Mechanical Technical Report 2

Building and Plant Energy Analysis

Miller Children's Hospital Pediatric Inpatient Addition

Long Beach, CA

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Mechanical Option

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Table of Contents

1. Executive Summary

The building and plant energy analysis for the Miller Children's Hospital Pediatric Inpatient Addition is comprised of several parts: LEED-NC analysis, ASHRAE Standard 90.1-2004 compliance, lost rentable space and first cost, design load estimation, and building energy consumption. The LEED-NC assessment results in 19 secured points with the possibility of grasping several more in Indoor Environmental Quality upon completion of construction. An additional 7 points will result in LEED Certification with a minimum of 26.

In order to comply with ASHRAE Standard 90.1–2004, the building must meet certain requirements regarding building envelope, HVAC systems, and power and lighting systems. The results are listed below in Table 1. The systems comply with the exception of lighting, which has higher than acceptable values for energy usage.

Table 1: ASHRAE Standard 90.1-2004 Compliance Summary

	Building Envelope			HVAC Systems				Power & Lighting	
	Roof Insulation	Wall Insulation	Glass U-Value	Chiller COP	Boiler Efficiency	Cooling Tower	Pipe Insulation	Voltage Drop	Lighting
Compliance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

The mechanical systems, including equipment and vertical air shafts, covers 2,200 sq. ft. of the total building floor area. This results in a loss of approximately 2% of rentable space. The mechanical bid awarded for the Pediatric Inpatient Addition was $2.1 million, resulting in a first cost per sq. ft. of $16.59.

The design load estimation used Trane's Trace 700 software program to calculate the building loads and design air flow rates. The result is similar supply air flow rates to those designed by the mechanical engineer. Only one of the seven air handling units has a calculated supply air flow rate that is higher than what was designed. A cost estimate of the mechanical, power, and lighting systems results in an annual operation cost of approximately $320,000. The HVAC system comprises 60% of that cost.

2. LEED Assessment

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. The rating system, LEED-NC Version 2.2, has been developed by the US Green Building Council (USGBC) and is a point system intended to create a positive impact on public health and the environment. It also is intended to reduce operating costs for the building.

The Pediatric Inpatient Addition design has been analyzed using the LEED-NC for new construction, striving to reach one of four levels of certification:

- LEED Certified (26-32 points)
- Silver (33-38 points)
- Gold (39-51 points)
- Platinum (52-69 points)

The results of the analysis can be seen in the summary in Table 2 below.

Table 2: LEED-NC Certification Points Summary

	Sustainable Sites	Water Efficiency	Energy and Atmosphere	Materials and Resources	Indoor Environmental Quality	LEED Innovation Credits	Total
Secure Points	5	0	0	7	3	4	19
Possible Points	7	3	5	0	11	1	27
No Points	2	2	12	6	1	0	23
Total	14	5	17	13	15	5	69

Table 2 is a summary of the total points for LEED-NC certification. 19 points have already been secured with the possibility of several more.

There are several possible points that still need to be confirmed in order to achieve compliance including Indoor Environment Quality points for low-emitting materials (paints and adhesives) that still need to be confirmed upon construction. Another is Daylight and Views, where calculations need to be done to ensure the project incorporates enough daylight to achieve credit.

It is important to understand that it is extremely difficult to obtain LEED certification for hospitals. Out of those new construction projects built in the US which have obtained LEED certification since 2000, very few have been hospitals. The reason for this is because the importance of patient health and safety exceeds the need to reduce energy consumption. This is why hospitals in California are exempt from power consumption limits such as Title 24, which limits the lighting system on a watts per square foot basis.

Although it is difficult for the Pediatric Inpatient Addition to achieve a LEED-NC certification, it is certainly not impossible and up to this point the designers and contractors have made great strides towards receiving certification. The entire LEED-NC checklist can be found in Appendix A.

