STENGEL HALL – ACADEMIC CENTER FOR EXCELLENCE

Linden Hall School for Girls
Lititz, Pennsylvania

TECHNICAL REPORT 2

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EXECUTIVE SUMMARY

The Stengel Hall – Academic Center for Excellence is part of a campus-wide effort to upgrade the existing facilities of the Linden Hall School for Girls. Many of the existing facilities operate from centralized steam heating distribution and use window air-conditioners. The Stengel Hall renovation and addition parts ways from this system and integrates new split-system condensers and boilers to provide heating and cooling to the buildings occupants. The purpose of this report is to analyze the buildings heating and cooling demand as well as provide an energy use overview and operating costs based on the designed mechanical system.

Trane Trace® version 6.2.6.5 was used in combination with Revit Architecture 2012 to produce and evaluate the loads of Stengel Hall based on the designed mechanical system. Using block load assumptions a simulation model of Stengel Hall was developed based on construction documents and conversing with the design teams. The simulation model accounted for loads from solar heat gain, ground temperature, occupancy loads, lighting densities, and additional equipment loads. Ventilation rates were prescribed on a general cfm/sf basis for all occupied spaces in order to closely reflect the designed outdoor air quantities. For the purposes of this report attic mechanical space, mechanical shafts, and stairwells were not analyzed. All air handlers were modeled in this report and the areas in which they serve were assigned. Systems were assigned to plants which were a direct reflection of the designed heating and cooling system.

While variation from computed values to design values is always expected, the results of both the heating and cooling load and energy analysis returned reasonable loads. In general, the computed values were larger than the designed values. This was not initially expected due to the common practice of oversizing equipment but could easily be due to differing assumptions which are discussed later in this report. The computed heating and cooling airflow resulted in a 7% increase over the design documents. The cooling load was 17.1 tons greater and the heating demand was 30% greater than the design documents. All assumptions and results are discussed in more depth in the design load estimation section of this report.

The results of the energy simulation also yielded reasonable results. Even though there was not an energy simulation produced from the designer, a campus wide facilities study of Linden Hall was used to compare energy consumption and operating costs. An average of $1.75/SF was computed for the Stengel Hall- Academic Center for Excellence. This varies only 3 cents from the actual $1.78/SF operating cost of Stengel Hall in 2007. The annual electrical cost this building was estimated at approximately $50,000 based on 2006 electric rates. Overall, the results of this analysis and simulation seem practical and were within reason of the designer's intention.

EXISTING CONDITIONS

Image 1| Image provided by bing.com

The Stengel Hall Academic Center for Excellence site, shown in red on Image-1, is located along Main Street in the small, historic town of Lititz, PA on the Linden Hall School for Girls campus. Linden Hall, founded in 1746, is one the most prestigious and oldest girls' preparatory schools in the country and helps define the heritage of this unique town.

Stengel Hall has been an integral part of this school since 1748 and has had many additions and renovations since. The current Stengel Hall renovation and addition involves 22,600 SF of new construction and approximately 14,300 SF in renovations to the existing building. The building is comprised of one level below grade, three levels above grade, and an unoccupied attic which will be used for mechanical equipment. Construction for this design-build project started on May 28th, 2011 and the majority of the demolition and excavation was completed over the summer of 2011. Construction is expected to be complete before students return for the 2012 school year (August 2012).

The goal of the Academic Center for Excellence is to provide the Linden Hall students a 20th century learning environment while keeping its historical roots. The architecture of this new addition and renovated areas is consistent with the existing building. This project is designed to replace recent additions to Stengel Hall, and infill the existing U-shaped footprint. This infill will provide a connection to the adjacent Steinman Performing Arts Center & Classrooms on the first level and basement level as well as create a new entrance off of Main Street on the north side of the building which can be seen in Image-2.

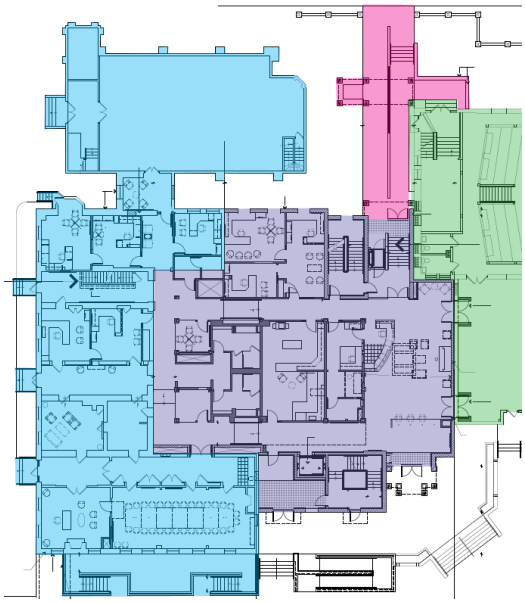


Image 2| Plan Courtesy of Chambers & Associates

The first level is mostly comprised of reception areas, and administrative offices that will address the buildings need for growth. The addition will also provide new classrooms with a modern technology-based atmosphere on the second and third levels as well as a large group room on the basement level. A new learning center is featured on the second level with a 2-story atrium that will allow daylight into computer labs,

classrooms, and the library (See Image-3). Overall, the addition and renovations will increase the functionality of the campus and stimulate learning for the students of Linden Hall.

Rightfully, any construction on this site must comply with many historical requirements in addition to the standard zoning set by the Lititz Borough. The building must also comply with the 2009 International codes as well as the Americans with Disabilities Act.

The exterior elements of the addition are required to match those of the existing building. The façade of the building primarily consists of golden stucco on CMU or metal studs as well as clapboard on the inner surfaces of the third floor porch. The roofing consists of dimensional shingles and cooper flashing to also match the existing building. Powder Coated steel railings will be used to match those in the near vicinity and for ease of maintenance. New aluminum clad wood double-hung windows will be used to match the existing windows in Stengel Hall. These elements can be seen in Image-4. There is also a green roof designed for the lower roof level. Overall, the entire project will revamp Stengel Hall, and the Linden Hall Campus.

Image 4| Image Courtesy of Chambers & Associates

Image 4| Image Courtesy of Chambers & Associates

MECHANICAL OVERVIEW

The unique heating, ventilating, and air-conditioning design of Stengel Hall is able to overcome many limitations and provide acceptable airflow to its occupants. The mechanical system is comprised of four outdoor split-system units, four boilers, twenty-eight air handling units, and eleven energy recovery ventilators. The energy recovery ventilators primarily serve air supplied to and returned from classroom spaces. There are very few office spaces that are supplied air from the ERVs. The majority of this equipment is either located in the basement or attic. However, a few of the air handlers have been incorporated on the second and third levels in mechanical closets.

