EXISTING CONDITIONS REPORT

LANDSCAPE BUILDING

AT

JANELIA FARM
HOWARD HUGHES MEDICAL INSTITUE

ASHBURN, VIRGINIA

PREPARED FOR
DR. BAHNFLETH
BY
JULIE THORPE
MEHCANICAL OPTION
NOVEMBER 21, 2005

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EXECUTIVE SUMMARY

The Landscape Building at Janelia Farm Research Campus is a 546,436 square foot world-class biomedical research facility owned by Howard Hughes Medical Institute. The facility is built into the side of a large hill overlooking the Potomac River on the grounds of the history Janelia Farm Mansion. It is currently beginning its third year of construction in Ashburn, Virginia located 45 minutes outside of Washington, D.C.

This report looks into the design of the mechanical system by analyzing the system starting at the conceptual phase through competition and operation if possible.

The primary design requirement is to separate the mechanical and electrical systems and equipment from the laboratory, office, and other primary occupied spaces was the principal design consideration. HHMI researched and studied many other scientific campuses around the world, such as the Medical Research Council Laboratory of Molecular Biology (MRC LMB) in Cambridge, England, Cold Spring Harbor Laboratory, the European Molecular Biology Laboratory, the Carnegie Institution of Washington's Department of Embryology, and AT&T's Bell Laboratories in Murray Hill, New Jersey. After concluding existing building studies, HHMI determined that in order for the scientists and researchers to perform at the highest levels, it would be necessary to locate all mechanical and electrical equipment and controls to isolated areas. This allows maintenance to be done without entering laboratory or office space and therefore, research can be continued uninterrupted.

In addition to the owner's requirements, the engineers followed ASHRAE design standards and The National Institutes of Health's HVAC Design Requirements. The latter have a medical facility focus that is applicable to the Landscape Building.

The mechanical system used central boiling and chiller plants to condition air for the variable air volume (VAV) distribution system. Due to the nature of the building, 100 percent outdoor air is required to decrease the risk of contamination. Supply air must pass through a prefilter and filer on the upstream side with efficiencies of 30% and 95% respectively, based on ASHRAE Standard 52-76. The system has pressure-independent hot water terminal reheat devices and individual laboratory and office area temperature zone control. It is also designed to maintain the proper temperature, humidity, differential pressure, outdoor air exchange rate, and acoustic criteria within the building.

The laboratory spaces are arranged with supply air distributed by multiple air handlers to ensure that fresh air is supplied 100% of the time. This concept is also applied to the exhaust fans. If one piece of equipment is not working properly or needs to be serviced, the load can be transferred to other equipment. The ventilation rates must be sufficient to remove and/or dilute volatile compounds present in the laboratory spaces. Concentrations can be determined using methodology found in National Institutes of Health's (NIH) HVAC Requirements.

DESIGN OBJECTIVES & REQUIREMENTS

BACKGROUND

The Landscape Building at Janelia Farm Research Campus is a 546,436 square foot world-class biomedical research facility owned by Howard Hughes Medical Institute. The facility is built into the side of a large hill overlooking the Potomac River on the grounds of the history Janelia Farm Mansion. It is currently beginning its third year of construction in Ashburn, Virginia located 45 minutes outside of Washington, D.C.

SYSTEM LOCATION

The need to separate the mechanical and electrical systems and equipment from the laboratory, office, and other primary occupied spaces was the principal design consideration. HHMI researched and studied many other scientific campuses around the world, such as the Medical Research Council Laboratory of Molecular Biology (MRC LMB) in Cambridge, England, Cold Spring Harbor Laboratory, the European Molecular Biology Laboratory, the Carnegie Institution of Washington's Department of Embryology, and AT&T's Bell Laboratories in Murray Hill, New Jersey. After concluding existing building studies, HHMI determined that in order for the scientists and researchers to perform at the highest levels, it would be necessary to locate all mechanical and electrical equipment and controls to isolated areas. This allows maintenance to be done without entering laboratory or office space and therefore, research can be continued uninterrupted.

As seen in the first floor rendering below, the light gray band below is the service corridor. All rooms below that corridor are mechanical space and the majority of rooms shaded gray are mechanical space as well.

