New Science & Technology Center

The Chestnut Hill Academy

Philadelphia, PA

Technical Report 3:

Mechanical Systems Existing Conditions Evaluation

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Executive Summary

Tech 3 is a summary of the HVAC system for the Science and Technology Center at the Chestnut Hill Academy. Based on feedback from the owner, the mechanical designer based the HVAC design around several specific design objectives. One objective was the use of a dual temperature control system, which allowed for extra savings for the owner. Another objective was LEED certification. The owner required at a minimum that the building be LEED Certified, if not better.

Also included is a comparison of the design and calculated ventilation rates. Results show that the design rates are greater than the calculated rates. This shows that the indoor spaces will be supplied with more than enough outdoor air. The heating and cooling loads, both designer and calculated, are also included. The design data was used, via HAP, to calculated an estimate for annual energy consumption and operating cost. In comparison with the calculated energy consumption and cost from Tech 2, it was found that the design cost was greater that the calculated. Several factors are responsible for this, mainly due to an underestimation of the included electric equipment.

The total cost of the HVC system for the Science and Technology Center was $1,287,000. This includes both HVAC equipment and piping that was used for the fire protection system. The cost equated to 13% of the overall project cost.

In evaluation of the HVAC system, there are a few things that should have been considered in a different light. One is the acoustical impact of the equipment on the classroom spaces. Another is how long the payback period will be for the daylight harvesting system.

Building Summary

The New Science and Technology Center at the Chestnut Hill Academy is a two level building with a footprint area of 9,200 square feet and an aggregate area of 18,400 square feet on the two levels. The cost of construction is $9.6 million. The first and second levels are both occupied by classrooms and laboratories with the second level also containing a faculty office suite. The labs will be equipped to teach physics, biology, and chemistry classes, with a separate lab for robotics that will include a workshop area. The building will include a photovoltaic roof array and a wind turbine to harvest solar and wind energy. Both will be owner installed and operated. The adjacent parking lot and sidewalks will be paved with porous asphalt covering an uncompacted subgrade, providing better absorption back into the earth. It is the intent of the owner to achieve a LEED certified level once the construction of the building is completed in November of 2008. Floor plans are provided at the end of Appendix B

Mechanical System Summary

The New Science and Technology Center is planned to act as an addition to the already existing MEP infrastructure on campus. Power and water (domestic, heated, and fire suppression) will all be supplied from the central plant. A 480/277 V feeder will be run from the neighboring Inn building for the power supply. The first and second levels will both be supplied by separate AHU's, AHU-1 and AHU-2, respectively. AHU-1 has a 6,300 CFM capacity and AHU-2 a 8,000 CFM capacity. Both are VAV units with an economizer and energy recovery in the form of a variable speed heat recovery wheel. The initial supply air setpoint from each AHU is 55ºF. Once the zones are satisfied, the setpoint will be gradually adjusted to reduce energy use from heating and cooling. The air is supplied to the different zones using a single duct VAV system. The system is run on a user defined schedule with both occupied and unoccupied modes. During the occupied mode, the cooling setpoint is 74ºF and the heating setpoint is 70ºF. During the unoccupied mode, the cooling setpoint is raised to 85ºF and the heating setpoint is dropped to 65ºF. The system is also equipped to monitor zone CO_2 levels and override the damper controls to maintain a level of 500 PPM. Several exhaust fans are located in the labs to provide extra ventilation, if needed.

Design Objectives

The design of the mechanical system for the New Science and Technology Center included several specific objectives. The first was the control sequence of the various exhaust fans. There are three types of exhausts installed in the building: teacher fumehoods, student fumehoods, and snorkel exhausts. The teacher fumehoods are in continuous operation, while the student fumehood only operates when called for by the teacher. The snorkel exhaust is a local exhaust located at every student workstation in the labs.

One problem with the exhausts was with the student fumehood and snorkel exhausts. If both were activated at the same time, the makeup air would be significantly larger, causing an increase in zone loads. That would require a larger size AHU unit, which would lead to an overall increase in the project cost. The solution lay in the sequencing. The system controls were developed to only allow either the student fumehood or the snorkel exhaust to run, but not both at the same time.

One specific design objective was the inclusion of energy recovery wheels in each AHU. These wheels allow for either pre-heating or pre-cooling of air, thus lower the energy required to condition each zone.

The most interesting objective was the use of a two-pipe dual temperature system as opposed to a more traditional four-pipe system. Though the transition period between seasons can be uncomfortable with this system, the school agreed in order to further lower their energy consumption. A schematic of the two-pipe system is provided in Appendix B, along with the schedule for the exhaust fans.

The last design objective was the goal of LEED certification. In order to help achieve a rating level, the school installed two sources of alternate energy; two groups of photovoltaic cells and a wind turbine. The PV panels are also used to create hot water as shown in the schematic in Appendix B. The adjacent parking lot and pathways were also paved with porous pavement in order to lower the percent of impervious covering on the site. Schematics of the construction are included in Appendix B.

Design Conditions

The design conditions for the New Science and Technology Building were broken into four categories: indoor and outdoor design conditions, ventilation requirements, heating and cooling loads, and annual energy usage.

Indoor and Outdoor Design Conditions

The indoor design conditions were fairly simple; there was a cooling setpoint of 74ºF and a heating setpoint of 70ºF during the occupied hours of operation. When the space is un-occupied, the setpoints were adjusted to 85ºF and 65ºF, respectively, to lower the cooling and heating loads. The relative humidity was 47%. The design cooling load occurred on August 14 when the outdoor air was at 91.5ºF dry bulb and 74.9ºF wet bulb. The outdoor air for the design heating load was 47.4ºF dry bulb for AHU-1 and 21.9ºF for AHU-2.

Ventilation requirements

The ventilation requirements, heating and cooling loads, and annual energy use for the building have been previously calculated in the first and second technical reports. The calculated ventilation rates for AHU-1 and AHU-2 were 1,955 and 2,801 CFM, respectively. The design rates were 2,257 and 2,239 CFM, respectively. Charts showing the zone breakdown for the calculated and design values are included in Appendix A. The supply and return fans for each AHU were sized for standard flows of 6,305 and 7,947 CFM. In comparison, the design rates for ventilation are slightly higher than the calculated rates. This resulted from the more conservative use of required OA CFM/person in the design. The calculated results from the first tech report used the minimum requirements as suggested by ASHREA Standard 62.1. The air distribution effectiveness in the design was also calculated to be 0.8, as opposed to 1.0 as used in Tech 1.

Heating and Cooling Loads

HAP was used to calculate the design heating and cooling loads for the New Science and Technology Center. The table on the following page shows the cooling and heating load breakdown for each AHU.