The mechanical equipment located in the basement provides air distribution at the ceiling level for occupied spaces in the basement as well as floor distribution to many of the offices on the first level in the existing portion of Stengel Hall. The first level of the addition portion is also served by the equipment located in basement but air is distributed from the ceiling rather than the floor.

The majority of the air supply to the second and third levels is routed from equipment located in the attic. These levels have a ceiling supply as well as high or low return which depend on the space. The air handlers located within the occupied floor plan distribute air to both the second and third level. Outdoor air is supplied from a single attic fresh air intake location to these air handlers.

The mechanical equipment is located in two different areas due to the many size limitations of Stengel Hall. The existing portion of Stengel Hall has extremely low ceilings, which is understandable since it was built in 1748, and running ductwork within these areas is extremely difficult.

Design Load Estimation

To conduct heating and cooling load estimations the exterior envelope and room layout of Stengel Hall was first modeled in Revit. An energy simulation model was then created in Trane Trace® using the space layout of the Revit model. For the purposes of this simulation the attic spaces, mechanical shafts, and elevator shafts were not analyzed. Although there is heat gain to the building from these spaces, they are not conditioned and it was assumed that there is little, if any, infiltration into conditioned spaces. In addition, stairwells were also not analyzed in this report. The stairwells are heated by cabinet unit heaters and even though they experience solar heat gain it was assumed that they had little effect on the building as a whole.

In the simulation model, fenestration, doors, occupancy, lighting, additional loads, and construction materials were assigned to the spaces which are discussed in more depth below. Each system was modeled as a fan coil unit with a generic fan coil supply fan since the Trace options were difficult to distinguish between. Further, one heating plant comprised of four boilers was created and five outdoor air cooled split system plants were created for cooling.

Estimated Design Heating & Cooling Loads

The available mechanical information provides design values for heating and cooling loads. These loads are summarized in Table A1–Designed & Simulated Heating/Cooling Information. However, the maximum capacity of the split system units and boilers exceed the loads of the air handling units. For instance the total capacity of the boilers is 1,151,960 BTU/hr (after accounting for efficiency) whereas the designed heating load is 586,000 BTU/hr. Also, the split system units provide an available 80 tons of cooling and the building is designed for 73.5 tons.

Outdoor Air Ventilation

To ensure that the outdoor air ventilation rates that were designed for this building were properly calculated in the simulation model a simplified method was used. Since Trace can either use ASHRAE Std. 62.1 ventilation rates or a prescribed ventilation rate, a prescribed ventilation rate was chosen to get a more accurate representation of the intentions of the designer. This rate was calculated by the following equation:

$$\text{Ventilation Rate} = \frac{\text{Sum of designed outdoor air [CFM]}}{\text{Sum of occupied spaces [SF]}}$$

This resulted in a ventilation rate of 0.306 CFM/SF which was applied to all occupied spaces with the exception of restrooms and stairwells because the mechanical design of these

spaces rely on air transfer and infiltration, not ducted supply air. A complete summary of all designed ventilation rates can be found in Table A1-Designed & Simulated Heating/Cooling Information of the appendix.

A disadvantage that was discovered using this method was that the ventilation loads for individual systems varied from the designed loads. However, the total ventilation load only varied by expected amounts and accurately represented the design. Also, an assumed value of 2 air changes per hour was assigned to all vestibule areas and spaces that provide access in and out of the building.

Lighting & Equipment Loads

Many specialized lighting and equipment loads were analyzed in the Stengel Hall simulation. The majority of the lighting in the renovation is fluorescent lighting either recessed (mostly corridors) or pendant mounted (mostly classrooms and offices). However some more decorative luminaires and featured lighting displays are present in entryways and lobbies. The lighting densities were analyzed on a watt per square foot basis for each individual room. These densities can be found in Table A2-Additional Load Summary in the appendix. In some of the existing newly renovated spaces, lighting information was not provided and in those cases the load was determined based on similar room function and size.

The Academic Center for Excellence incorporates many new educational technologies into the learning spaces which result in added load to the space. Smart boards have nearly replaced traditional chalkboards and add significant load to the space while in use. Also, the Linden Hall School provides personal netbooks for every student and students are expected to use them during class. Each workstation in most of the classrooms accounted for this additional load resulting from the netbooks. Additional equipment loads were estimated based on general manufacturer's specifications as well as assumptions on a watt per square foot basis. All additional equipment loads can be found in Table 1 below.

TABLE 1-Miscellaneous Loads

Load Source	Associated Load	Source of Value
Smart Boards	300W, in use	Manufacturer's Specifications
Netbooks	30W, charging	Average of varied manufacturers
Desktop Computer	30W	Average of varied manufacturers
Beverage Refrigerator	150W	Manufacturer's Specifications
Technology Server Room	25W/SF	Assumed
Elevator Equipment	400W	Assumed
Mechanical/Electrical Equipment	10W/SF	Assumed

A summary of all equipment room assignments can be found in Table A2-Additional Load Summary of the appendix.

Design Occupancy

The design documents included the occupancy of all offices, classrooms, conference rooms, and library areas. These occupancies are also summarized in Table A2-Additional Load Summary in the appendix. The internal loads due to people that were estimated for the building simulation are 250 BTU/hr sensible load and 200 BTU/hr latent load. These loads were the default loads provided by Trane Trace®.

Outdoor & Indoor Air Conditions

Outdoor design conditions were determined from the ASHRAE Handbook – Fundamentals (2005). The most extreme weather data (0.4% and 99.6%) for Philadelphia, PA were used for this study. The outdoor air temperatures used were 11.3ºF for heating and 93.2ºF for cooling. The complete ASHRAE design conditions can be found on page 19 in the appendix.

Indoor thermostat set points were not provided with the design information for Stengel Hall. Assumed temperatures for heating and cooling can be found in Table 2-Indoor Conditions to the right.

TABLE 2 – Indoor Conditions	
Cooling dry bulb	72ºF
Heating dry bulb	70ºF
Relative Humidity	50%

Load Sources & Schedules

Stengel Hall experiences standard loads found in all buildings such as fenestration, wall, and roofing loads. The envelope construction in this building varies greatly between the existing structure and the new construction. One level of this building is underground and this was modeled in Trace as a partition with the adjacent space temperature set to "ground." Plenum spaces were not modeled in this simulation because finished ceiling heights, if any, are currently unknown. A summary of construction materials, U-values, and floor to floor heights can be found in the Table A3-Building Composition in the appendix. Since the attic was not modeled in this simulation the floor of the attic was modeled as a roof. Also, the building is designed with cupola-like fenestration on some areas of the roof. These areas were simply considered skylights in Trace.