3. ASHRAE Standard 90.1 Building Envelope Compliance

The purpose of ASHRAE Standard 90.1 is to provide minimum energy-efficient requirements for the design and construction of buildings and building systems. The provisions apply to building envelopes, HVAC systems, water heating, electric power distribution, motors and belt drives, and lighting.

The first step in the building envelope compliance is to determine a climate zone. According to Figure B-1 and Table B-1 of ASHRAE Standard 90.1, the Pediatric Inpatient Addition is in Climate Zone 3C. Once the climate zone has been determined, the percent of vertical fenestration must be calculated in order to determine the proper compliance path. If the vertical fenestration area does not exceed 50% of the gross wall area and the skylight fenestration area does not exceed 5% of the gross roof area, then the Prescriptive Building Envelope Option may be used. Otherwise, the Building Envelope Trade-Off Option must be used. Table 3 on the next page shows the vertical fenestration calculation.

Table 3: Vertical Fenestration Calculation

Total Wall Area (sq. ft.)	Total Glass Area (sq. ft.)	% Total Vertical Fenestration
29,321	9,397	32.0

Table 3 shows the total area for the exterior walls and the total glass area for the Pediatric Inpatient Addition. The calculation shows that the percent total vertical fenestration is less than 50%, warranting the use of the Prescriptive Building Envelope Option.

Because the percent total vertical fenestration does not exceed 50% and there are no skylights in the building, the Prescriptive Building Envelope Option will be used for the building envelope compliance. Table 5.5-3 of ASHRAE Standard 90.1 gives the required U and R-values for the roof, walls. Also included are maximum U-values for building fenestration requirements. The values fall under non-residential, residential, and semi-heated categories. The Pediatric Inpatient Addition is in the non-residential category. Table 4 lists the required values and the designed values for ASHRAE Standard 90.1 building envelope compliance. The typical building envelope constructions are as follows:

- Exterior Wall – 12" concrete w/ 4" metal studs, R-19 insulation, and 5/8" GWB
- Roof – 6" composite metal deck concrete structure, R-30 insulation, 5/8" deck board, and bitumen roofing material
- Floor – 6" concrete w/ vented steel decking
- Exterior Glazing – Dual-glazed w/ 1/4" layer of laminated Low-E glass inboard, 1/2" inert gas airspace, and 1/4" layer of laminated clear glass w/ PVB interlayer on the outboard side

Table 4: Building Envelope Compliance Summary

	Roof Insulation Min. R-Value	Wall Insulation Min. R-Value	Floors (Slab on Grade)	Fenestration Assembly Max U-Value	Fenestration Assembly Max SHGC
Req'd Value per ASHRAE Std. 90.1	R-19	R-13	N/A	1.22	0.34
Designed Value	R-30	R-19	N/A	0.32	0.3
	(Metal Building)	(Metal Building)	(Unheated)	(Fixed)	(All orientations)

Table 4 shows the required building envelope values. The roof insulation, wall insulation, and fenestration values exceed the minimum requirements per ASHRAE Standard 90.1. The floor slab had no required minimum value for unheated slab on grade floors.

As indicated in Table 4, the designed R-values for both the roof insulation and wall insulation are greater than the minimum R-values required. Moreover the fenestration U-value is significantly smaller than the maximum required assembly U-value, and the SHGC is also less than the required value. Therefore, the building envelope complies with ASHRAE Standard 90.1.

4. ASHRAE Standard 90.1 HVAC Compliance

The HVAC portion of Standard 90.1 (Section 6) deals with mechanical equipment and systems that serve heating, cooling, and ventilation needs of new buildings. Similar to the building envelope compliance section, the HVAC section also has two methods for determining compliance. For buildings with a gross floor area less than 25,000 square feet, the Simplified Approach Option may be used. Because the Pediatric Inpatient Addition is greater than 25,000 square feet, the alternative Mandatory Provisions Method must be used. Requirements are outlined in section 6.4 and reference Table 6.8.1A-J of Standard 90.1.