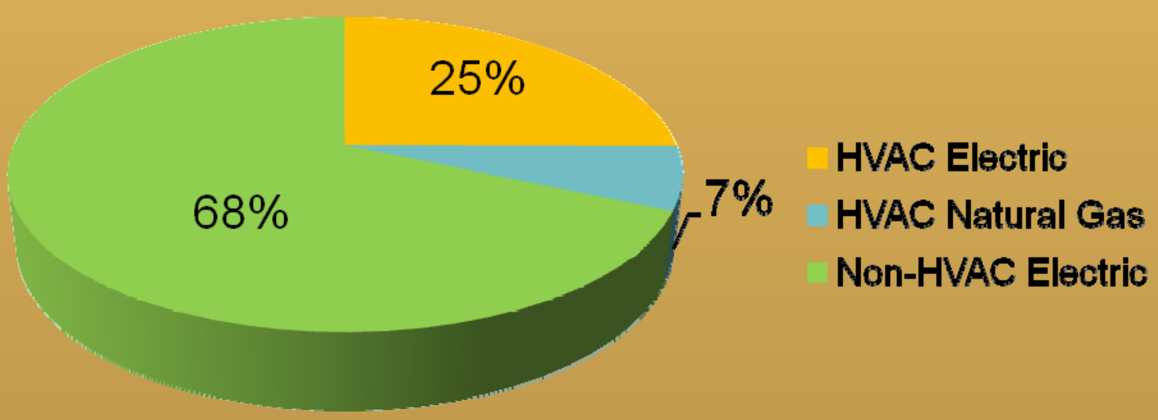
Design Conditions

	Cooling (BTU/hr)		Heating (BTU/hr)	
	Total Sensible	Latent	Total Sensible	Latent
AHU-1	168,763	119,447	147,731	-
AHU-2	170,926	123,514	179,380	59,559

These values represent all of the building loads, including the building envelope, people, lights, and HVAC equipment among others. Data from Tech 2 regarding the estimated energy usage is included in Appendix A.

Annual Energy Use

HAP was also used to calculate the design annual energy usage and operating costs for the building. The following charts show the energy breakdown between systems and the annual operating costs.



Design Conditions

	Annual Cost ($/yr)	($/ft^2)
HVAC Components		
Electric	13,272	0.583
Natural Gas	3,440	0.151
Sub-Total	16,712	0.735
Non-HVAC Components		
Electric	36,156	1.589
Sub-Total	36,156	1.589
Total	52,868	2.324

The non-HVAC electric components include lights, equipment, and miscellaneous loads. The design cooling coil load was calculated at 1,543,900 kBTUs and the heating coil load was 504,004 kBTUs. The following chart shows the breakdown by system component.

Component	Site Energy		Source Energy	
	(kBTU)	(kBTU/ft^2)	(kBTU)	(kBTU/ft^2)
Air System Fans	105,133	4.621	375,476	16.503
Cooling	431,488	18.965	1,541,029	67.732
Heating	482,026	21.186	482,026	21.186
Pumps	15,645	0.688	55,876	2.456
Lights	793,119	34.859	2,832,567	124.877
Electric Equipment	576,846	25.354	2,060,164	90.549
Misc. Electric	134,501	5.912	480,361	21.113
Total	2,538,758	111.584	7,287,498	344.036

Design Conditions

Component	Annual Cost ($)	Annual Cost ($/ft^2)
Air System Fans	2,527	0.111
Cooling	10,370	0.456
Heating	3,440	0.151
Pumps	376	0.017
Lights	19,061	0.838
Electric Equipment	13,863	0.609
Misc. Electric	3,232	0.142
Total	52,869	2.324

The above table shows the annual costs by system component. If we compare the overall design and estimated operating costs, the design value is roughly twice the estimated value; $52,869 vs $25,000 from Tech 2 (energy consumption calculated in Tech 2 is provided in Appendix A). This is a significant difference in monetary value. From the system component breakdown it is clear that the difference lies mainly in the non-HVAC equipment, which includes lights, electrical equipment, and miscellaneous electric use. In particular, the electric equipment was much higher in the design calculations than in the estimation from Tech 2. As the design values were not yet released for comparison in Tech 2 this was not adjusted for. One example of higher electric consumption was the underestimation of the robotic arms located in the labs. After receiving the design calculations adjustments were made to concur with a more appropriate estimation.

System Description

The general system description is provided at the beginning of the report. Schematics of some individual systems are included in Appendix B. Detailed descriptions of these schematics follow on the next page.

System Description

Dual Temperature System Control Diagram

The dual temperature system is a two-pipe system that replaces the more traditional four-pipe system. It was described earlier in the design objectives. The layout is shown in the schematics attached in Appendix B. The system includes two VFD pumps with monitoring devices, several loop and changeover bypass isolation valves, and a water differential pressure sensor between the supply and return lines. The pumps are monitored and controlled automatically, but can be manually overridden.

Air Cooled Chiller Control Diagram

The schematic for the chiller show the flow of the chilled water through the two VFD pumps. The flow then continues on to the loads before it returns through the return piping. A chilled water bypass is located between the supply and return systems to ensure proper flow. Both pumps have delay times for start-up, shutdown, and sequencing. These controls are automatically run by the controller, although they can be manually overridden. The chiller also has the same delay times for start-up, shutdown, and sequencing. The overall system has built in alarms that monitor the chiller water temperature. Alarms will sound if the supply temperature rises above 55ºF or falls below 38ºF.

Grey-Water Schematic

The grey-water schematic shows the collection and re-distribution of rainwater. The rainwater is collected via a 5” pipe where it is stored in a holding tank. The tank is also supplied with a 2-1/2” makeup pipe as well as a 5” rainwater overflow pipe. The make-up water is controlled by a low-level solenoid controller. The grey-water is pumped from the holding tank and distributed through a 3” supply pipe to the bathroom facilities located on the first and second floor. The centralized monitoring system will monitor the connected supply pump.

Solar Energy Collection Schematic

The solar energy collection system is quite simple. Water passes underneath the solar panels, gaining heat in the process. The hot water then runs through a heat exchanger in the solar hot water storage tank. En route to the tank the hot water passes through an air separator and a pump. After the heat exchanger, the now cooler water returns to the solar panels to repeat the cycle. The system is monitored by a control panel that senses the temperature in the tank via a temperature probe. The storage tank is also provided with a backup electric heating coil.

Lost Usable Space

The mechanical space, both floor and vertical, in the New Science and Technology Building is approximately 500 square feet. While this is a small number, the overall square footage is not that large either. The 500 square feet of mechanical space equates to 2.2% of the total aggregate area. This percentage is the lost usable space due to mechanical equipment located on the floor and vertical space taken by air shafts and piping. Floorplans showing the location of these spaces are located in Appendix C.

Mechanical Systems Costs

The costs for the building system are shown in the table below. Costs were broken down into HVAC and plumbing related to fire protection. The table shows the total cost and the cost per square foot. The total cost, including HVAC and fire protection, is roughly 13.4% of the overall cost for the building.

	Total Cost ($)	Cost ($)/ft^2
Fire Protection	90,300	3.97
HVAC	1,196,700	52.57
Total	1,287,000	56.53

LEED

The New Science and Technology Center was evaluated under the Energy & Atmosphere and the Indoor Environmental Quality sections of the LEED for New Construction guidelines. The charts in Appendix D show the breakdown of each section. There were five guaranteed and six possible points for the Energy & Atmosphere section and eight guaranteed and four possible points for the Indoor Environmental Quality section. The possible points for the first section are based on the commissioning of the building once completed. The possible points for the second section are for system monitoring and adjustments based on future feedback from the building occupants. The overall intent is to achieve a minimum level of LEED Certified for the building.

Overall System Evaluation

The New Science and Technology Center was built with a very modern engineering approach. All aspects from the exterior to the interior were taken into consideration while designing the HVAC system. The exterior wall construction was evaluated to assure it met ASHREA standards and the ventilation rates exceeded the minimum required rates. The owner even decided to apply for a LEED certification rating to showcase the level of sustainability the building was designed to achieve. The estimated operating cost of approximately $53,000 equates to 0.55% per year of the total project cost. The design range for operating costs is approximately 1-2% of total project cost per year. One concern regarding the mechanical system is the extensive use of exhaust fans in the labs. While the system is properly designed from a ventilation standpoint, acoustically the space may suffer with all of the supply and exhaust fans running simultaneously.