In the load simulation one standard schedule was applied to all occupied space loads. The assumed schedule, which can be found in Table A4-Assumed School Schedule in the appendix, was based off of a middle school schedule that was developed by Trace. However, because Linden Hall is a boarding school, some of values and times were changed. During the school year it can be expected that students will occupy Stengel Hall later into the evening than at a public school. Also, the load fraction was increased from 5% to 15% on the weekends because it was also assumed that students may occupy the space over the weekend as well. Mechanical and server loads however were assumed to be continuously running.

Designed vs. Computed Summary

The results of the heating and cooling load analysis were within reason of the designed mechanical system. Variations were immediately expected during this analysis because of the method used for determining the volume of spaces. In Revit the areas of spaces were determined from the centerline of the walls and therefore included the thickness of the walls as occupied spaces. This resulted in an average increase of 15% in the simulation model versus the designed areas. A complete summary of the design vs. Revit areas can be viewed in Table A5-Area Comparison Summary in the appendix. However, when the loads were compared on load/ft^2 basis the results were an adequate reflection of the design. These values can be compared in Table 3 below.

TABLE 3 – Load Comparison			
	Designed	Computed	% Difference
Total Airflow (cfm/ft^2)	0.896	0.856	4.45%
Ventilation Airflow (cfm/ft^2)	0.275	0.269	2.18%
Cooling Load (ft^2/ton)	390.2	355.7	8.8%
Heating Load (Btuh/ft^2)	20.4	23.7	16%

In addition to the room areas differing from design the plenum spaces were not modeled. Finished ceiling heights were not provided in the design documents because the majority of the spaces are open to the floor above. However, some spaces do have a ceiling cavity which was not accounted for. This added unnecessary load to the simulation and could have been a reason for the increase between computation and design.

Overall the loads of the cooling demand were consistently higher, about ½ ton greater, than the designed system capacity. However, a few air-handlers are inconsistent with this difference such as AHU-102 (serving the board room and passage area), AHU-105 (serving the main entryways, lobby, and reception areas), and AHU-203 (serving offices and corridors on the second floor). The more substantial increase in the computed values for AHU-102 and AHU-105 may have been due to the increased load assumptions in those areas. The lobby area is a centralized space for not only Stengel Hall but the Steinman Center for Performing Arts and increased occupancy loads were added to this space. The areas in which AHU-203 were somewhat assumed because not all corridors on the second level were directly supplied and relied on adjacent space air transfer.

The heating demand was substantially higher than the designed heating capacity. This increase may have been due to errors in outdoor air quantities. Even though outdoor air rates were prescribed on a square foot basis Trace reported many of the areas to use 100% outdoor air. This error was not able to be corrected for this report. Additionally, server and computer lab areas appear to have heating loads that are not designed for or expected.

Annual energy consumption and operating costs

The same simulation model used to determine the heating and cooling loads was used to determine the energy consumption of Stengel Hall. The mechanical engineer was required to perform a code analysis of the mechanical design but at this point has not performed a complete energy analysis on the building. This may be due to the small size of the project. It may not have been realistic and beneficial to perform an energy analysis on this building.

However, a study of the entire Linden Hall campus was performed in 2007. This study includes, among other information, the 2007 state of all of the school's facilities. This discussed the mechanical and electrical program, condition, and projected costs of repair or modification. The report also provided a summary of the 2005 & 2006 annual energy costs of each building. For the sake of this report the average 2005/2006 utility rates will be used.

Energy Consumption & Operating Costs

The annual energy consumption is of The Academic Center for Excellence is summarized in Table 4 below.

TABLE 4 - Energy Consumption

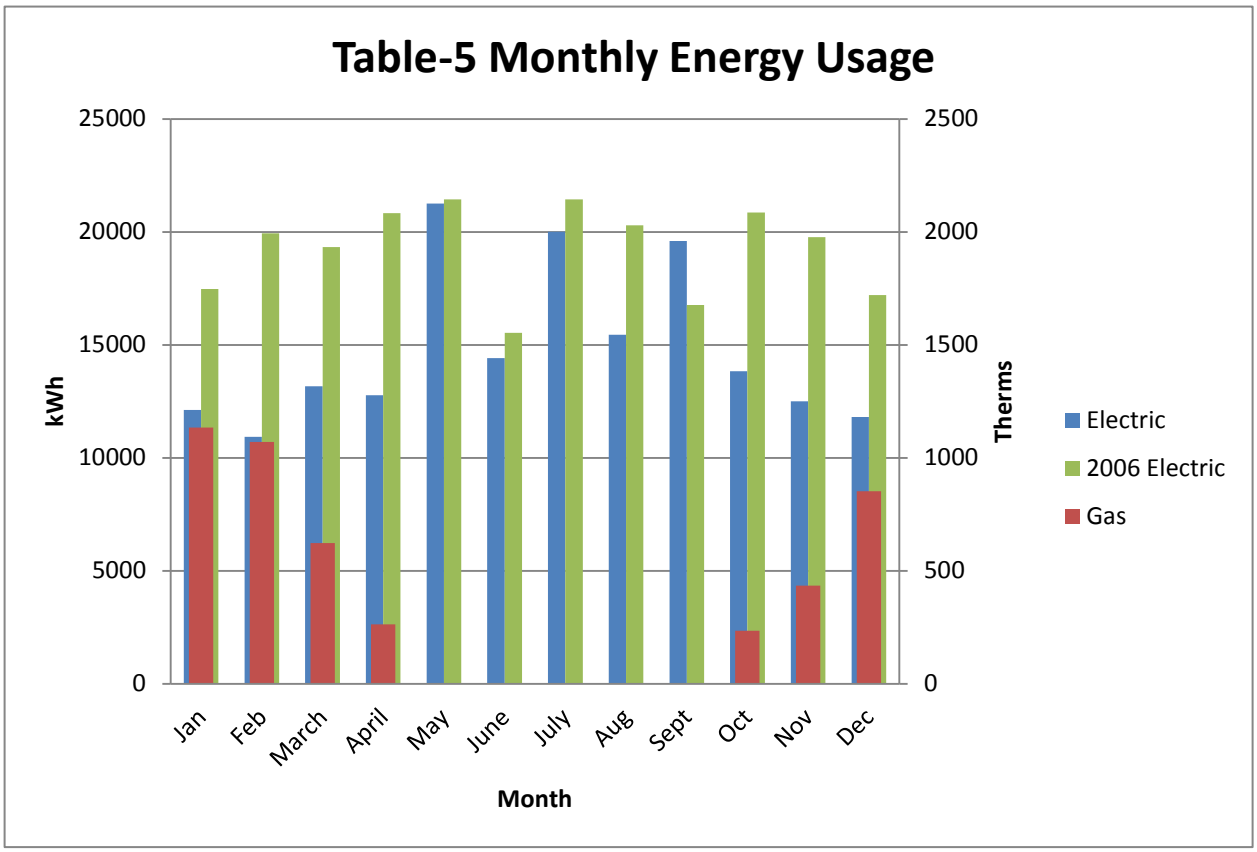
Source	ELECTRIC kWh	GAS kBTU	TOTAL ENERGY kBTU/yr	ELECTRIC OPERATING COST (0.0842 $/kWh)
Heating	3,573	461,631	473,826	$301
Supply Fans	62,883		92,686	$7,806
Lighting	27,157		151,230	$12,736
Receptacles	44,310		136,374	$11,485
Cooling	39,957		214,620	$18,074
TOTALS	**177,880**	**461,631**	**1,068,736**	**$50,402**