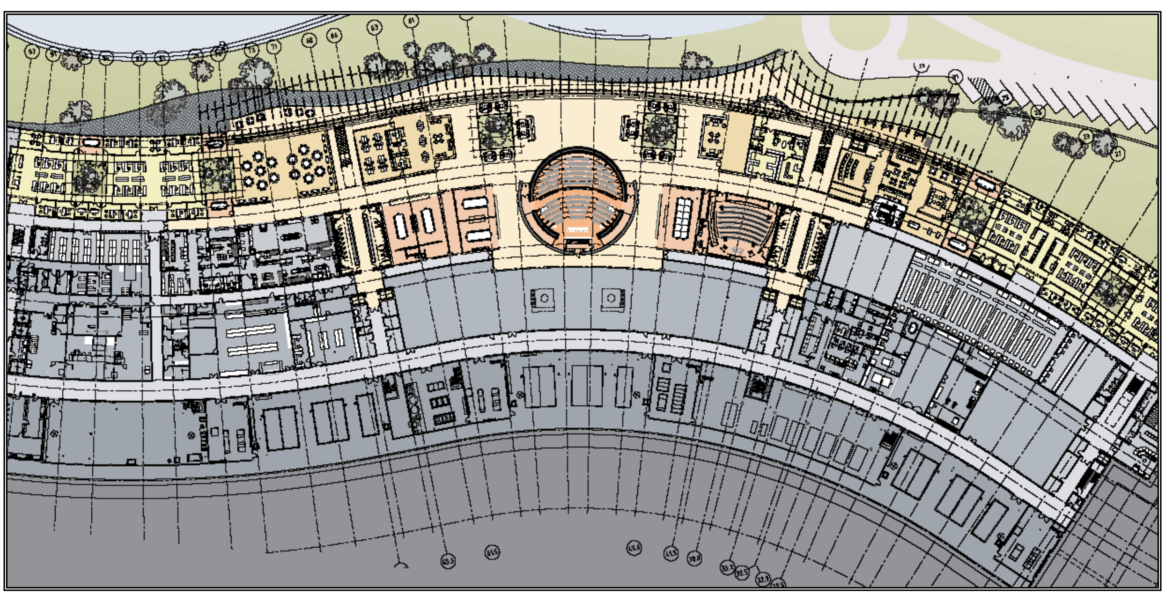


Figure 1

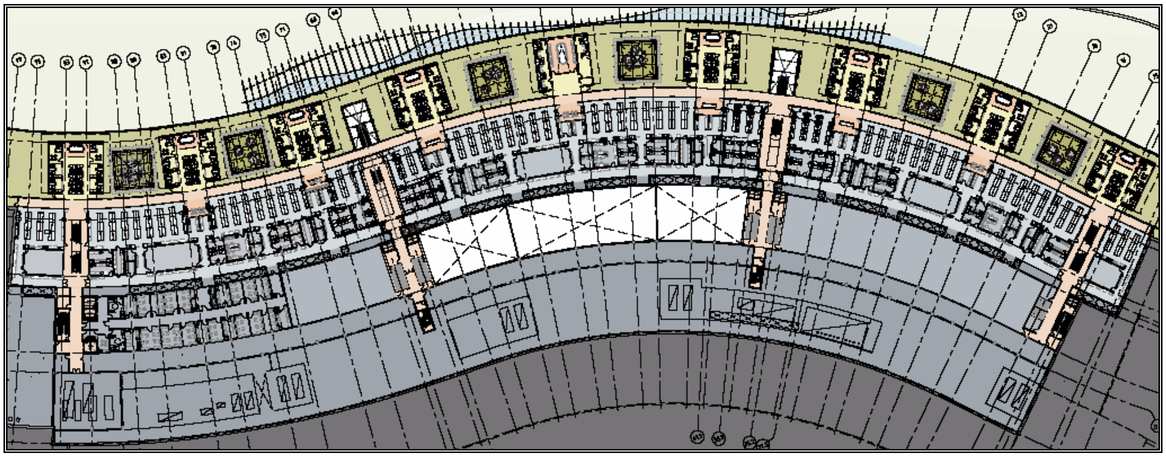


Figure 2

The bottom fourth of the second floor is completely dedicated to mechanical systems. The third floor is almost identical to the second. Some of the spaces are two stories in height. Approximately 220,235 square feet of useable space is dedicated to mechanical systems. This is 49.5% of the building's total area. Clearly HHMI was more concerned about providing an excellent working environment for the medical experts than the cost of using so much space for systems.

Floor	Mechanical Area [sf]	Total Area [sf]	Percent Lost
First	147,773	240,461	61.5
Second	46,049	122,649	37.5
Third	26,413	82,013	32.2
Total	**220,235**	**445,123**	**49.5**

Table 1

DESIGN OBJECTIVES

The mechanical system used central boiling and chiller plants to condition air for the variable air volume (VAV) distribution system. Due to the nature of the building, 100 percent outdoor air is required to decrease the risk of contamination. Supply air must pass through a prefilter and filer on the upstream side with efficiencies of 30% and 95% respectively, based on ASHRAE Standard 52-76. The system has pressure-independent hot water terminal reheat devices and individual laboratory and office area temperature zone control. It is also designed to maintain the proper temperature, humidity, differential pressure, outdoor air exchange rate, and acoustic criteria within the building.

The laboratory spaces are arranged with supply air distributed by multiple air handlers to ensure that fresh air is supplied 100% of the time. This concept is also applied to the exhaust fans. If one piece of equipment is not working properly or needs to be serviced, the load can be transferred to other equipment. The ventilation rates must be sufficient to remove and/or dilute volatile compounds present in the laboratory spaces. Concentrations can be determined using methodology found in National Institutes of Health's (NIH) HVAC Requirements.

The multimillion dollar mice are the center of ground-breaking bio-medical research. Their living environment must be maintained with precision to ensure their health and accurate test result.
The required air flow to the Vivarium spaces is not based on occupancy or space type, but the necessary air changes per hour. In addition, the animals housed in the Vivarium require warmer temperatures than do people. Accordingly, the supply air must be reheated to 64^{o}F supplied 24 hours per day. Individual control is provided to each holding room, treatment room, procedures room, and operating room. The Vivarium facilities are serviced by AHU-1, AHU-2, and AHU-3(back-up) that run in parallel to heat, ventilate and provide air-conditioning. The arrangement with stand-by equipment ensures continuous operation during equipment failure and scheduled maintenance.
The space requires HEPA filters because the animals will be involved in chronic testing. Supply air is introduced through high-volume and uniformly drawn across the holding areas to provide uniform mixing. It is important to ensure that the system does not create drafts on the animals. Ventilation Design Handbook on Animal Facility and Animal Facility design published by NIH and ASHRAE Application Handbook were used to design the Vivarium system.