The building has several advance control sequences for the lighting of each zone. Each classroom or lab is equipped with daylight and occupancy sensors to minimize the electricity usage. However, given the adjacent Inn Building, as well as the location of surrounding trees, one concern is whether the interior spaces will see enough daylight through the year to justify the design systems. A daylight study might be helpful to help identify any possible improvements.

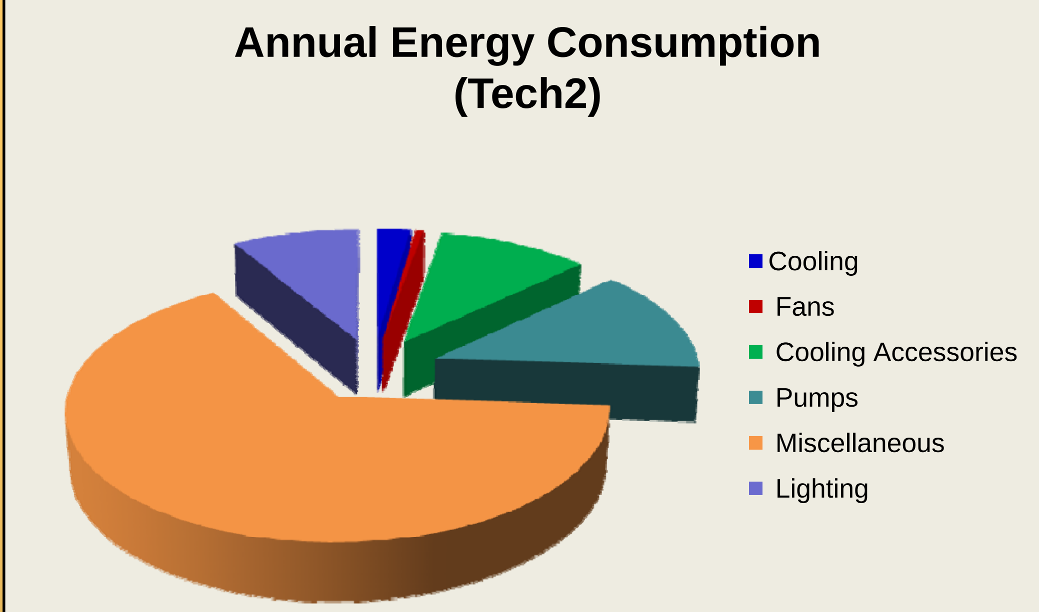
The general layout of the building flows well. Traffic is fed from the lobby area to the first or second floor corridors to the various classrooms and offices. The second stairwell located next to the side door should help to ease any overcrowding moving from the first to second floor. As for the space requirements, according to the designed occupancy level each classroom and lab should be able to provide at a minimum adequate space for each student and teacher.

While the heating and cooling setpoints are automatically control, one concern is that students or faculty may override the system. This could be result from a change in room functions, or simply by someone unaware of the system capabilities. Regarding the louvers controlling the outdoor air intake and exhaust, one concern is that they work as design. They are all gravity louvers located off of the roof, so they should be checked occasionally for performance.

References

- ANSI/ASHRAE Standard 62.1-2007. Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA.
- ANSI/ASHRAE/IESNA Standard 90.1-2007. Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta, GA.
- Chestnut Hill Academy New Science & Technology Center Construction Documents. Lilley Dadagian Architects. Lexington, MA
- USGBC. LEED for New Construction & Major Renovations. Version 2.2. October 2005. Washington, DC.
- Ryan Fitzpatrick, E.I.T. Mechanical Project Engineer. Bruce E. Brooks & Associates. 2209 Chestnut St. Philadelphia, PA.

Appendix A



Cooling	8,777 kWh	**Pumps**	50,786 kWh
Fans	2,035 kWh	**Miscellaneous**	256,666 kWh
Accessories	40,433 kWh	**Lighting**	33,610 kWh

Local Utility Rates

Electricity	
On-Peak Consumption	0.0753 $/kWh
Off-Peak Consumption	0.0202 $/kWh
On-Peak Demand	11.88 $/kW
Off-Peak Demand	6.534 $/kW
Gas	
Rate and Distribution	0.3213 $/therm

Appendix A

Standard 62.1 Tables and Sample Calculations

Table A-2

	R_p	R_a	V_{bz}	E_z	V_{oz}	V_{pz}	Z_p	E_v	D	V_{ou}	V_{ot}
	(cfm/person)	(cfm/ft^2)	(cfm)		(cfm)	(cfm)				(cfm)	(cfm)
Second Level											
Chem./Biology Lab	10	0.18	403	1	403	1460	0.28	-	1		
Chem./Bio./Phy. Prep.	5	0.06	33	1	33	1400	0.02	-	1		
Ind. Lab	10	0.18	61	1	61	300	0.20	-	1		
Chem./Physics Lab	10	0.18	400	1	400	1680	0.24	-	1		
Office Suite	5	0.06	58	1	58	500	0.12	-	1		
Conference Room	5	0.06	77	1	77	275	0.28	-	1		
Bio. Prep	10	0.18	53	1	53	700	0.08	-	1		
Biology	10	0.18	417	1	417	1450	**0.29**	0.8	1		
Corridor	-	0.06	63	1	63	420	0.15	-	1		
							Total	0.8	1	1564	1955
									AHU 2 MAX OA (CFM)		8000
First Level											
Physics Lab	10	0.18	396	1	396	820	0.48	-	1		
Phy. Prep.	5	0.06	23	1	23	80	0.28	-	1		
Ind. Phy. Lab	10	0.18	40	1	40	100	0.40	-	1		
Robotics and Workshop	10	0.18	514	1	514	874	0.59	-	1		
Porch	5	0.06	118	1	118	2220	0.05	-	1		
Commons	5	0.06	71	1	71	110	**0.65**	0.61	1		
K-2 Lab	10	0.18	226	1	226	480	0.47	-	1		
Prep	5	0.06	11	1	11	140	0.08	-	1		
3-5 Lab	10	0.18	231	1	231	480	0.48	-	1		
Corridor	-	0.06	63	1	63	435	0.15	-	1		
							Total	0.61	1	1709	2801
									AHU 1 MAX OA (CFM)		6300