The boilers were designed to have an efficiency of 92.9% and cooling efficiencies were unable to be entered/determined for this simulation. However, an energy rate of 1.38kW/ton was assumed for the split system condensers.

The electric operating costs above are representative of 2006 electric rates because we can easily compare them to the operating costs provided by the owner. The computed operating cost of Stengel Hall is 1.76 $/SF and 2005/2006 the actual operating cost was 1.78 $/SF. It should be noted that the 2006 Stengel Hall is not completely representative of the newly renovated Stengel Hall but the electric consumption and costs are a helpful comparison. The operating cost of the entire Linden Hall campus was approximately 1.51 $/SF. This value was compared to operating costs of 1.52 $/SF for other regional schools. At the time this was

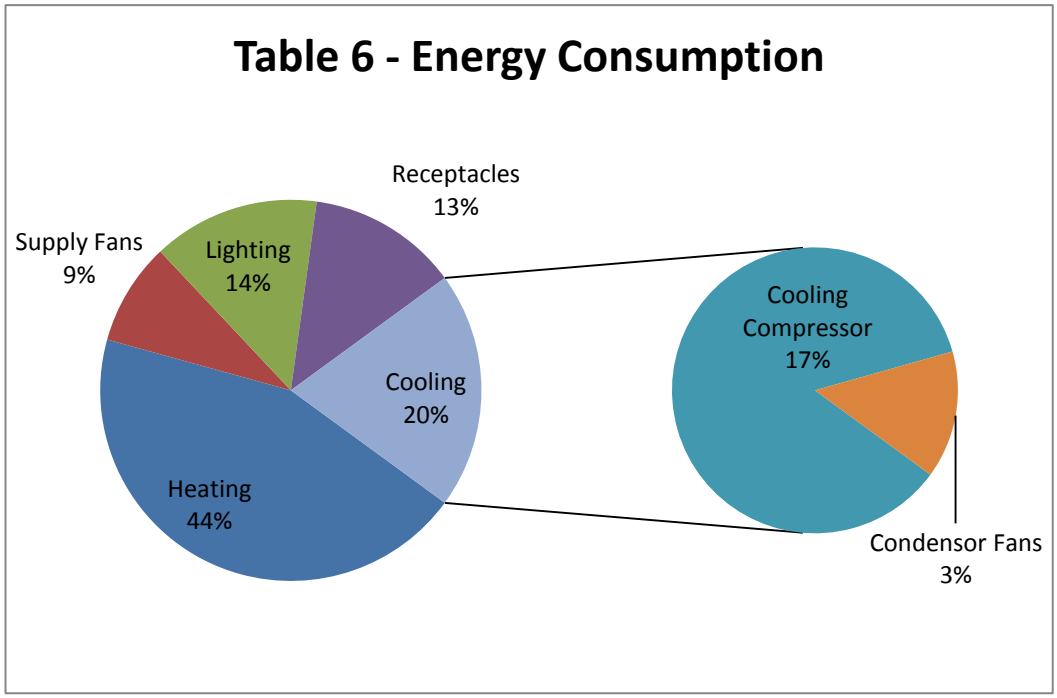
determined, by the preparer of the report, to be higher than expected because of the "residential nature" of Linden Hall.

However, the information supplied included two other campus buildings. A correction factor was applied to the energy consumption (kWh) based on the area of the combined buildings versus Stengel Hall alone. The results can be seen in Table-5 below on monthly basis.



The peak electric load was not originally expected to occur in May but it makes sense because of the decreased occupancy and demand during the summer at a school. Another interesting outcome of the compared energy usage is the dramatic difference in electric usage during the winter months. It is unclear why this occurs but the data provided may have included gas consumption in addition to electric consumption.

A breakdown of the computed energy system based on the load source is summarized below in Table-6. Overall, the values seem to accurately represent the nature of the load sources of Stengel Hall.



Emissions

Electricity for the Linden Hall campus is distributed from PPL Power. The emissions rates for this generation corporation can be seen below in Table 6. From these rates, the emissions for the computed Stengel Hall energy consumption can be estimated. These results can also be viewed below. The on-site emissions due to boilers could not be determined from the manufacturer's catalog. However, the acceptable level of CO_2 is specified to be less than 60ppm.

TABLE 6 - Emissions	SOX	NOX	CO2	
PPL Emissions	10	1.9	1169.4	lbs/MWh
Stengel Hall	1779	338	208013	lbs
	0.062	0.012	7.253	lbs/ft^2