Mechanical, electrical, elevator machine, boiler, and cage wash equipment spaces are conditioned to ensure worker comfort, to increase equipment life, and to avoid excessive heat gains/losses to adjacent occupied areas.

In compliance with NFPA Standard, 90A exhaust ducts are not located in the same shaft supply and/or return air ducts. All toilet and general exhaust is discharged using systems in independent of the lab exhaust systems. For information about exhaust and/or supply duct material, please see Table 2 based on NIH Requirements.

NIH has developed recommended NC levels based on years of experience for spaces common in hospitals and medical research facilities. NC levels are based on rooms not being occupied and with all use equipment turned off. Values can be found in Table 3 on the following page. The separation of mechanical equipment the in rear of the building helps to reduce sound transmission into occupied spaces.

Minimum Duct Construction Standards			
Application	**SMACNA Pressure Classification**	**Materials of Construction**	**Field Pressure Testing**
Low-pressure Supply Ductwork	498 Pa POS	Galvanized Steel	No
Medium-Pressure Supply Ductwork Upstream of Terminal Units	1494 Pa POS	Galvanized Steel	Yes
Low-pressure Supply Ductwork Downstream of Terminal Units	498 Pa POS	Galvanized Steel	No
Low-Pressure Outdoor, Relied, Return Air Ductwork	498 Pa POS	Galvanized Steel	No
Medium-Pressure Return Ductwork Downstream of Terminal Units	747 Pa NEG	Galvanized Steel	Yes
Low-Pressure General Exhaust Ductwork	498 Pa NEG	Galvanized Steel	No
Low-Pressure Wet Process Exhaust Ductwork	498 Pa NEG	Aluminum or Stainless Steel	No
Low-Pressure Hazardous Exhaust Ductwork Upstream of Terminal Unit	498 Pa NEG	Epoxy-Coated Galvanized Steel or Stainless Steel	No
Medium-Pressure Hazardous Exhaust Ductwork Downstream of Terminal Units	Class I/Indust. 1494 Pa NEG	Epoxy-Coated Galvanized Steel or Stainless Steel	Yes
Special Hazard Exhaust Ductwork	747 Pa NEG	Stainless Steel	Yes

Table 2

Recommended NC Levels	
Area	**NC Level**
Auditoriums	20-25
Audiology Suites, Audio/Speech, Pathology, Phonology/Caridac	25
Chapel, Capel Mediations	25
Private Residences	25-30
Conference Rooms	25-30
Hospital Rooms	25-35
Patient Rooms	35
Executive Offices	30-35
Open-Plan Offices	35-35
Dinning Rooms, Offices, Lobbies	40
Central Sterile, Food Service/Serving	45
Operating Rooms	40-45
Research Laboratories	40-45
Corridors	45
Kitchen, Lockers, Warehouse, Shops	50
Research Animal Housing Areas	--

Table 3

SYSTEM DESIGN & OPERATION

In addition to the above discussion, more system design and operation information is discussed below.

AIR SYSTEMS

The Landscape Building is served by 15 identical custom type 45,000cfm air handling units; 14 primary and one back up. All 15 air handling units feed into one plenum which then serves the entire building using a primarily variable air volume system. AHU-1 and AHU-2 are separated from the rest of the air handlers by mechanical dampers. They serve the Vivarium during typical operations with AHU-3 serving as back-up. AHU-4 thought AHU-15 serve the rest of the building through one plenum. If needed, AHU-3 can also be connected in parallel with the rest of the units. Lab and Vivarium spaces will receive 100% outdoor air and pass through 30% efficient prefilters, 95% efficient final filters, energy recovery coils, direct injection steam humidifiers, chilled water cooling coils, and single plenum0type fans. The supply fans operate at 88.5 BHP and the AHU supply temperature is 45.8°F.

As mentioned above, the air handling units are connected to one main plenum so that a minimum of 67% capacity can be maintained in the case of equipment failure or maintenance.

Ductwork reaches each occupied level through a network of riser ducts in mechanical shafts. All supply ducts are made of galvanized, insulated sheet metal. Fume hood branches are welded stainless steel and all other exhaust ducts are galvanized steel.

Outdoor air inlet dampers in each plenum open to bring in outdoor air to mix with exhaust air to maintain a constant discharge velocity from each exhaust stack with exhaust air volume demand decreases. Each exhaust plenum will maintain at least 67% efficiency in the case of equipment failure. All radio-chemistry or perchloric acid hoods are located on the third level of the Landscape Building and are equipment with dedicated direct exhaust to the roof.

All occupied spaces are equipped with climate control which is accomplished by variable air volume terminal unit and reheat coil. Air volumes are throttled to minimum flow rate before the reheat coils are activated to heat the space. Fan powered air terminal units with reheat coil are installed in the office areas where occasional, minimal cooling requirements would result in air flows that are sufficiently low to cause air quality problems.

Air inlets for the Atrium space will be low and relief vents located as high as possible to promote natural convection. This will reduce annual energy consumption during cooling.