Mechanical Equipment

The mechanical equipment for the Pediatric Inpatient Addition must meet certain criteria to comply with ASHRAE Standard 90.1. The criteria for the chillers, cooling towers, and boilers are summarized in Table 5 on the follow page. A description of the mechanical equipment analyzed is listed below:

- (2) 500 ton centrifugal water chillers (located in central plant)
    - ✓ Leaving chilled water temperature: 44˚F
    - ✓ Entering condenser water temperature: 85˚F
    - ✓ Condenser Flow: 2 gpm/ton
- (2) Induced draft cooling towers (located on central plant roof)
    - ✓ Entering water temperature: 95˚F
    - ✓ Leaving water temperature: 85˚F
    - ✓ Fan motor: 25 hp
    - ✓ Water gpm: 1500 gpm

- (2) Gas-fired tube boilers (located in mechanical penthouse)
    - ✓ Size category: > 300,000 Btuh and ≤ 2,500,000 Btuh
    - ✓ 2000 MBH input, 1740 MBH heat output
    - ✓ Hot water system

Table 5: Mechanical Equipment Performance Summary

	Centrifugal Water Chiller		Induced Draft Cooling Tower	Gas-fired Tube Boiler
	COP	**NPLV**	**Gpm/Hp**	**Minimum Efficiency**
Req'd Value per ASHRAE Std. 90.1	5.47	5.75	≥20 gpm/hp	75%
Designed	6.21	5.01	60 gpm/hp	87%
Compliance	**NO**		**YES**	**YES**

Table 5 summarizes the performances of the given mechanical equipment compared to the required values for ASHRAE Standard 90.1 compliance. Notice that the COP value is higher but the NPLV value does not meet the criteria for compliance.

The design values obtained for the mechanical equipment performance were either calculated or read directly from the mechanical schedules. Appendix B contains the calculations used to determine these values. Chillers are found in Table 6.8.1J of Standard 90.1. Boilers can be found in Table 6.8.1F of Standard 90.1, and the cooling towers are in Table 6.8.1G of Standard 90.1. With the exception of the water chiller NPLV, the mechanical equipment in the Pediatric Inpatient Addition does comply with ASHRAE Standard 90.1 requirements.

Mechanical Insulation

ASHRAE Standard 90.1 also has minimum requirements for duct and pipe insulation for mechanical systems. Minimum duct insulation R-values are listed in Table 6.8.2B of Standard 90.1 according to climate zone and duct location. The minimum R-value required for an unconditioned space duct location is R-3.5. The specifications require an R-6 value be installed on ducts in unconditioned spaces, complying with Standard 90.1. Minimum pipe insulation thicknesses are listed in Table 6.8.3 of Standard 90.1 according to fluid design operating temperature. Table 6 below summarizes the insulation thicknesses for the Pediatric Inpatient Addition.

Table 6: Pipe Insulation Thickness Summary

	Heating Systems		Domestic Hot Water Systems		Cooling Systems	
	141-200°F Fluid Operating Temp		105+°F Fluid Operating Temp		40-60°F Fluid Operating Temp	
	Nominal Pipe Size		Nominal Pipe Size		Nominal Pipe Size	
	1" to <1.5"	1.5" to <4"	1" to <1.5"	1.5" to <4"	1" to <1.5"	1.5" to <4"
	Min Pipe Insulation Thickness		Min Pipe Insulation Thickness		Min Pipe Insulation Thickness	
Req'd per ASHRAE Std. 90.1	1"	1"	0.5"	1"	0.5"	1"
Designed	1.5"	1.5"	1"	1" - 1.5"	1"	1"
Compliance	Yes		Yes		Yes	

Table 6 shows the pipe insulation thicknesses required by ASHRAE Standard 90.1 and the designed pipe insulation thicknesses according to the specifications. Heating systems include steam, steam condensate, and hot water. Cooling systems include chilled water, brine, and refrigerant.

In addition to the mechanical equipment, the insulation in the Pediatric Inpatient Addition complies with ASHRAE Standard 90.1 requirements.