Appendix A

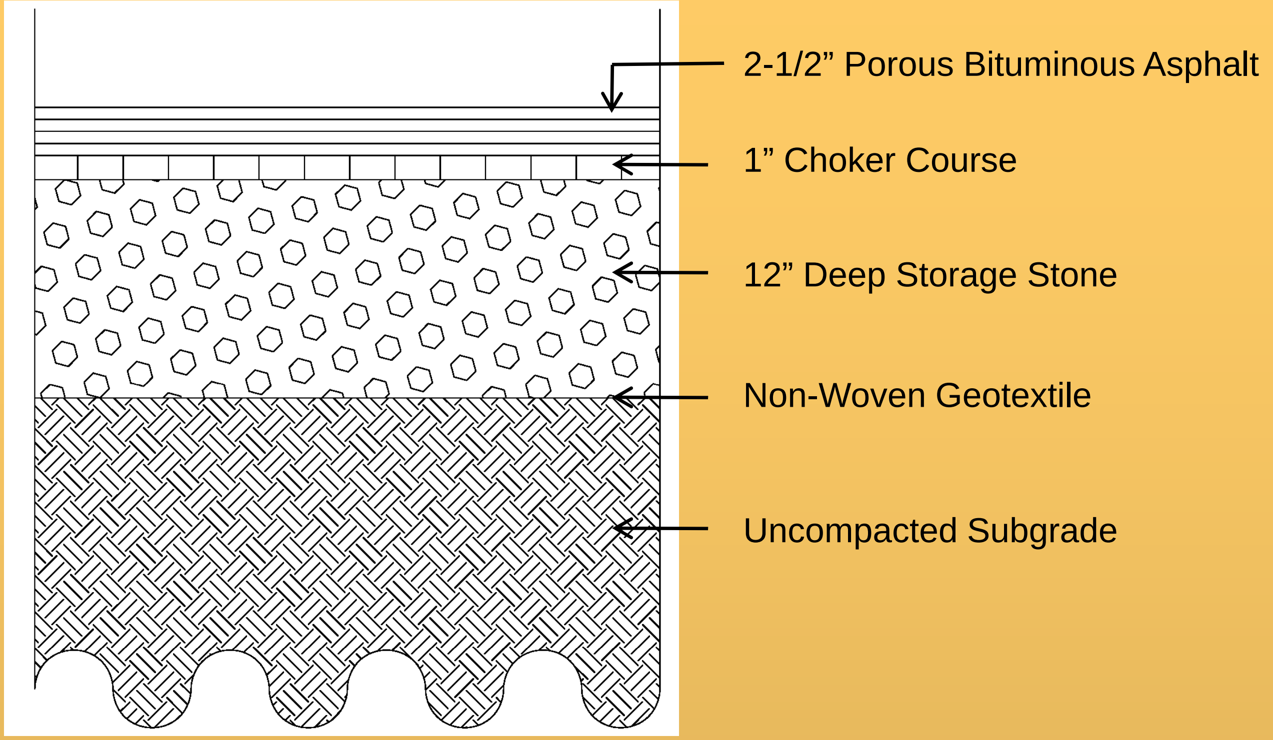
AHU-1 Design Ventilation Requirements

Zone	Min SA (CFM)	Floor Area (FT^2)	Required OA (CFM/FT^2)	Time Averaged Occupancy	Required OA (CFM/Person)	Air Distribution Effectiveness	Required OA (CFM)
Zone 1							
3-2 Class	500	780	0	20	20	0.8	500
Zone 2							
Commons	84	210	0.1	8	0	0.8	26
Zone 3							
Corridor	292	730	0.1	0	0	0.8	91
Data Closet	5	12	0.05	0	0	0.8	1
Electrical Closet	6	15	0	0	0	0.8	0
Entrance Vestibule	35	87	0.1	0	0	0.8	9
Janitors Rm	12	30	0.05	0	0	0.8	2
Mens Rm	60	150	0	0	50	0.8	0
Womens Rm	78	195	0	0	50	0.8	0
Mech	16	40	0.05	0	0	0.8	2
Zone 4							
Electrical	34	84	0.05	0	0	0.8	4
Pump Room	48	120	0.05	0	0	0.8	6
Zone 5							
Recycle	25	62	0.05	0	0	0.8	3
Zone 6							
Independent Lab	58	145	0	2	20	0.8	40
Zone 7							
K-2 Class	425	615	0	17	20	0.8	340
Zone 8							
Physics Lab	504	1260	0	20	20	0.8	400
Zone 9							
Physics Prep	100	225	0	4	20	0.8	80
Zone 10							
Workshop	250	590	0	10	20	0.8	200
Zone 11							
Lobby	442	1105	0.1	6	0	0.8	111
Zone 12							
Prep Storage	16	40	0.05	0	0	0.8	2
Toilet Rm	20	50	0	0	50	0.8	0
Prep Lab	108	270	0	2	20	0.8	40
Zone 13		11					
Robotics	500	1190	0	20	20	0.8	400
						Total	2257

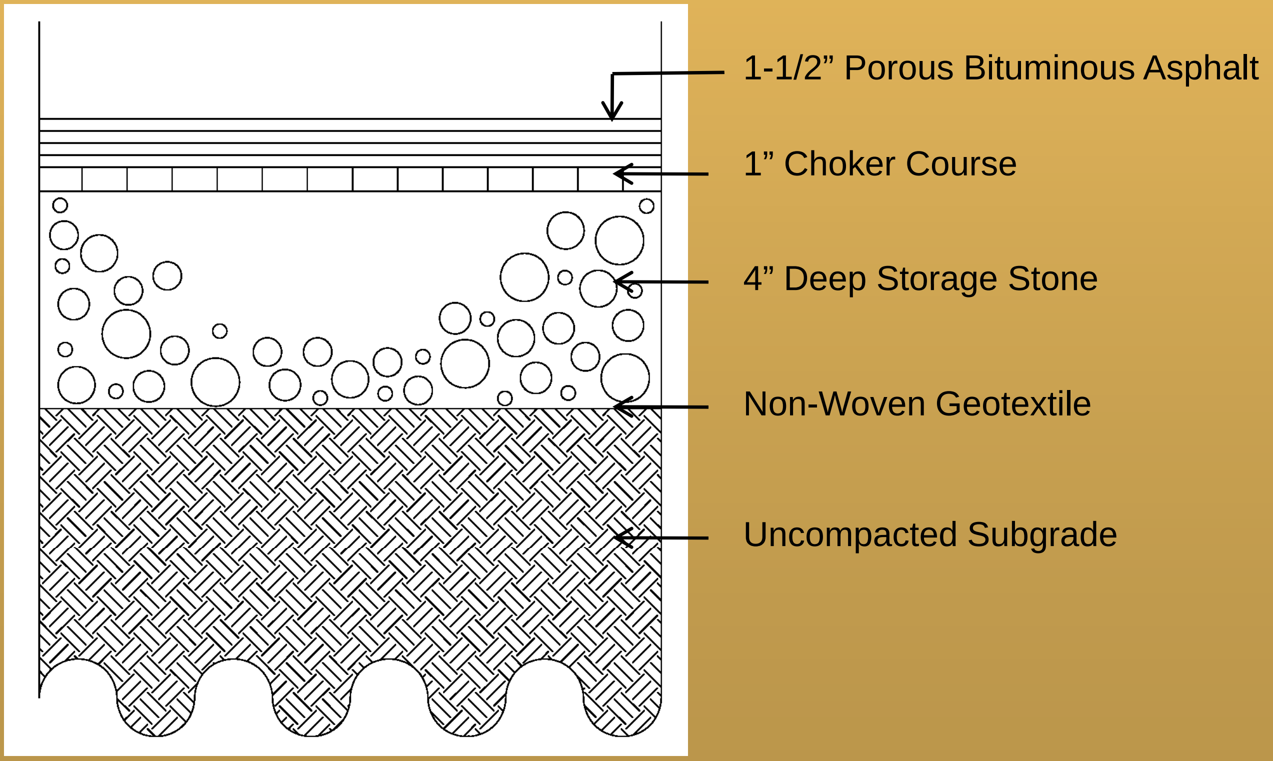
Appendix A
AHU-2 Design Ventilation Requirements