Smoke control systems are provided to meet codes. Stairwell pressurization is provided were required.

CHILLED WATER & STEAM

The estimated demand for each utility is 23,210 kW (6600tons) for chilled water and 26,000 kW (100,000 lb/hr) for steam. The chilled water and steam enters the lower level of the Landscape Building via the utility tunnel. There is a two-stage pressure-reducing station that supplies medium pressure steam for sterilizers, washers, and other scientific equipment. Secondary chilled water and return chilled water from air handling unit cooling coils are used for lab equipment cooling and environmental room condensers.

HYDRONIC HEATING

Heat exchangers provide hot water for variable and constant air volume terminal reheat coils and cabinet heaters and convectors. These are used for secondary heating throughout the building. There are dedicated circulation variable frequency drive for each heat exchangers as well as one redundant heat exchanger/pump combination.

BOILER PLANT

The boiler plant contains three boilers and room for an addition of a fourth. Two have a capacity of 50,210 MBH and on is 30,125 MBH, a total energy input is 163,181 MBH, and an efficiency of 80%. They make 80 lbs steam and convert it to 15 lbs steam when needed. In general, two boilers run in any combination to meet desired load. The majority of the steam generated by the boilers is used by the air handler steam coils. Any remaining steam is used with the shell and tube heat exchangers (see TableA.8) XR-1 and XR-2 (back-up) are used to heat water that is pumped to reheat coils in the VAV boxes and XR-3 and XR-4 (back-up) used to heat water that is pumped to the radiant flooring in the lobby area.

CHILLER PLANT

There are six w/c centrifugal chillers and one back up that have full load capacity of 1,200 tons. The full load LCHWT and ECWT are 42.0°F and 85.0°F respectively. The full load power is 0.670 kW/ton. The condenser flow rate is 2,400 gpm and pressure drop of 13.0 ft. Any remaining capacity is used for various equipment, such as, the fan coil units in the data center room.

OUTDOOR & INDOOR DESIGN CONDITIONS

OUTDOOR DESIGN CONDITIONS

Design Weather Data	
Location	Washington, D.C.
Latitude	38.0^{o}
Longitude	77.0^{o}
Time Zone	5
Elevation	14 ft
Barometric Pressure	29.9 in Hg
Air Density	0.0760 lb/cf
Air Specific Heat	0.2444 Btu/lb-^{o}F
Density-Specific Heat Poduct	1.1146 Btu/h-cfm-^{o}F
Latent Heat Factor	4,906.9 Btu-min/h-cf
Enthalpy Factor	4.5604 lm-min/hr-cf
Summer Design Dry Bulb	95^{o}F
Summer Design Wet Bulb	78^{o}F
Winter Deisgn Dry Bulb	-10^{o}F
Summer Clearness Number	0.85
Winter Clearness Number	0.85
Summer Ground Reflectance	0.20
Winter Ground Relectance	0.20

Table 4

The outdoor deisgn conditions were provided by the mechanical engineer with the load calculations. Data is not available for Ashburn, Virginia. Washington, D.C. is the closet location where weather data could be found. It is possible that the winters are slightly colder than indicated by this above data suggests because DC generally records warmer temperatures than the surrounding areas.

INDOOR DESIGN CONDITIONS

Design Indoor Conditions				
Space	Supply Air T_{DB} °F		Plenum Air TDB °F	
	Cooling	Heating	Cooling	Heating
Data Center	55.0	72.1	74.0	72.0
Factory Zone	55.0	72.1	78.3	73.1
Front Support	55.0	104.4	74.5	72.0
Lab Support	55.0	72.1	77.5	75.0
Office Pods	55.0	125.0	75.6	67.3
Open Labs	55.0	94.8	76.2	73.9

Table 5

The data in the above table was taken from the load calculations provided by the mechanical engineer. It is important to note that the supply air dry bulb during cooling for the office pods and front support are significantly higher than the rest of the spaces. This can be attributed to more concentrated occupancy and sedentary activity levels.

The space conditions as provided by the mechanical engineer can be summarized by the following:

For tissue or special procedure rooms:

- T_{db} = 69.8°F (summer & winter)
- RH = 50% (summer)
- RH = 30% (winter)

Other spaces:

- T_{db} = 73.4°F
- RH = 50% (summer)
- RH = 30% (winter)

Vivrarium conditions will vary in accordance with NIH Guidelines. Please see page 6 for more information.

DESIGN HEATING & COOLING LOADS

BASED ON MECHANICAL DESIGN REPORTS SUBMITTED TO HHMI

In order to calculate the heating and cooling loads for the Landscape Building using Carrier's Hourly Analysis Program 4.20A (HAP), the following assumptions were made.