5. ASHRAE Standard 90.1 Power and Lighting Compliance

Section 8 of ASHRAE Standard 90.1 requires a certain voltage drop in feeders and branch circuits for power compliance. The conductors must be sized for a 2% voltage drop for feeders and 3% for branch circuits. The electrical engineer for the Pediatric Inpatient Addition designed to meet these requirements and therefore, the building complies. Section 9 sets requirements for lighting systems using two methods, the Building Area Method and the Space-by-Space Method. The Space-by-Space Method is used when the building does not comply with the Building Area Method. Because the Pediatric Inpatient Addition is a hospital, different standards and codes are used for design, primarily those set forth by the Office of Statewide Health Planning and Development (OSHPD). These standards are more lenient in regards to energy consumption, but have strict design guidelines in order to ensure patient health and safety. Therefore, the Space-by-Space Method was applied in order to identify areas where proper lighting takes priority over energy consumption. Such spaces include operating rooms, recovery units, and corridors. The values for space LPDs were obtained from Table 9.6.1 in ASHRAE Standard 90.1. The results can be seen in Table 7 on the following page.

Table 7: Lighting Design Summary

Space	Area	Allowed Power	Actual Power	Allowed LPD	Actual LPD	Compliance
	(sq. ft.)	(Watts)	(Watts)	(W/sq. ft.)	(W/sq. ft.)	
Recovery	8,015	6,412	32,942	0.8	4.11	**NO**
Nurse Station	1,477	1,477	2,865	1	1.94	**NO**
Exam/Treatment	674	1,011	1,631	1.5	2.42	**NO**
Pharmacy	594	713	576	1.2	0.97	**YES**
Patient Room	8,377	5,864	15,497	0.7	1.85	**NO**
Operating Room	3,864	8,501	12,519	2.2	3.24	**NO**
Nursery	1,423	854	1,466	0.6	1.03	**NO**
Medical Supply	3,612	5,057	2,637	1.4	0.73	**YES**
Radiology	633	253	772	0.4	1.22	**NO**
Laundry/Washing	2,054	1,232	904	0.6	0.44	**YES**
Office-Enclosed	4,307	4,738	4,608	1.1	1.07	**YES**
Conference	2,700	35,100	13,716	13	5.08	**NO**
Corridor	19,267	9,634	20,230	0.5	1.05	**NO**
Lobby	6,958	9,045	8,698	1.3	1.25	**YES**
Restrooms	3,270	2,943	7,227	0.9	2.21	**NO**
Lockers	1,172	703	1,266	0.6	1.08	**NO**
Elec/Mech	2,039	3,059	1,550	1.5	0.76	**YES**
Other	14,101	11,281	16,921	0.8	1.20	**NO**
Totals	84,537	107,876	146,025	1.28	1.73	**NO**

Table 7 shows the results of the Space-by-Space method for ASHRAE Std. 90.1 compliance. The spaces used were for a hospital and any spaces not defined fell under the "other" category, which applied a conservative, general value of 0.8 W/sq. ft. for allowed LPD.

6. Lost Rentable Space

Most of the lost rentable space due to the mechanical system is from the mechanical shafts. Two centrally-located vertical shafts house the supply and return ducts for each of the four levels. The ground level (below grade) has no lost rentable space because the mechanical vertical shaft discontinues at that level. All of the air is supplied from the ceiling of each level and takes up no floor area. The air handling units are located on the roof and are not included in the lost rentable space. The boilers and pumps, however, are included as they are housed in an enclosed mechanical structure on the roof level. There are also electrical rooms, storage spaces, and elevator machine rooms located on that level. The chillers, cooling towers, and other mechanical equipment are housed in the central plant. Because the central plant is separate from the Pediatric Inpatient Addition, the area calculation excludes it. Figure 1 indicates the tower area that is used by the mechanical system.