Zone	Min SA (CFM)	Floor Area (FT^2)	Required OA (CFM/FT^2)	Time Averaged Occupancy	Required OA (CFM/Person)	Air Distribution Effectiveness	Required OA (CFM)
Zone 1							
Bio Prep	84	210	0.1	4	0	0.8	26
Zone 2							
Biology Lab	532	1330	0	20	20	0.8	500
Zone 3							
Chem/Phys Prep	200	500	0	4	20	0.8	100
Zone 4							
Chem/Physics Lab	500	1220	0	20	20	0.8	500
Zone 5							
Conference Room	200	300	0	8	20		200
Faculty WC	25	62	0	0	50	0.8	0
Zone 6							
Corridor	340	850	0.1	0	0		106
Data Closet	5	12	0.05	0	0		1
Electrical Closet	6	15	0	0	0		0
Janitors	22	55	0.05	0	0		3
Unisex Toilet	31	77	0	0	50		0
Storage	16	40	0.05	0	0	0.8	3
Zone 7							
Individual Lab	106	265	0	2	20	0.8	50
Zone 8							
Office Suite	280	700	0	10	20	0.8	250
Zone 9							
Chem/Bio Lab	524	1370	0	20	20	0.8	500
						Total	2239

Appendix B

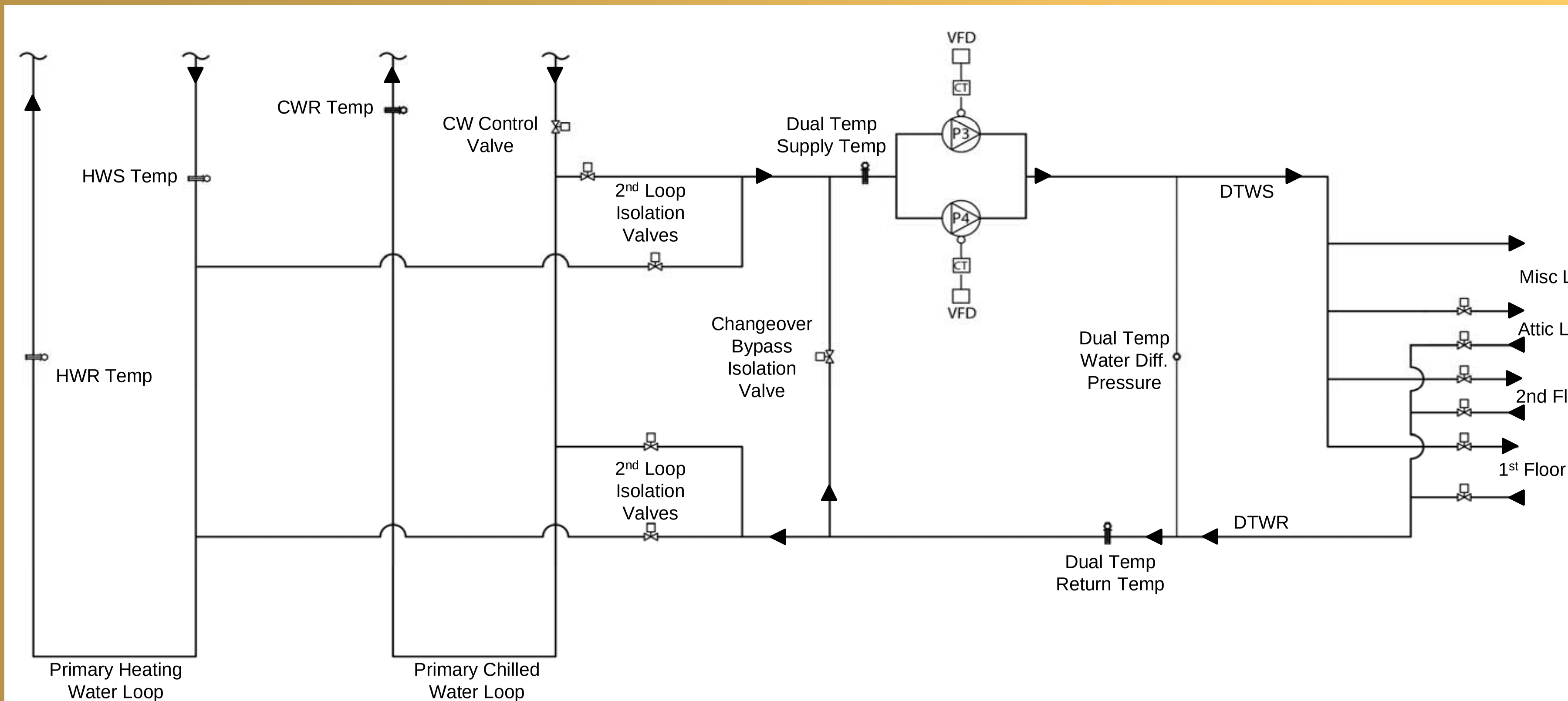


Porous Asphalt Paving



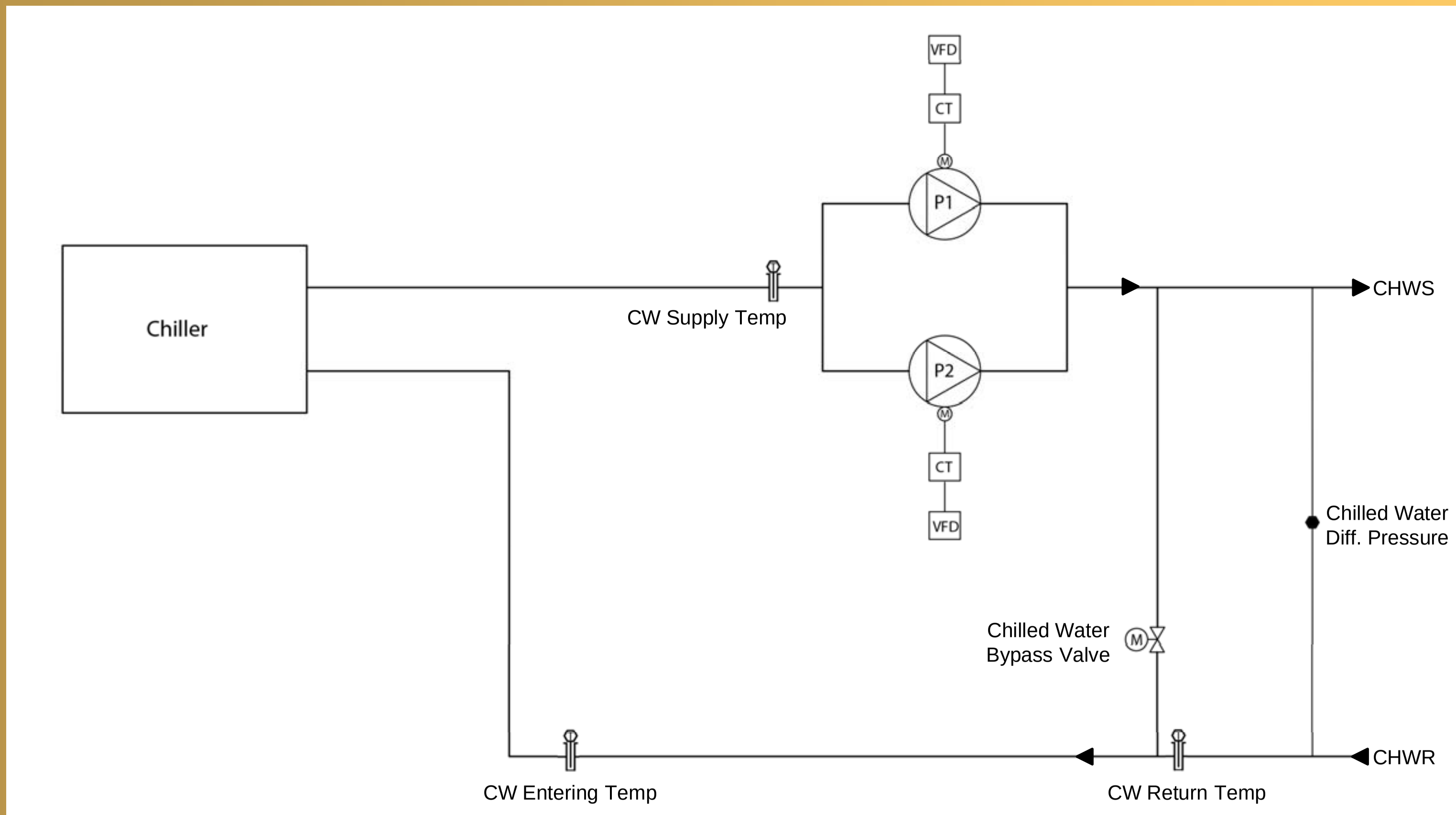
Porous Asphalt Walk

Appendix B



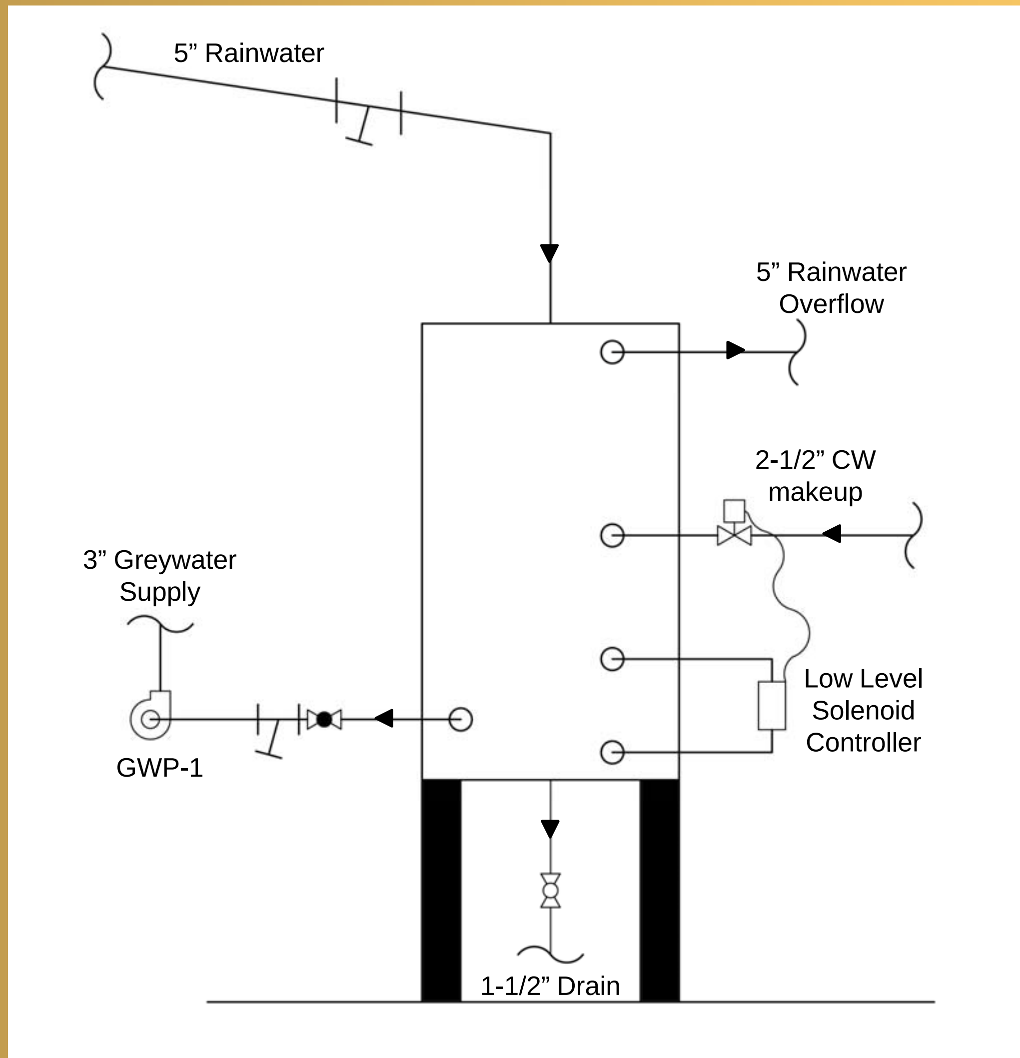
Dual Temperature System Control Diagram

Appendix B



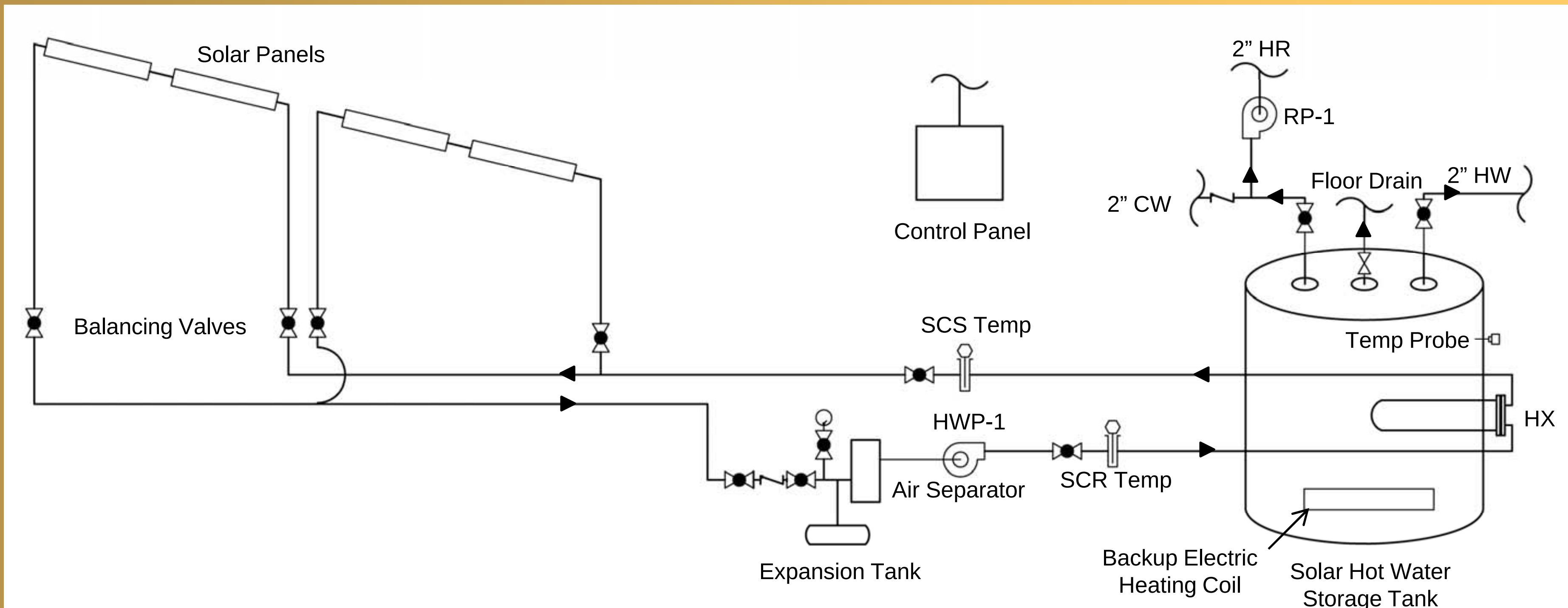
Air Cooled Chiller Control Diagram