- The nearest location to the Landscape Building in Ashburn, VA is Washington, D.C. The weather data for Washington is adequate for simulating heating and cooling loads.
- The glass doors have the same U-value and shading coefficient as the windows.
- U-values for unknown doors have been assumed.
- HAP has a maximum depth below grade of 50ft. The back wall of the first floor is greater than 60ft below grade. I am assuming that 50ft below grade is acceptable distance.
- Where the depth below grade changes, the average depth is used in the HAP calculation.
- A space above conditioned space cannot be modeled as below grade in HAP. For all spaces below grade and above conditioned space, I am treated exterior walls as interior. This is as close an approximation that can be made.
- The 900 foot long south wall bordering the parking lot is technically an exterior wall, but it does not have a solar load because it is underground. If modeled in HAP as exterior, it will receive solar loads. Instead the parking lot will be modeled as an unconditioned space with temperature minimums and maximums equivalent to those of the climate.
- The majority of exterior walls are glass. HAP does not have a "glass wall" feature. The window area is as close to the total wall area as possible.
- Occupancy has not been assigned to the day care center. I am assuming ten children and one teacher per room, plus two people in the administrative offices.
- A fan/thermostat schedule was not available from the mechanical engineer. It has been assumed to be the same as the major occupancy schedule: office. "Occupied" status is between 8:00am and 4:00 pm during normal working hours every day of the year. This is because people live at this facility and can work any day. "Unoccupied" status is given to all other times.
- "Medium" building weight has been assumed.
- "Office work" is the assumed activity level.
- No infiltration due to positive pressurized building designed to keep contaminated air from entering.
- No miscellaneous loads lave assumed.
- Equipment loads were provided by the engineer and assumed to be accurate.

The assumptions are included to explain why the loads calculated by HAP shown in Table 6 are only 77.5% of the design load.

HAP Output Loads vs Design Loads						
	Capacity [MBH]	**Supply [cfm]**	**Ventilation [cfm]**	**Cooling [sf/ton]**	**Supply[cfm/sf]**	**Ventilation [cfm/sf]**
HAP Output	31,761	335,969	336,772	168	0.76	0.76
Design Data	44,828	630,000	567,000	Unknown	1.15	1.04

Table 6

Design Airflow Quantities								
Space	**System Type**	**Outside Airflow [cfm]**	**Cooling Airflow [cfm]**	**Heating Airflow [cfm]**	**Return Airflow [cfm]**	**Exhaust Airflow [cfm]**	**Auxiliary System Airflow [cfm]**	**Room Exhaust Airflow [cfm]**
Data Center	CRU	400	171,298	171,298	171,298	400	0	0
Factory Zone	VAV Reheat	79,049	79,049	23,715	79,049	79,049	0	79,049
Front Support	VAV Reheat	83,620	100,601	96,232	100,601	83,620	0	83,636
Hotel	VAV Reheat	7,200	29,555	8,867	29,555	29,555	0	0
Lab Support	VAV Reheat	184,086	184-86	55,226	184,086	184,086	0	184,086
Office Pods	VAV Reheat	4,350	42,226	21,004	42,226	4,350	0	4,350
Open Labs	VAV Reheat	140,556	140,556	48,032	140,556	140,556	0	160,106

Table 7

Design Load									
Space	**%OA**		**cfm/sf**		**cfm/ton**	**sf/ton**	**Btu/hr-sf**		**No. People**
	Cooling	**Heating**	**Cooling**	**Heating**			**Cooling**	**Heating**	
Data Center	0.2	0.2	34.26	34.26	532.06	15.53	772.69	-13.62	20
Factory Zone	100	333.3	0.88	0.26	129.45	147.82	81.18	-74.25	361
Front Support	22.4	74.7	0.81	0.24	301.57	370.16	32.42	-32.59	142
Lab Support	100	333.3	2.86	0.86	129.47	45.22	265.37	-242.91	184
Office Pods	10.3	20.7	1.02	0.51	329.92	324.02	37.03	-46.85	290
Open Labs	100	292.6	1.58	0.53	137.41	87.12	137.65	-150.54	356

Table 8

As it can be see in Tables 7 & 8, the cooling load is the controlling factor for system sizing. The exhaust air is 100 percent for the factory zone, lab support, and open lab space. This is in accordance with system design requirement discussed on page 6.

UTILITY RATES & ANNUAL COSTS

UTILITY RATES

Electric service is provided by Dominion Virginia Power. Table 9 shows the expected rates for the Landscape Building. Natural Gas is provided by Washington Gas. The rates can be seen in Table 10. All data has been provided by the mechanical engineer and was used in the actual energy analysis.

Electricity Cost Summary	
Energy Charges	
On-peak	$0.05599 per kWh
Off-peak	$0.03166 per kWh
Supply Charge	
On-peak	$1.17150 per kW
Off-peak	$0.6320 per kW

Table 9

Natural Gas Cost Summary	
Distribution Charge	
Flat Price	$0.570 per therm

Table 10

ANNUAL ENERGY COST

As can be seen in Table ___, the total energy cost was calculated to be $957,719 where the actual cost has been estimated to be $3,533,903. The calculated value is only 27.9% of the design cost. These differences can be attributed to inputs available and assumptions made during analysis. Information such as fenestration area and floor to floor heights were estimated, it is impossible to expect similar results as the design analysis. Also, several large assumptions were made to simplify the building to make the calculation process simpler. These assumptions may be a source of inaccuracy.