Figure 1: Lost Rentable Space

Level 1

Level 2

Level 3

Roof Level

Figure 1 indicates which areas are used by the mechanical systems. The red indicates vertical shaft area and the blue indicates floor area used by mechanical equipment.

The Pediatric Inpatient Addition has a total square footage of 127,000 sq. ft. The lost rentable space due to the mechanical systems is 2,200 sq. ft., including the roof level mechanical room and vertical shaft areas. Therefore, the mechanical systems only comprise about 2% of the total building area.

7. Mechanical System Cost

The mechanical bid awarded for the tower was $2.1 million by Turner Construction. The central plant was another $1.3 million. The first cost per square foot for the tower mechanical system was $16.59/sq. ft.

8. Design Load Estimation

Trane's Trace 700 software program was used to estimate the design loads for the HVAC system in the Pediatric Addition. No such program was used in the initial design of the building, and instead used hand calculations for sizing the HVAC system. The system was designed by JBA Consulting Engineers. The engineer's values for lights and equipment loads, design occupancy, and the design indoor and outdoor air conditions for heating and cooling were inputted into Trace for each space. The schedules for lights, people, and equipment loads were all created according to the use of a typical hospital facility. The HVAC system was then created according to the design documents. The air handling units are constant volume with space reheat, two chillers with cooling towers (located in the central plant) provide chilled water to the cooling coils, and two boilers provide the hot water to the space reheat coils.

The results for the design loads are summarized in Table 8 and Table 9 on the next page. The designed supply air values for the Pediatric Inpatient Addition are slightly higher than the Trace calculated values, which is typically the case when comparing Trace output to hand calculations in that the hand calculations tend to be slightly more conservative. The Trace calculations are a closer approximation to the actual building loads than the hand calculations. This trend continues with the cooling loads as well. However, the ventilation air values are higher in Trace for more than half of the air handling units. One reason for this could be that for hospital facilities, Trace uses a set 25 cfm/person rate for ventilation. The engineer may have used a slightly lower value in some areas, causing the ventilation rates to be lower in some areas of the building.

Table 8: Design Loads Summary 1

	Trace 700 System Output						
		Supply Air		Ventilation Air		Cooling Load	
	Areas (ft^2)	Supply Air (cfm)	Supply Air (cfm/ft^2)	Ventilation Supply Air (cfm)	Ventilation Supply Air (cfm/ft^2)	Cooling (tons)	Cooling (ft^2/ton)
AH-1	10,408	15,347	1.48	2,725	0.26	44	237
AH-2	6,895	4,057	0.59	1,125	0.16	12	575
AH-3	12,989	10,171	0.78	4,675	0.36	34	382
AH-4	20,327	16,187	0.81	3,975	0.20	50	407
AH-5	13,629	16,084	1.18	5,875	0.43	63	216
AH-6	27,911	20,778	0.75	5,600	0.20	70	399
AH-7	16,837	14,707	0.87	3,675	0.22	50	337

Table 8 shows the design calculated values for supply air, ventilation air, and cooling loads according to Trace 700.

Table 9: Design Loads Summary 2

	JBA Design Values						
		Supply Air		Ventilation Air		Cooling Load	
	Areas (ft^2)	Supply Air (cfm)	Supply Air (cfm/ft^2)	Ventilation Supply Air (cfm)	Ventilation Supply Air (cfm/ft^2)	Cooling (tons)	Cooling (ft^2/ton)
AH-1	10,408	20,000	1.92	4,634	0.45	66	158
AH-2	6,895	7,000	1.02	1,786	0.26	25	279
AH-3	12,989	15,000	1.16	3,575	0.28	80	162
AH-4	20,327	20,000	0.98	3,714	0.18	58	348
AH-5	13,629	18,000	1.32	2,978	0.22	59	232
AH-6	27,911	20,000	0.72	3,191	0.11	66	422
AH-7	16,837	18,000	1.07	4,511	0.27	57	297

Table 9 shows the design calculated values for supply air, ventilation air, and cooling loads as designed by JBA Consulting Engineers. The designed supply air values are all greater than the Trace values, with the exception of one unit, AH-6.