Appendix B



Grey-Water Schematic Diagram

Appendix B



Solar Energy Collection Schematic

Appendix B

AHUs

	FAN/ELECTRICAL DATA																
	SUPPLY FAN				EXHAUST FAN					MAX COIL	AIR FILTERS		Energy Recover Wheel				
	TOTAL CFM	ESP (IN WG)	MAX FAN RPM	FAN HP	TOTAL CFM	ESP (IN WG)	MAX FAN RPM	FAN HP	MIN OA (CFM)	FACE VEL (FPM)	TYPE	EFF %	LAT (SUMMER)		LAT (WINTER)		WHEEL HP
													DB	WB	DB	WB	
AHU-1	6300	1.75	2635	7.5	4150	1.25	1660	5	2150	500	2"	30	79.3	67.1	47.6	39.9	1/4
AHU-2	8000	1.75	2439	10	4000	1.25	1636	7.5	4000	500	2"	30	79.3	67	47.8	40.1	1/4

	COOLING/HEATING COIL DATA															
	CHILLED WATER COOLING COIL										HOT WATER HEATING COIL					
	MIN NET CAP (MBH)		LAT (^{0}F)		EAT (^{0}F)		CHILLED WATER				MIN. NET CAP (MBH)	EAT (^{0}F)	HOT WATER			
	TOTAL	SENS	DB	WB	DB	WB	GPM	EWT	LWT	PD (FT)		DB	GPM	EWT	LWT	PD (FT)
AHU-1	191.6	146.3	55	54	76.5	64.3	36.8	44	54	0.9	51.7	62.4	9.3	120	100	0.6
AHU-2	265	191.8	55	54	77.2	65	55.6	44	54	7.2	98.5	58.6	12.4	120	100	1.2

	SUPPLY/EXHAUST FAN						
	SERVICE	LOCATION	CFM	ESP	FAN RPM	MOTOR HP	SONES
EF-1	Toilet Exhaust	Attic	1100	1.0	1853	0.5	83