Calculated Annual Costs	
Component	**[$]**
All System Fans	13,200
Cooling	180,206
Heating	25,138
Pumps	6,344
Cooling Tower Fans	86,182
HVAC Sub-Total	**311,070**
Lights	93,700
Electric Equipment	552,949
Non-HVAC Sub-Total	**646,649**
Total	**957,719**

Table 11

Design Monthly & Yearly Utility Cost ($)													
Utility	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Total**
Electric On-Pk Cons.	45,699	41,446	54,189	51,093	71,492	66,813	65,308	69,562	54,014	55,654	50,639	43,623	669,531
Electric Off-Pk Cons.	39,436	35,602	37,314	41,977	49,460	65,220	79,925	67,659	61,774	40,661	38,575	40,981	598,584
Electric On-Pk Demand	150,149	150,149	150,149	150,149	150,149	150,149	150,149	150,149	150,149	150,149	150,149	150,149	1,801,788
Gas On-Pk. Cons.	55,514	47,800	33,936	24,322	19,547	18,403	18,892	19,332	19,258	26,482	31,231	46,141	360,858
Water On-Pk Cons.	36	36	1,676	3,757	13,087	19,294	24,290	14,059	20,513	3,945	2,414	36	103,142
Based on Revised Occupancy Schedules												**Total**	**3,533,903**

Table 1

COST & SITE FACTORS

HISTORICAL CONSIDERATIONS

Janeilia Farm is a 281 acre farm which features a "modified French-style manor" built in 1936 by a Philip Smith from Smith and Walker of Boston. It is one of Virginia's last country estates based on European country manors. The house is protected by the National Trust for Historic Preservation. Also, the view of Sugarloaf Mountain in Fredrick County Maryland from the dinning room window is also protected. Therefore, any building on this site needed to preserve both the house and the view. Accordingly, architect Rafael Vinoly's designed the building to be underground. The view of the mountain is framed by the 4 exhaust stacks. This can be seen in the rendering below.

Figure 3

As a result of the building being underground, the designers found it appropriate to use green roof technology. Every roof surface excluding the office pod roofs is a green roof. The architect requested that there be no punctures in the roof except the four exhaust stacks. This required all laboratory exhaust to be routed either to the central stacks or to the east or west perimeters of the building.

Initially, the architect requested that the chiller plant be completely separate from the Landscape Building at a more remote location on the site. After cost analysis, it was determined that it would be too expensive to have the chiller plant located far away and it was moved directly next to the building.

A cogeneration plant was considered and designed, but it was determined to be too expensive, and value engineered out of the design.

OPERATING HISTORY

The building is not yet completed and therefore does not have an operating history.

CRITIQUE OF SYSTEM

Program Evaluation

The mechanical system successfully accomplishes the goals of the building program. One primary goal of the owner and architect was to separate the mechanical and electrical systems and equipment from the laboratory, office, and other primary occupied spaces was the principal design consideration. If any piece of equipment requires maintenance, there is no need for building staff to interrupt work being done in the offices or research laboratories. Economically, this building requirement dramatically increased the cost of the building. Almost 50 percent of the building area is dedicated to mechanical systems or for future equipment. This is almost excessive, but on this point the Howard Hughes was more interested in function than cost.

Building orientation has a large impact on the mechanical system. Due to the fact that the only exposed side of the building is on the north side, solar loads are minimized while maintaining natural light and scenic views. Also, because the building is located underground and has a green roof, it is subject to much more subtle exterior temperature gradients than typical buildings.

System Evaluation

The system adequately meets all ASHRAE requirements analyzed up to this point. The system also follows the stricter guidelines developed by the National Institutes of Health. On these points, the system is successful.

There are major flaws that stem from issues during the design phase of the project. The main problem is that the design was bid out at about 75 percent completions. According to the project engineer, this has led to extensive redesign on site due to incomplete design or space conflicts with other building components. For a system that cost so much money, problems such as these should have been kept as infrequent as possible. Also, the contractors have indicated that the system is greatly oversized. For example, only the 30,125MBH boiler is needed for operation, while the 2-50,210 MBH are not needed. If the contractors are correct, this is a huge cost that could have been avoided had the system been designed more completely before being bid.

In terms of energy, the Landscape Building mechanical system has much to be desired. The design annual energy bill is $3 million. The design team has an obligation to design an energy conscious system within the owner's constraints. Again, had the system been farther along in the design process when bid, it is possible that the engineers could have looked more closely into energy saving concepts.

The saving grace of the building's mechanical system is the focus on sustainable design. HHMI stressed achieving gold rating which resulted in innovative design in some areas. More information on the LEED rating can be found in Appendix B on page 27.

REFERENCES

DOCUMENTS USED TO OBTAIN INFORMATION

Howard Hughes Medical Institute, Janelia Farm Research Campus, Landscape Building, Volume 2.1 Master Set.

Janelia Farm Research Campus Cogeneration Feasibility Study. Burt Hill. May 3, 2002.

Janelia Farm Research Campus HVAC Description.

Janelia Farm Research Campus LEED Recommendations and Evaluation. February 14, 2002.

Janelia Farm Research Campus Program Development Report.

Reference Design and Safety Guidelines for the HVAC Designer. National Institutes of Health.

APPENDIX A – EQUIPMENT SCHEDULES

INFORMATION PROVIDED BY MECHANICAL DRAWINGS

Table of Equipment Schedules

1. There are 15 air handlers. All 15 are exactly the same and therefore only one was included in the table.
2. There are 7 cooling towers that are identical.
3. There are 7 chillers that are identical.