9. Annual Energy Consumption and Operating Costs

The annual energy consumption for the Pediatric Inpatient Addition was modeled using Trace 700. An energy analysis was not performed by the engineer on the project. The reason for this is because the energy consumption of the building was not the primary element driving the design. As stated previously, the importance of patient health and safety exceeds the need to reduce energy consumption. The building was designed in accordance with OSHPD standards, which exempt medical facilities from meeting many energy consumption requirements.

The annual electric energy consumption for the Pediatric Inpatient Addition is approximately 4,410,000 kWh, and the gas consumption is 42,000 therms. The percent breakdown can be seen in Figure 2 below.

Figure 2: Annual Energy Consumption

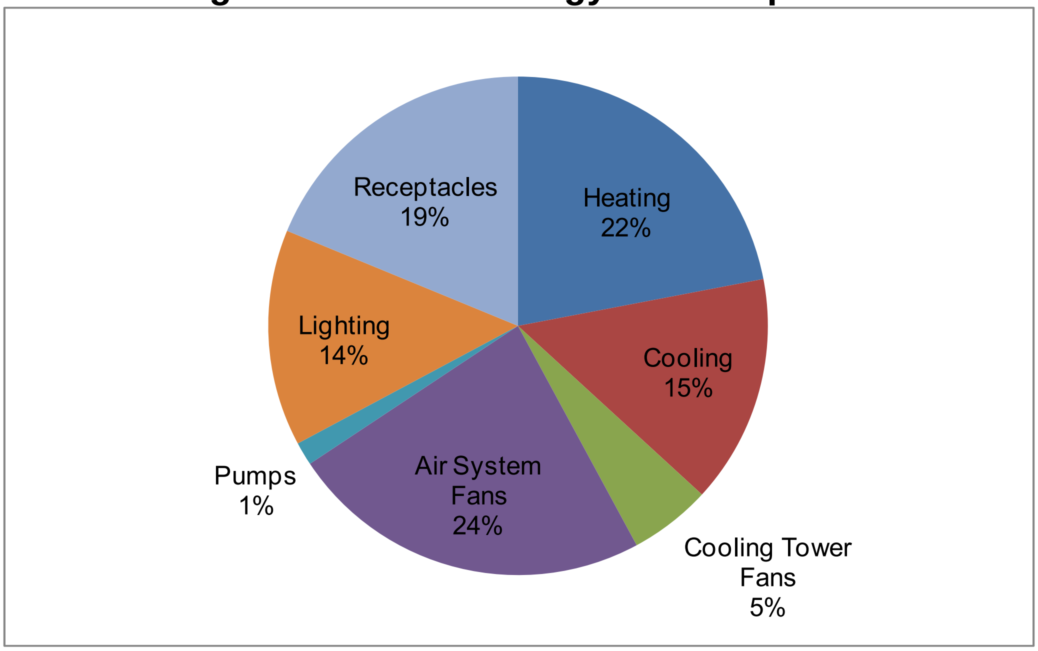

Figure 2 shows the percent breakdown of the annual total energy consumption for the Pediatric Inpatient Addition. The mechanical systems comprise 67% of the entire building energy consumption.

The annual operating cost for the Pediatric Inpatient Addition was also calculated using Trace. Values used for electric rates and gas rates were obtained from the Center for Energy and Economic Development and the Long Beach Gas and Oil Department websites. The electric rate used for Long Beach, CA was $0.07/kWh through Southern California Edison, and the gas rate used was $0.24/therm through the Long Beach Gas and Oil Department. Table 10 on the following page summarizes the findings. The total annual operating cost for the Pediatric Inpatient Addition is $318,718. Also an annual emissions report was done to determine the amount of emissions produced each year for the building. The results can be seen on Table 11 on the following page. The values were determined using emission values on a per kWh basis, taken from the Energy Information Administration's website. Southern California Edison power generation is comprised of hydro, coal, and nuclear power. For the emissions report, only coal emission values were used because the exact ratios of each form of power generation were not obtainable. Although this is an overestimate, it is more representative of the actual value than to use hydro power or nuclear power because neither produces emissions.