EF-2	Fumehood Exhaust	Attic	730	1.0	1513	0.5	76
EF-3	Fumehood Exhaust	Attic	730	1.0	1513	0.5	76
EF-4	Fumehood Exhaust	Attic	730	1.0	1513	0.5	76
EF-5	Snorkel Exhaust	Attic	750	1.0	1528	0.5	76
EF-6	Snorkel Exhaust	Attic	750	1.0	1528	0.5	76
EF-7	Fumehood Exhaust	Attic	730	1.0	1513	0.5	76
EF-8	Fumehood Exhaust	Attic	730	1.0	1513	0.5	76
EF-9	Attic Ventilation	Attic	3600	0.5	1767	1.5	26
EF-10	Snorkel Exhaust	Attic	1050	1.25	1894	0.5	83
SF-1	Attic Ventilation	Attic	3600	0.5	1767	1.5	26

	CHILLER							
	TYPE	REFRIG TYPE	NOMINAL CAP. TONS	EER	Evaporator			
					EWT	LWT	GPM	WATER PD
CH-1	Scroll	R410A	144.4	9.7	54	44	345.3	7.5

Appendix B

PUMP SCHEDULE

	SERVICE	TYPE	GPM	HEAD (FT)	RPM	MOTOR HP
P-3	Dual Temp	End-Suction	93	45	1750	2
P-4	Dual Temp	End-Suction	93	45	1750	2
RP-1	HW Recirc.	In-line	2	5	3250	1/40
HWP-1	Glycol Recirc.	In-line	2	10	3250	1/25
GWP-1	Greywater System	Booster Pump	65	40	3250	2

P-1 and P-2 are 5 HP pumps rated for 48 FT head and are provide with chiller

EXPANSION TANK SCHEDULE

	LOCATION	H OR V	SERVICE	TYPE	VOLUME	DIA X L	CONNECTION SIZE	
							FILL	SYSTEM
ET-1	ATTIC	VERTICAL	HW	DIAPHRAM	10.3	15" X 15"	-	1"