Air Handling Unit Schedule																		
				Fan Data														
				Capacity Control		Statis Press. [in wc]		Outlet Veloc.				Wheel		Premium Effic. Motor		Vibration Isolator		
Unit Tag	Location	Total Air [cfm]	Min O.A. [cfm]	Range	Type	ESP	TPS	[fpm]	Class	Speed [rpm]	BHP	Dia [in]	Type	Power Supply	MHP	Speed [rpm]	Type	Min. Statis Deelec. [in]
AHU	AHU Room	45000	45000	50000-13500	VFD	6	9.75	326.3	III	1522	88.47	36.5	BAF-DWDI	480V 3φ 60 Hz	125	1800	TEFC	2

Air Handling Unit Schedule																	
Filters						Steam Preheat Coil with Integral Face & Bypass Damper [IF % BP]											
Efficiency [%]		Total Face	Air Velocity	Press. Drop [in wc]			Air Data				Steam Data			Coil			
Pre	Final	Area [sf]	[fpm]	Clean	Replace	Total MBH	Face Velocity [fpm]	EAT [°F]	LAT [°F]	PD [in wc]	Ent. Psig	Temp. [°F]	LBS/HR	No. of Coils	Face Area [sf]	Row	Fin/in
30	95	132	381	0.3	1.23	3202	605	-10	56	0.18	15	250	3385	2	74.3	2	13

Air Handling Unit Schedule													
Cooling Coil													
	Air Data						Chilled Water Data				Coil			
Total	Face Velocity	EAT [°F]		LAT [°F]		PD		EWT	LWT		No. of	Face		
MBH	[fpm]	DB	WB	DB	WB	[in wc]	CPM	[°F]	[°F]	PD [ft]	Coils	Area [sf]	Row	Fin/in
4696	381	95	78	45.8	45.8	1.02	701	42	55.4	12.7	6	118.2	10	9.75

Table A.1 – Table A.3

AHU in table is typical of 15 located in three rooms on Level One.

Boiler Schedule												
	Dual Fuel Brner, Ng/Propane Air				ABMA	SF	ASME	Safety	Operating	Weight of	Flooded	Max
	Natural Gas 10 ppm Nox		Motor hp		Output,	Heating	Max.	Valve	Press.	Water	Weight of	Operating
Tag	cfh	psig	480V 3φ 60Hz	hp	MBH	Surface	Woking	Setting	[psig]	[lbs]	Water [lbs]	Weight [lbs]
B-1	63,000	10	100	1500	50,210	7500	250	90	80	71,000	9,600	196,000
B-2	63,000	10	100	1500	50,210	7500	250	90	80	71,000	9,600	196,000
B-3	46,100	10	75	900	30,125	4500	250	90	80	50,000	62,000	128,000
B-4(future)	46,100	10	75	900	30,125	4500	250	90	80	50,000	62,000	128,000

Table A.4

Fan Powered Variable Volume Terminal Unit Schedule								
Mark	Max. CFM	Min. CFM	Coil Cap. [MBH]	Heating GPM @ 180°F EWT	LWT [°F]	Motor HP	Open Max. PD (Unit Plus Coil)	Max. Coil Water PD [ft]
FPB - 1	400	200	8.7	0.9	160	1/4	0.04	0.28
FPB - 2	450	225	9.8	1.0	160	1/4	0.04	0.28
FPB - 3	540	270	11.7	1.2	160	1/4	0.05	0.39
FPB - 4	630	315	13.7	1.4	160	1/4	0.07	0.79
FPB - 5	700	350	15.2	1.5	160	1/4	0.09	0.86
FPB - 6	720	360	15.6	1.6	160	1/4	0.09	0.90
FPB - 7	810	405	17.6	1.8	160	1/4	0.11	2.03

Table A.5

HEPA Filter Schedule					
Mark	Location	Qty.	Total CFM	Max. Face Velocity [fpm]	PD [in]
HF-1	Exh. Shaft 1A	3	1500	250	1.3
HF-2	Exh. Shaft 2A	3	1500	250	1.3
HF-3	R/1 Waste Room 1st Floor	1	400	200	1.0

Table A.6

Plate and Frame Heat Exchanger Schedule											
		No.	Hot Side				Cold Side				Effect Htg.
Tag	Service	Plates	GPM	EWT [°F]	LWT [°F]	PD [ft]	GPM	EWT [°F]	LWT [°F]	PD [ft]	Surface [sf]
CX-2	Cold Room	80	340	45	55	23	340	42	52	23	537
CX-3	Room Bac	80	340	45	55	23	340	42	52	23	537

Table A.7

Shell and Tube Heat Exchanger Schedule											
					Tube Side Water				Shell Side Steam		
Tag	Service	Surface [sf]	Capacity MBH	No. / Passes	GPM	EWT [°F]	LWT [°F]	PD [ft]	lbs/hr	psig	Temp. [°F]
HX-1	Rehead Coils & FSU	500	28,339	2	2900	180	180	2.7	29970	15	250
HX-2	Rehead Coils & FSU	500	28,339	2	2900	180	180	2.7	29970	15	250
HX-3	Low Temp. Hot Water for Underslab Radiation	12.7	1,251	2	663	80	120	0.2	128.3 gpm	N/A	190/170
HX-4	Low Temp. Hot Water for Underslab Rad. Back-up	12.7	1,251	2	63	80	120	0.2	128.3 gpm	N/A	190/170
HX-5	Conference Housing	35.3	1,755	2	180	170	190	0.9	1856	15	250
HX-6	Conference Housing	35.3	1,755	2	180	160	180	0.9	1856	15	250