Table 10: Annual Cost Summary

HVAC Equipment	Annual Cost/year	Annual Cost/sq. ft.	Percent of Total Energy Cost
Primary Heating	$11,360	$0.10	4%
Cooling Compressor	$33,892	$0.31	11%
Tower/Condenser Fans	$21,016	$0.19	7%
Condenser Pumps	$24,387	$0.22	8%
Supply Fans	$93,161	$0.85	29%
Circulation Pumps	$5,877	$0.05	2%
Non-HVAC Equipment			
Lighting	$55,154	$0.51	17%
Receptacles	$73,870	$0.68	23%
Total	$318,718	$2.92	100%

Table 10 shows the annual cost to operate the Pediatric Inpatient Addition. Notice that the operating cost for the HVAC system is 60% of the total annual cost.

Table 11: Annual Emissions

Pollutant	Amount Produced (lbs)
SO_2	56,500
NO_x	36,000
CO_2	11,100,000

Table 11 shows the emissions produced for the power generation required to operate the Pediatric Inpatient Addition. The values assume 100% coal electric power generation but also include gas emissions as the building uses both.

10. References

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Appendix A – LEED NC Checklist

Figure 3: LEED NC Registered Project Checklist

LEED for New Construction v2.2
Registered Project Checklist

Project Name:
Project Address:

Yes	?	No			
5	7	2		**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 & Fuel-Efficient Vehicles	1
1			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
	1		Credit 5.1	**Site Development,** Protect or 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	2		**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

Figure 3: LEED NC Registered Project Checklist cont'd

	5	12	Energy & Atmosphere		17 Points
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1**: All LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

	2	8	Credit 1	**Optimize Energy Performance**	1 to 10
				10.5% New Buildings or 3.5% Existing Building Renovations	1
				14% New Buildings or 7% Existing Building Renovations	2
				17.5% New Buildings or 10.5% Existing Building Renovations	3
				21% New Buildings or 14% Existing Building Renovations	4
				24.5% New Buildings or 17.5% Existing Building Renovations	5
				28% New Buildings or 21% Existing Building Renovations	6
				31.5% New Buildings or 24.5% Existing Building Renovations	7
				35% New Buildings or 28% Existing Building Renovations	8
				38.5% New Buildings or 31.5% Existing Building Renovations	9
				42% New Buildings or 35% Existing Building Renovations	10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
				2.5% Renewable Energy	1
				7.5% Renewable Energy	2
				12.5% Renewable Energy	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

continued…

Yes	?	No			
7		6	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 Regioı	1
1			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regioı	1
		1	Credit 6	**Rapidly Renewable Materials**	1
1			Credit 7	**Certified Wood**	1

Figure 3: LEED NC Registered Project Checklist cont'd

Yes	?	No			
3	11	1		**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			
4	1			**Innovation & Design Process**	**5** Points
1			Credit 1.1	**Innovation in Design**: Provide Specific Title	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			
19	27	23		**Project Totals** (pre-certification estimates)	**69** Points
				Certified: 26-32 points, **Silver:** 33-38 points, **Gold:** 39-51 points, **Platinum:** 52-69 po	

Appendix B – Mechanical Equipment Calculations

Chiller COP Calculation

COP = Effective Cooling / Energy Input

Input Energy = (0.566 kW/ton)x(500 tons) = 283 kW

Effective Cooling = (500 tons)x(3.516 kW/ton) = 1758 kW

COP = (1758 kW)/(283 kW) = 6.21

Boiler Efficiency Calculation

Boiler Efficiency = Heat Output / Input = (1740 Mbh)/(2000 Mbh) = 87%