorocarbon (CFC)-based refrigerants will be used in new base building heating, ventilating, air conditioning and refrigeration (HVAC&R) systems.

Credit 1: Optimize Energy Performance

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use. The prerequisite standards are determined using a computer simulation model based on Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007. The number of points achieved is proportional to the percentage savings over Appendix G. The Army Reserve Center was designed to achieve a 30% energy savings over Appendix G, thus giving it nine LEED points for this credit.

Indoor Environmental Quality

Prerequisite 1: Minimum IAQ Performance

To establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants. To achieve this, the Army Reserve Center meets the requirements of Sections 4 through 7 of ASHRAE Standard 62.1-2007 and the mechanical ventilation system is designed using the ventilation rate procedure.

Prerequisite 2: Environmental Tobacco Smoke (ETS) Control

To prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to environmental tobacco smoke (ETS).

Credit 3.1 Construction IAQ Management Plan, During Construction

To reduce indoor air quality (IAQ) problems resulting from construction or renovation and promote the comfort and well-being of construction workers and building occupants.

Credit 3.2 Construction IAQ Management Plan, Before Occupancy

To reduce indoor air quality (IAQ) problems resulting from construction or renovation to promote the comfort and well-being of construction workers and building occupants.

Credit 4.1 Low-Emitting Materials, Adhesives & Sealants

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Credit 4.2 Low-Emitting Materials, Paints & Coatings

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Credit 4.3 Low-Emitting Materials, Composite Wood & Agrifiber Products

To reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and occupants.

Credit 5 Indoor Chemical & Pollutant Source Control

To minimize building occupant exposure to potentially hazardous particulates and chemical pollutants.

Credit 6.1 Controllability of Systems, Lighting

To provide a high level of lighting system control by individual occupants or groups in multi-occupant spaces (e.g., classrooms and conference areas) and promote their productivity, comfort and well-being.

Credit 7.1 Thermal Comfort, Design

To provide a comfortable thermal environment that promotes occupant productivity and well-being.

Conclusion

The mechanical systems for the Army Reserve Center seem to suit the building well. The Army Reserve Center is architecturally designed with three core spaces, the auditorium, the western area of the first floor, and the second floor, with storage area and smaller conditioned spaces composing the rest of the building. Since the storage area does not need to be conditioned, it would not be cost effective to run ductwork across the whole building to reach the smaller spaces to the east of the storage areas. Thus, smaller unit ventilators are used on these spaces.

Although there are several distinct systems, it seems to be a good idea based on the architectural design of the Army Reserve Center.

One problem with the current design of the Army Reserve Center is the small ceiling to floor height between the first and second floor. This leads to ducts with aspect ratios that are higher than recommended. To fix this, a variable refrigerant flow system could have been installed to handle the heating and cooling loads, with smaller ducts in place to supply the required outside air to each space. This would lead to either smaller ducts with lower aspect ratios or a smaller height of the building, which may reduce the total cost.

The total cost to operate the Army Reserve Center is $48,683 per year or $0.83 / square foot. This was based on an estimate performed using Trane Trace 700.

The space taken up for the mechanical systems of the Army Reserve Center is 2373 square feet or 4% of the total area of 59,000 square feet.

The systems, although there are several, should be maintainable by a maintenance staff. They offer good environmental control and comply with ASHRAE's requirements for indoor air quality. As mentioned above, the Army Reserve Center does a good job using several systems in a cost effective way.

References

Michel Baker Corporation. Construction Documents & Specifications. 101 Airside Drive, Pittsburgh, PA, 15108.

Previous Senior Thesis Reports 2009-2010.

Trane Trace 700.

ASHRAE. (2007). Standard 62.1 - 2007, Ventilation for Acceptable Indoor Air Quality. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

ASHRAE. (2007). Standard 90.1 - 2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. Atlanta, GA: American Society of Heating Refrigeration and Air Conditioning Engineers, Inc.

Appendix A

LEED-NC

LEED-NC Version 2.2 Registered Project Checklist
Newport Army Reserve Center
Newport Naval Station, Newport RI — Certified Final Design 6-30-09

Yes	?	No			
8	1	5	**Sustainable Sites**		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
1			Credit 1	**Site Selection**	1
		1	Credit 2	**Development Density & Community Connectivity**	1
		1	Credit 3	**Brownfield Redevelopment**	1
	1		Credit 4.1	**Alternative Transportation,** Public Transportation Access	1
1			Credit 4.2	**Alternative Transportation,** Bicycle Storage & Changing Rooms	1
1			Credit 4.3	**Alternative Transportation,** Low-Emitting and Fuel-Efficient Vehicles	1
1			Credit 4.4	**Alternative Transportation,** Parking Capacity	1
		1	Credit 5.1	**Site Development,** Protect of Restore Habitat	1
1			Credit 5.2	**Site Development,** Maximize Open Space	1
		1	Credit 6.1	**Stormwater Design,** Quantity Control	1
1			Credit 6.2	**Stormwater Design,** Quality Control	1
		1	Credit 7.1	**Heat Island Effect,** Non-Roof	1
1			Credit 7.2	**Heat Island Effect,** Roof	1
1			Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
3	1	1	**Water Efficiency**		5 Points
1			Credit 1.1	**Water Efficient Landscaping,** Reduce by 50%	1
		1	Credit 1.2	**Water Efficient Landscaping,** No Potable Use or No Irrigation	1
	1		Credit 2	**Innovative Wastewater Technologies**	1
1			Credit 3.1	**Water Use Reduction,** 20% Reduction	1
1			Credit 3.2	**Water Use Reduction,** 30% Reduction	1

Yes	?	No			
9		7	**Energy & Atmosphere**		17 Points
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
9			Credit 1	**Optimize Energy Performance**	1 to 10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
		1	Credit 3	**Enhanced Commissioning**	1
		1	Credit 4	**Enhanced Refrigerant Management**	1
		1	Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

Yes	?	No			
5	1	7	**Materials & Resources**		13 Points
Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
	1		Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
		1	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		1	Credit 3.1	**Materials Reuse**, 5%	1
		1	Credit 3.2	**Materials Reuse**,10%	1
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
1			Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regic	1
1			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regic	1
		1	Credit 6	**Rapidly Renewable Materials**	1
1			Credit 7	**Certified Wood**	1

Yes	?	No			
9	3	3	**Indoor Environmental Quality**		15 Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
	1		Credit 1	**Outdoor Air Delivery Monitoring**	1
	1		Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
	1		Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
		1	Credit 7.2	**Thermal Comfort**, Verification	1
		1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No			
2		3	**Innovation & Design Process**		5 Points
1			Credit 1.1	**Innovation in Design**:Water Use Reduction, 40% Reduction	1
		1	Credit 1.2	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.3	**Innovation in Design**: Provide Specific Title	1
		1	Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No		
36	6	26	**Project Totals** (pre-certification estimates)	69 Points

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points