TABLE A1 - DESIGNED & SIMULATED HEATING/COOLING INFORMATION

			VENTILATION		TOTAL COOLING & HEATING		NOMINAL TONAGE		HEATING CAPACITY	
ERV (IF APPLICABLE)	AHU	ROOMS SERVED FROM AIR HANDLING UNITS	*DESIGNED* AIRFLOW (CFM)	*CALCULATED* AIRFLOW (CFM)	*DESIGNED* AIRFLOW (CFM)	*CALCULATED* AIRFLOW (CFM)	*DESIGNED*	*CALCULATED*	*DESIGNED* (BTU/HR)	*CALCULATED* (BTU/HR)
ERV-2	AHU-001*	007-Day Lounge	600	475	1400	475	4	3.9	40000	41576
	AHU-002	002-Corridor 005-Elevator Lobby 001-Corridor 006-Corridor	100	387	525	387	1.5	1.3	18000	29462
ERV-3	AHU-003*	003-Testing/Lecture	710	435	1600	810	4.5	5.6	24000	32088
	AHU-101	134-Existing Entry 135-Headmaster	80.0	174.0	700.0	1101.0	2	2.2	22000	23065
ERV-1	AHU-102	136-Board Room 137-Existing Passage	250.0	357.0	825.0	1954.0	2.5	4.9	32000	30742
	AHU-103	129-Business Manager 130-Business Assistant 131-Existing Passage 132-Conference 133-Mech/Elec	150.0	421.0	1050.0	1527.0	3	3.7	23000	41156
	AHU-104	121-Manager 124-Corridor 126-Advancement Office 127-Director of Advancement 128-Existing Passage	80.0	357.0	875.0	1116.0	2.5	3.1	20000	43488
	AHU-105	101-North Entry 102-Centre Lobby 103-Receptionist 104-South Entry 106-Vestibule	380.0	548.0	1400.0	1621.0	4	6.3	35000	64010
	AHU-106	118-Administrative Assistant 119-Director of Admissions 120-Assistant Director of Admission	60.0	226.0	525.0	287.0	1.5	1.6	14000	17037
	AHU-107	105-Corridor 107-Cot 108-Work Room 109-Faculty Work Room 110-Faculty 113-Conference 114-Passage 115-Display 116-Corridor 117-Corridor	180.0	733.0	1225.0	881.0	3.5	3.8	38000	47724
	AHU-201	213-College Counseling 214-Offices 215-Offices 216-Corridor	60.0	193.0	525.0	826.0	1.5	1.9	9000	16986
ERV-4	AHU-202	217-Classroom	240.0	130.0	525.0	539.0	1.5	1.8	16000	11103

TABLE A1 - DESIGNED & SIMULATED HEATING/COOLING INFORMATION

			VENTILATION		TOTAL COOLING & HEATING		NOMINAL TONAGE		HEATING CAPACITY	
ERV (IF APPLICABLE)	AHU	ROOMS SERVED FROM AIR HANDLING UNITS	*DESIGNED* AIRFLOW (CFM)	*CALCULATED* AIRFLOW (CFM)	*DESIGNED* AIRFLOW (CFM)	*CALCULATED* AIRFLOW (CFM)	*DESIGNED*	*CALCULATED*	*DESIGNED* (BTU/HR)	*CALCULATED* (BTU/HR)
	AHU-203	218-Corridor 219-Academic Dean 220-Corridor 221-Assistant 224-Assistant Head 225-Conference 228-Passage 226-Passage	150.0	549.0	1400.0	3432.0	4	6.9	24000	50237
	AHU-204	222-Tech Office/Server Room	40.0	71.0	525.0	71.0	1.5	0.4	0	4597
	AHU-205	223-Computer Lab	110.0	117.0	525.0	127.0	1.5	1	11000	7597
ERV-9	AHU-206	201-Classroom 231-Classroom	465.0	280.0	875.0	923.0	2.5	3.8	12000	22431
ERV-7	AHU-207	227-Classroom	300.0	168.0	700.0	818.0	2	2.4	19000	18064
	AHU-208	208-Bookshelves 206-Work Room	340.0	308.0	1225.0	682.0	3.5	5.6	14000	21590
ERV-10	AHU-209	202-Learning Center 203-Conference 204-Learning Center 207-Library Office/Work Room	300.0	408.0	1050.0	1641.0	3	3.4	21000	29625
	AHU-210	205-Conference 209-Passage 211-Passage 312-Corridor 313-Passage	240.0	426.0	875.0	865.0	2.5	2.9	19000	34347
ERV-4	AHU-301	316-Corridor 318-Classroom 322-Corridor 319-Existing Classroom	500.0	400.0	1400.0	2225.0	4	5.2	36000	37337
ERV-5	AHU-302	320-Existing Classroom	320.0	163.0	875.0	873.0	2.5	2.6	19000	18621
ERV-6	AHU-303	321-Existing Classroom	360.0	188.0	875.0	985.0	2.5	2.9	17000	17217
ERV-6	AHU-304	323-Existing Classroom	340.0	158.0	700.0	810.0	2	2.5	15000	14439
ERV-7	AHU-305	324-Archives 326-Office 325-Passage 327-Existing Storage	300.0	261.0	875.0	1046.0	2.5	2.7	24000	27744
ERV-8	AHU-306	301-Classroom 304-Classroom	625.0	313.0	1225.0	798.0	3.5	4	32000	27645
	AHU-307	302-Corridor 305-Passage 309-Classroom	300.0	280.0	700.0	317.0	2	2.3	16000	21375
	AHU-308	307-Classroom 308-Classroom	300.0	149.0	700.0	442.0	2	1.9	16000	12997
		TOTALS	*7880*	*8675*	*25700*	*27579*	*73.5*	*90.6*	*586000*	*764300*
		PERCENT DIFFERENCE	10%		7%		23%		30%	

TABLE A2 – ADDITIONAL LOAD SUMMARY					
ROOM #	ROOM NAME	OCCUPANCY (PEOPLE)	LIGHTING LOAD (WATTS)	LIGHTING LOAD (W/SF)	ADDITIONAL EQUIPMENT LOADS
BASEMENT					
1	Corridor		260	0.67	
2	Corridor		130	0.58	
3	Testing/Lecture	65	1228	0.94	Smartboard, Netbooks
3A	Storage		64	0.85	
4	Elev. Equipment		64	1.07	Equipment (400W)
5	Elev. Lobby		186	0.87	
6	Corridor		130	0.47	
7	Day Lounge	35	962	0.70	Netbooks
8	E. Mech/Elec		256	0.34	Equipment (10W/sf)
9	Unisex R. Rm.	1	64	1.23	
10	Unisex R. Rm.	1	64	1.23	
11	Mech/Boiler/Elec	4	576	0.60	Equipment (10W/sf)
12	Mech/Elec	2	384	0.65	Equipment (10W/sf)
FIRST LEVEL					
101	North Entry		150	0.60	
102	Centre Lobby	19	937	1.31	
103	Receptionist	1	502	4.33	Computer
104	South Entry		153	0.79	
105	Corridor		312	0.64	
106	Vestibule		104	0.46	
107	Cot	1	128	1.66	
107A	Toilet	1	64	1.07	
108	Work Room	1	134	0.91	Netbooks
109	Faculty Work Room	4	320	1.24	Computer (.5 wst/pers)
110	Faculty	4	268	1.06	Computer (.5 wst/pers), Refrigerator
111	Men	2	160	1.19	
112	Women	2	160	1.16	
113	Conference	4	108	1.15	Netbooks
114	Passage		78	0.62	
115	Display	2	550	5.85	
116	Corridor		208	0.99	
117	Corridor		234	0.66	
118	Administrative Assistant	4	324	1.16	Computer (.25 wrk/pers)
119	Director of Admissions	1	216	0.86	Computer