SOLAR HOT WATER HEATER SCHEDULE

	WATTAGE	CAPACITY (GAL)	EWT	LWT
WH-1	4500	120	40	100

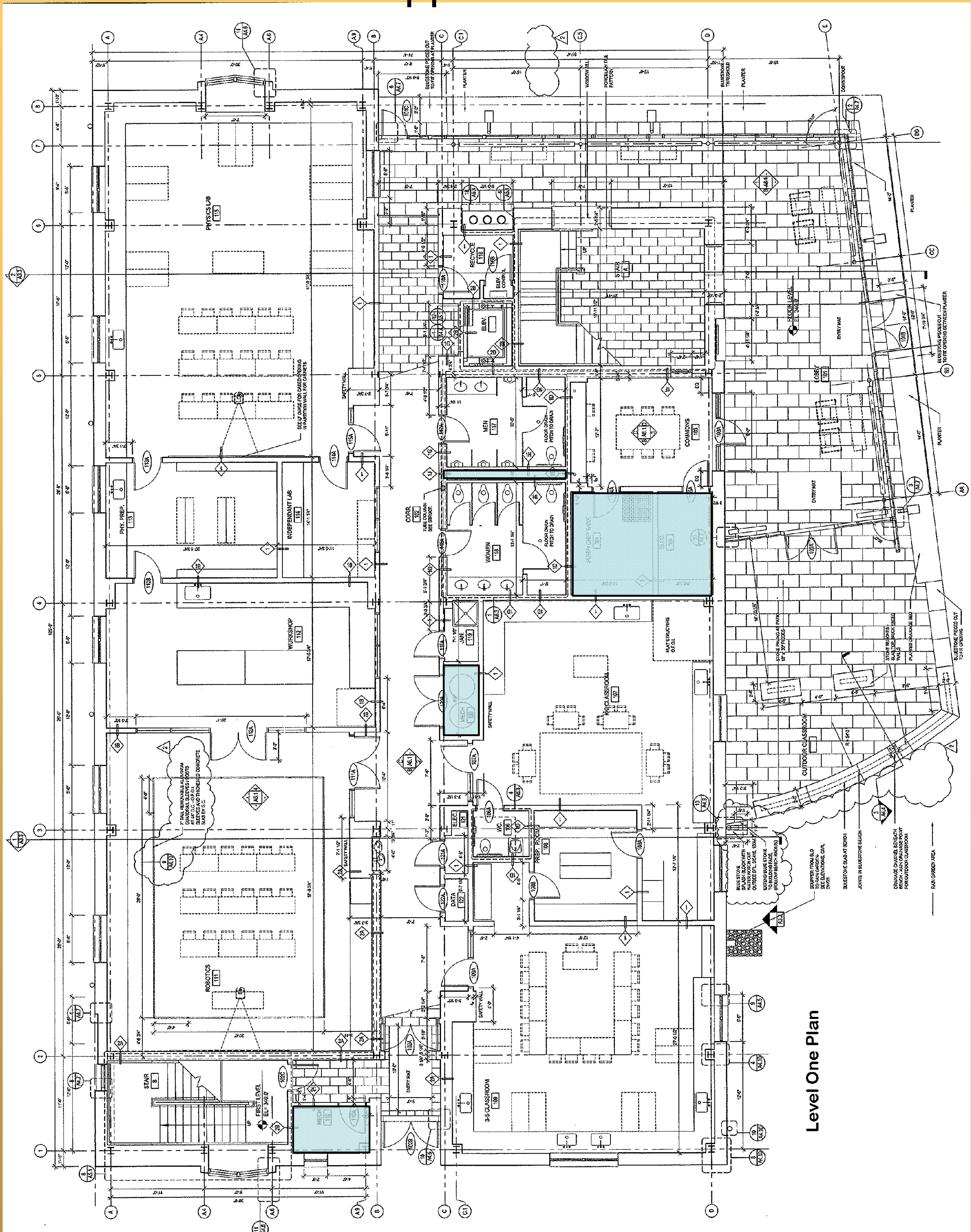
CABINET/UNIT HEATER SCHEDULE

	LOCATION	TYPE	FAN				HOT WATER COIL					
			CFM	RPM	HP	AMPS	MBH	EAT	GPM	WATER PD (FT)	EWT	LWT
CUH-A	Stair A	Recessed	300	1370	1/12	1.2	7.5	60	0.75	0.5	180	160
CUH-B	Stair A	Recessed	300	1371	1/12	1.2	7.5	60	0.75	0.5	180	160
CUH-C	Entrance Vestibule	Recessed	300	1372	1/13	1.2	7.5	60	0.75	0.5	180	160
CUH-D	RM 207	Recessed	300	1373	1/14	1.2	7.5	60	0.75	0.5	180	160
UH-1	Attic	Horizontal	750	900	1/20	1.8	36.2	30	2.7	-	180	160
UH-2	Attic	Horizontal	750	900	1/20	1.8	36.2	30	2.7	-	180	160

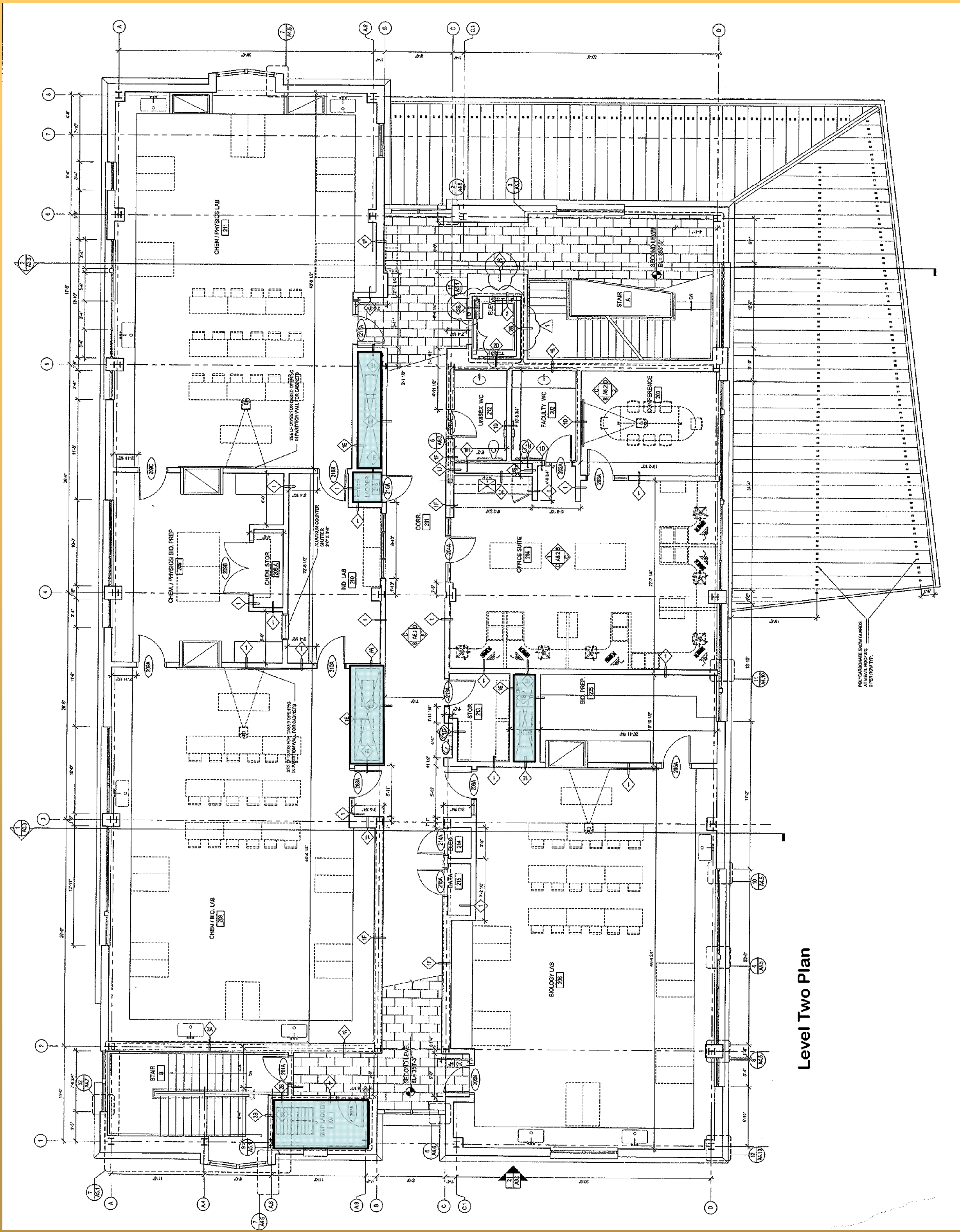
FIN TUBE CONVECTOR SCHEDULE

	ELEMENT					WATER				
	TUBE SIZE	FINS / FT	FIN THICK	FIN LENGTH	BTUH/LF @ 170^{0}F AWT	MBH	EWT	LWT	EAT	GPM
FTC-1	3/4	40	0.02	10	440	4.4	180	160	60	0.5
FTC-2	3/4	40	0.02	4	210	3.4	180	160	60	0.3

Appendix C



Appendix C



Appendix D

Yes	?	No				
5	6	7	**Energy & Atmosphere**			17 Points
Yes			Prereq 1		**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 1		**Minimum Energy Performance**	Required
Yes			Prereq 1		**Fundamental Refrigerant Management**	Required

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

Yes	?	No				
2	5	5	Credit 1		**Optimize Energy Performance**	1 to 10
				Credit 1.1	10.5% New Buildings / 3.5% Existing Building Renovations	1
			-->	Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
				Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
				Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
				Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
				Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
				Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
				Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
				Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
				Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
1	1	1	Credit 2		**On-Site Renewable Energy**	1 to 3
			-->	Credit 2.1	2.5% Renewable Energy	1
				Credit 2.2	7.5% Renewable Energy	2
				Credit 2.3	12.5% Renewable Energy	3
1			Credit 3		**Enhanced Commissioning**	1
1			Credit 4		**Enhanced Refrigerant Management**	1
	0		Credit 5		**Measurement & Verification**	1
		1	Credit 6		**Green Power**	1

Yes	?	No			
8	4	3	**Indoor Environmental Quality**		15 Points
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			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