TABLE A2 – ADDITIONAL LOAD SUMMARY, *continued*					
ROOM #	**ROOM NAME**	**OCCUPANCY (PEOPLE)**	**LIGHTING LOAD (WATTS)**	**LIGHTING LOAD (W/SF)**	**ADDITIONAL EQUIPMENT LOADS**
120	Asst. Director of Admissions	1	108	0.72	Computer
121	Manager	1	216	1.34	
122	Janitor		64	1.36	
123	Mechanical		64	1.73	Equipment (10W/sf)
124	Corridor		108	0.78	
126	Advancement Office	1	216	1.03	Computer
127	Director of Advancement	1	216	0.84	Computer
128	Existing Passage		200	0.98	
129	Business Manager	1	216	1.01	Computer
130	Business Assistant	1	216	0.97	Computer
131	Existing Passage		200	0.74	
132	Conference	5	216	0.86	Computer @ .75 workstation/person
133	Mechanical/Storage	1	128	0.75	
134	Existing Entry		100	0.60	
135	Headmaster	1	696	1.99	Computer
136	Board Room	32	502	0.70	Laptops @ .5 workstations/person
137	Existing Passage		456	1.41	Refrigerator
SECOND LEVEL					
201	Classroom	23	648	1.03	Netbooks, Smartboard
202	Learning Center	20	740	1.03	(4) Computer Stations
203	Conference	12	212	0.98	Netbooks @ .75 workstations/person
204	Learning center	21	432	0.87	(2) Computer Stations
205	Conference	5	108	1.00	Netbooks @ .75 workstations/person
206	Work Room	1	160	1.88	Computer Station @ 50W
207	Library Office Work Room	1	366	2.44	
208	Bookshelves	6	856	1.80	Smartboard, Refrigerator
209	Passage		156	0.54	
210	Toilet	1	64	1.21	
211	Passage		128	0.56	
212	Toilet	1	64	1.21	
213	College Counseling	4	160	0.95	(2) Computer Stations
214	Office	1	108	0.98	Computer
215	Office	1	108	0.98	Computer
216	Corridor		156	0.78	
217	Classroom	16	428	0.99	Netbooks, Smartboard
218	Corridor		130	0.77	
219	Academic Dean	1	268	1.07	Computer
220	Corridor		182	0.65	
221	Assistant	1	216	1.15	Computer
222	Tech Office/Server	2	216	1.19	Server (25W/sf)

TABLE A2 – ADDITIONAL LOAD SUMMARY, *continued*					
ROOM #	**ROOM NAME**	**OCCUPANCY (PEOPLE)**	**LIGHTING LOAD (WATTS)**	**LIGHTING LOAD (W/SF)**	**ADDITIONAL EQUIPMENT LOADS**
223	Computer Lab	8	324	0.94	Computer
224	Assistant Head	1	216	1.40	Computer
225	Conference	6	216	1.17	Netbooks @ .75 workstations/person
226	Passage		300	0.87	
227	Classroom	15	324	0.68	Netbooks, Smartboard
228	Passage		78	0.66	
231	Classroom	13	216	0.90	Netbooks, Smartboard
THIRD LEVEL					
301	Classroom	26	432	0.69	Netbooks, Smartboard
302	Corridor		208	0.57	
303	Mechanical				Equipment (10W/sf)
304	Classroom	11	216	0.68	Netbooks, Smartboard
305	Passage		78	1.18	
306	Mechanical				Equipment (10W/sf)
307	Classroom	9	216	0.94	No added equip loads due to nature of classroom design
308	Classroom	9	216	0.92	
309	Classroom	15	324	0.78	
311	Mechanical				Equipment (10W/sf)
312	Corridor		208	0.51	
313	Passage		136	0.60	
314	Toilet	1	64	1.21	
315	Toilet	1	64	1.21	
316	Corridor		216	1.14	
317	Mechanical				Equipment (10W/sf)
318	Classroom	17	324	0.83	Netbooks, Smartboard
319	Existing Classroom	11		0.90	Netbooks
320	Existing Classroom	21		0.90	Netbooks
321	Existing Classroom	23		0.90	Netbooks
322	Corridor			0.70	
323	Existing Classroom	21		0.90	Netbooks, Smartboard
324	Existing Work Room/Archives		192	1.09	
325	Passage			0.70	
326	Office	4	216	0.71	Computers
327	Existing Storage		150	2.00	

Design conditions for PHILADELPHIA NE PHILADELP, PA, USA

Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
1a	1b	1c	1d	1e	1f	1g	1h	1i
PHILADELPHIA NE PHILADELP	**724085**	**40.08N**	**75.02W**	**98**	**14.644**	**-5.00**	**NAE**	**8201**

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6%			99%			0.4%		1%			
			DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	**11.3**	**15.7**	**-3.0**	**4.7**	**13.6**	**1.2**	**5.9**	**18.0**	**24.8**	**33.1**	**23.1**	**31.5**	**10.1**	**300**

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
7	**19.0**	**93.2**	**75.8**	**90.4**	**74.6**	**88.0**	**73.5**	**79.0**	**88.7**	**77.1**	**87.0**	**75.6**	**84.4**	**9.8**	**300**

Dehumidification DP/MCDB and HR									Enthalpy/MCDB					
0.4%			1%			2%			0.4%		1%		2%	
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
12a	12b	12c	12d	12e	12f	12g	12h	12i	13a	13b	13c	13d	13e	13f
76.1	**136.8**	**83.5**	**74.2**	**128.3**	**81.6**	**72.8**	**122.1**	**80.3**	**34.6**	**88.5**	**32.7**	**87.1**	**31.3**	**84.5**

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%	WB	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
14a	14b	14c	15	16a	16b	16c	16d	17a	17b	17c	17d	17e	17f	17g	17h
21.0	**18.7**	**17.3**	**88.7**	**97.7**	**4.7**	**2.7**	**6.5**	**99.6**	**0.0**	**101.2**	**-3.8**	**102.7**	**-7.4**	**104.7**	**-12.1**

Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18a	18b	18c	18d	18e	18f	18g	18h	18i	18j	18k	18l
0.4%	**63.8**	**59.3**	**66.1**	**56.2**	**78.8**	**64.4**	**85.5**	**66.0**	**90.6**	**71.6**	**94.4**	**74.8**
1%	**61.2**	**57.8**	**62.8**	**54.5**	**74.2**	**61.5**	**80.7**	**64.6**	**88.4**	**70.9**	**92.7**	**74.4**
2%	**57.6**	**54.0**	**59.2**	**52.5**	**69.8**	**58.4**	**76.4**	**62.0**	**86.2**	**69.9**	**90.7**	**74.0**

%	Jul		Aug		Sep		Oct		Nov		Dec	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18m	18n	18o	18p	18q	18r	18s	18t	18u	18v	18w	18x
0.4%	**97.8**	**78.4**	**95.3**	**76.8**	**91.1**	**74.8**	**82.0**	**68.3**	**73.7**	**62.5**	**66.3**	**59.8**
1%	**96.3**	**77.7**	**92.9**	**76.5**	**88.4**	**73.2**	**80.2**	**67.8**	**70.9**	**62.3**	**63.7**	**57.6**
2%	**94.3**	**76.8**	**90.9**	**75.5**	**85.9**	**71.8**	**77.4**	**66.8**	**68.3**	**60.8**	**61.2**	**55.5**

Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19a	19b	19c	19d	19e	19f	19g	19h	19i	19j	19k	19l
0.4%	**61.3**	**63.2**	**59.3**	**62.6**	**65.8**	**76.7**	**68.5**	**80.6**	**75.7**	**86.3**	**79.8**	**86.7**
1%	**58.2**	**60.5**	**57.1**	**61.1**	**63.2**	**72.2**	**66.6**	**77.2**	**73.9**	**84.3**	**77.8**	**88.4**
2%	**54.8**	**57.4**	**54.0**	**57.1**	**60.5**	**66.9**	**64.6**	**74.1**	**72.1**	**82.6**	**76.4**	**87.1**

%	Jul		Aug		Sep		Oct		Nov		Dec	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19m	19n	19o	19p	19q	19r	19s	19t	19u	19v	19w	19x
0.4%	**82.9**	**90.3**	**81.5**	**89.0**	**77.6**	**85.3**	**72.0**	**77.5**	**66.5**	**70.6**	**61.8**	**65.1**
1%	**80.9**	**90.7**	**79.7**	**88.3**	**76.3**	**83.9**	**70.5**	**75.9**	**64.8**	**68.2**	**59.4**	**62.3**
2%	**79.5**	**90.3**	**78.1**	**87.4**	**75.2**	**82.4**	**69.2**	**74.5**	**63.2**	**66.1**	**57.2**	**60.1**

Monthly Mean Daily Temperature Range

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20a	20b	20c	20d	20e	20f	20g	20h	20i	20j	20k	20l
15.0	**16.2**	**18.2**	**20.0**	**20.4**	**20.2**	**19.0**	**18.4**	**18.9**	**20.0**	**17.9**	**15.2**

WMO#	World Meteorological Organization number	Lat	Latitude, °	Long	Longitude, °
Elev	Elevation, ft	StdP	Standard pressure at station elevation, psi		
DB	Dry bulb temperature, °F	DP	Dew point temperature, °F	WB	Wet bulb temperature, °F
WS	Wind speed, mph	Enth	Enthalpy, Btu/lb	HR	Humidity ratio, grains of moisture per lb of dry air
MCDB	Mean coincident dry bulb temperature, °F	MCDP	Mean coincident dew point temperature, °F	MCWB	Mean coincident wet bulb temperature, °F
MCWS	Mean coincident wind speed, mph	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East		

TABLE A3-Building Composition

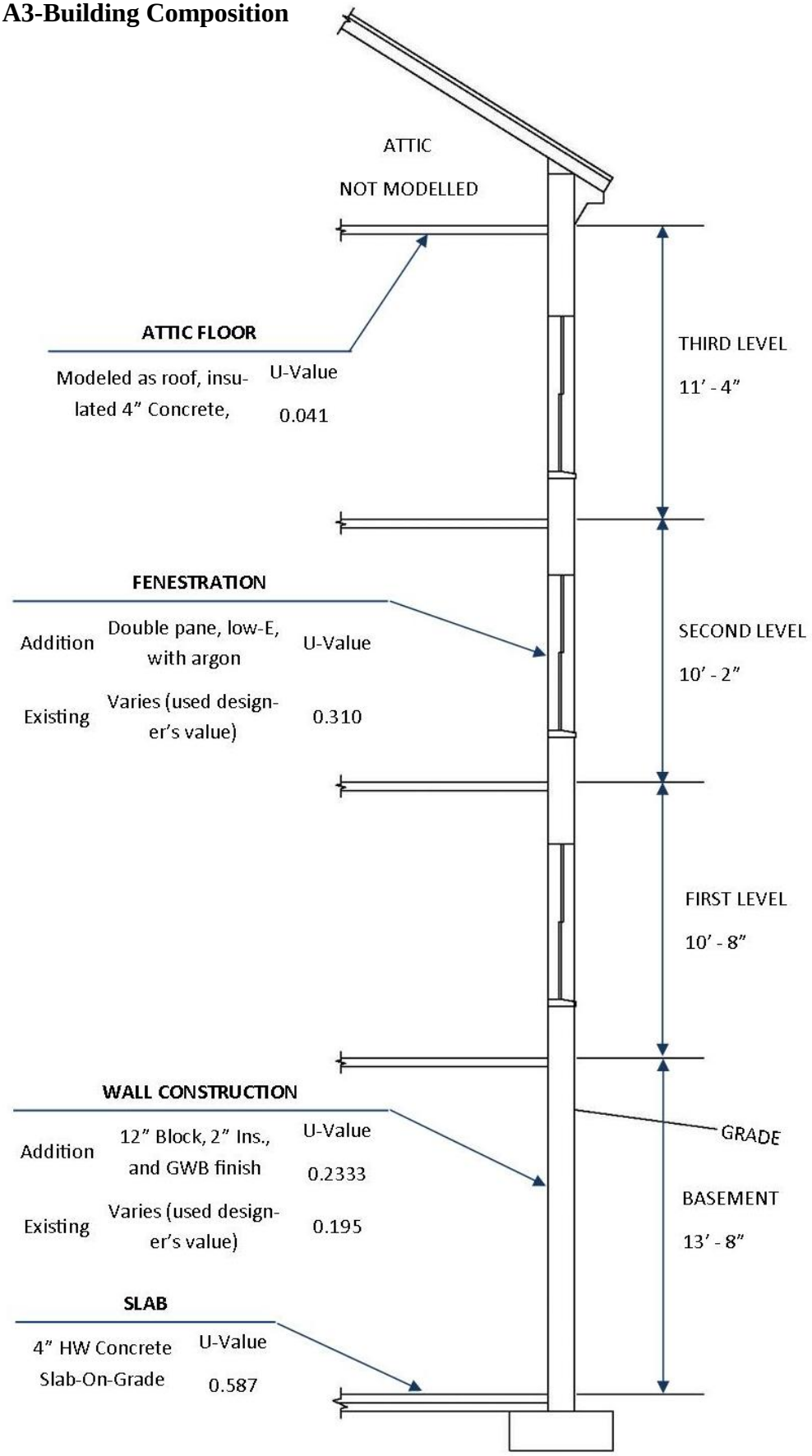


TABLE A4 - ASSUMED SCHOOL SCHEDULE			
	MONTHS	*TIME*	*%*
WEEKDAY	JANUARY -MAY	12AM-6AM	0
		6AM-7AM	10
		7AM-8AM	20
		8AM-11AM	80
		11AM-1PM	90
		1PM-3PM	80
		3PM-6PM	60
		6PM-12AM	0
	JUNE-AUGUST	12AM-8AM	0
		8AM-6PM	15
		6PM-12AM	0
	SEPTEMBER-DECEMBER	12AM-6AM	0
		6AM-7AM	10
		7AM-8AM	20
		8AM-11AM	80
		11AM-1PM	90
		1PM-3PM	80
		3PM-6PM	60
		6PM-12AM	0
WEEKEND	JANUARY-DECEMBER	12AM-8AM	0
		8AM-4PM	15
		4PM-12AM	0

TABLE A5 – AREA COMPARISON BY SPACE					
ROOM #	**ROOM NAME**	**DESIGN AREA (SF)**	**MODELED AREA (SF)**	**DIFFERENCE (SF)**	**PERCENT DIFFERENCE**
BASEMENT					
1	Corridor	387	467	80	21%
2	Corridor	226	252	26	12%
3 3A	Testing/Lecture Storage	1304 75	1425	46	4%
4	Elev. Equipment	60	72	12	20%
5	Elev. Lobby	215	236	21	10%
6	Corridor	277	310	33	12%
7	Day Lounge	1375	1554	179	13%
8	E. Mech/Elec	743	886	143	19%
9	Unisex R. Rm.	52	73	21	40%
10	Unisex R. Rm.	52	73	21	40%
11	Mech/Boiler/Elec	963	1105	142	15%
12	Mech/Elec	587	615	28	5%
FIRST LEVEL					
101	North Entry	250	292	42	17%
102	Centre Lobby	718	879	161	22%
103	Receptionist	116	120	4	3%
104	South Entry	193	246	53	27%
105	Corridor	491	538	47	10%
106	Vestibule	228	257	29	13%
107 107A	Cot Toilet	77 60	157	20	26%
108	Work Room	148	159	11	7%
109	Faculty Work Room	258	278	20	8%
110	Faculty	254	275	21	8%
111	Men	135	159	24	18%
112	Women	138	168	30	22%
113	Conference	94	95	1	1%
114	Passage	125	139	14	11%
115	Display	94	92	-2	-2%
116	Corridor	211	417	206	98%
117	Corridor	355	405	50	14%
118	Administrative Assistant	280	315	35	13%
119	Director of Admissions	250	263	13	5%
120	Asst. Director of Admissions	150	163	13	9%
121	Manager	161	170	9	6%
122	Janitor	47	55	8	17%
123	Mechanical	37	45	8	22%

TABLE A5 – AREA COMPARISON BY SPACE, *continued*					
ROOM #	**ROOM NAME**	**DESIGN AREA (SF)**	**MODELED AREA (SF)**	**DIFFERENCE (SF)**	**PERCENT DIFFERENCE**
124	Corridor	138	155	17	12%
126	Advancement Office	209	236	27	13%
127	Director of Advancement	256	271	15	6%
128	Existing Passage	204	336	132	65%
129	Business Manager	214	247	33	15%
130	Business Assistant	223	296	73	33%
131	Existing Passage	270	320	50	19%
132	Conference	250	302	52	21%
133	Mechanical/Storage	170	213	43	25%
134	Existing Entry	168	197	29	17%
135	Headmaster	350	374	24	7%
136	Board Room	718	762	44	6%
137	Existing Passage	324	406	82	25%
SECOND LEVEL					
201	Classroom	627	636	9	1%
202	Learning Center	720	801	81	11%
203	Conference	216	239	23	11%
204	Learning center	495	515	20	4%
205	Conference	108	111	3	3%
206	Work Room	85	96	11	13%
207	Library Office Work Room	150	158	8	5%
208	Bookshelves	476	535	59	12%
209	Passage	290	334	44	15%
210	Toilet	53	78	25	47%
211	Passage	227	256	29	13%
212	Toilet	53	70	17	32%
213	College Counseling	169	187	18	11%
214	Office	110	112	2	2%
215	Office	110	120	10	9%
216	Corridor	200	214	14	7%
217	Classroom	434	426	-8	-2%
218	Corridor	169	258	89	53%
219	Academic Dean	250	248	-2	-1%
220	Corridor	279	250	-29	-10%
221	Assistant	188	196	8	4%
222	Tech Office/Server	182	231	49	27%
223	Computer Lab	345	382	37	11%
224	Assistant Head	154	159	5	3%
225	Conference	185	208	23	12%
226	Passage	345	369	24	7%
227	Classroom	479	549	70	15%

TABLE A5 – AREA COMPARISON BY SPACE, *continued*					
ROOM #	ROOM NAME	DESIGN AREA (SF)	MODELED AREA (SF)	DIFFERENCE (SF)	PERCENT DIFFERENCE
228	Passage	118	110	-8	-7%
231	Classroom	239	280	41	17%
THIRD LEVEL					
301	Classroom	625	646	21	3%
302	Corridor	363	411	48	13%
303	Mechanical	40	47	7	18%
304	Classroom	317	377	60	19%
305	Passage	66	57	-9	-14%
306	Mechanical	18	22	4	22%
307	Classroom	230	243	13	6%
308	Classroom	235	244	9	4%
309	Classroom	418	449	31	7%
311	Mechanical	21	25	4	19%
312	Corridor	405	439	34	8%
313	Passage	228	253	25	11%
314	Toilet	53	87	34	64%
315	Toilet	53	76	23	43%
316	Corridor	190	211	21	11%
317	Mechanical	20	24	4	20%
318	Classroom	392	431	39	10%
319	Existing Classroom	387	397	10	3%
320	Existing Classroom	497	534	37	7%
321	Existing Classroom	568	614	46	8%
322	Corridor	252	271	19	8%
323	Existing Classroom	481	517	36	7%
324	Existing Work Room/Archives	176	200	24	14%
325	Passage	128	150	22	17%
326	Office	305	339	34	11%
327	Existing Storage	75	166	91	121%
		AVERAGE % DIFFERENCE			**16%**