Table A.8

Variable Volume Reheat Terminal Unit Schedule						
Mark	CFM Range	Coil Cap. [MBH]	Heating GPM @ 180°F EWT	LWT [°F]	Open Max. PD (Unit Plus Coil)	Max. Coil Water PD [ft]
X - 1	09 - 200	0 - 7.0	1.0	160	0.05	0.50
X - 2	201 - 400	7.0- 14.0	1.0	160	0.22	0.24
X - 3	401 - 600	14.0 - 21.0	2.0	160	0.36	0.33
X - 3H	451 - 600	22.0 - 34.0	2.0	160	0.40	0.80
X - 4	601 - 800	21.0 - 28.0	3.0	160	0.46	2.23
X - 5	801 - 10000	28.0 - 36.0	2.0	160	0.35	0.70
X - 6	1001 - 1200	36.0 - 47.0	3.0	160	0.15	0.84
X - 7	1201 - 1600	33.0 - 55.0	3.0	160	0.45	1.82
X - 8	1601 - 2400	55.0 - 69.0	3.0	160	0.45	1.25
X - 8H	1601 - 2400	86.0 - 130.0	6.0	160	0.72	2.77
X - 9	2401 - 3200	69.0 - 92.0	4.0	160	0.58	0.90
X - 10	3201 - 4800	92.0 - 130.0	5.0	160	0.46	1.41

Table A.9

Pump Schedule										
Tag	Type	System	GPM	PD Head [ft]	NPSH [ft]	Min Eff.	Pumping Temp [°F]	RPM	Motor HP	Voltage
P-1	Packaged Skid #1	Chilled Water	4300	120	23	Premium	42/56	1750	250	480V 3φ
P-2	Packaged Skid #1	Chilled Water	4300	120	23	Premium	42/56	1750	250	480V 3φ
P-3	Packaged Skid #1	Chilled Water Back-up	4300	120	23	Premium	42/56	1750	250	480V 3φ
P-4	Packaged Skid #1	Chilled Water Future	4300	120	23	Premium	42/56	1750	250	480V 3φ
P-7	Base Mounted	Conf. Housing Chilled Water	315	90	8	Premium	42/56	1750	15	480V 3φ
P-8	Base Mounted	Conf. Housing Chilled Water Back-up	315	90	8	Premium	42/56	1750	15	480V 3φ
P-9	Base Mounted	Cold Room	350	140	5	Premium	42/55	1750	25	480V 3φ
P-10	Base Mounted	Cold Room Back-up	350	140	5	Premium	42/55	1750	25	480V 3φ
P-H1	Base Mounted	Hot Water	2900	155	21	Premium	190/170	1750	150	480V 3φ
P-H2	Base Mounted	Hot Water Back-up	2900	155	21	Premium	190/170	1750	150	480V 3φ
P-H3	Base Mounted	Underslab Rad.	63	120	8.5	Premium	120/80	3500	7.5	480V 3φ
P-H4	Base Mounted	Underslab Tad. Back-up	63	120	8.5	Premium	120/80	3500	7.5	480V 3φ
P-H5	Base Mounted	Conf. Housing Hot Water	180	135	5.5	Premium	190/170	1750	15	480V 3φ
P-H6	Base Mounted	Housing Hot Water Back-up	180	135	5.5	Premium	190/170	1750	15	480V 3φ
P-C1	Packaged Skid #2	Cond. Water	4800	95	10	Premium	90/105	1200	150	480V 3φ
P-C2	Packaged Skid #2	Cond. Water	4800	95	10	Premium	90/105	1200	150	480V 3φ
P-C3	Packaged Skid #2	Cond. Water Back-up	4800	95	10	Premium	90/105	1200	150	480V 3φ
P-C4	Packaged Skid #2	Cond. Water Future	4800	95	10	Premium	90/105	1200	150	480V 3φ

Table A.10

Following Page:
Table A.11: Cooling Tower Schedule typical of 7.
Table A.12: Chiller Schedule typical of 7.
Table A.13: Fire Combustion Air Handler Schedule
Table A. 14: Coil Pump Schedule

Cooling Tower

Tag	No. of Coils	Service	Location	Nominal Tons	Condensor Water Flow [gpm]	Rate of Water Make-up [gpm]	Water Temp [°F]		Ambient WBT [°F]	Fan				Motor @ 480V 3φ 60Hz			Drift Eliminator	
							Entering	Leaving		CFM	RPM	TIP Speed [rpm]	dia [in]	HP	RPM	NC@5 Ft From Air Inlet Face	Construction	Drift Loss [gpm]
CT	1	Refrigeration Machine	Fenced Partially Below Grade	1200	2400	54	100	85	78	265,100	323	11,162	11	75	1725	84 dBA	Triple Pass PVC	0.12

Chiller Schedule

Tag	Capacity [tons]	Evaporator				Condensor				Refrigerant		Prime Mover - Electic Motor				Compressor Stages
		Water			PD [ft wg]	Water			PD [ft wg]	Type	Charge [lbs]	kW/ton	/ NPLV	kW	Draw @4160V 3φ 60Hz	
		In [°F]	Out [°F]	Fouling Factor		In [°F]	Out [°F]	Fouling Factor								
CH	1200	56	42	2150	0.0001	85	99.5	0.00025	13	LEED Compliant	3000	0.67	0.58	805	1163	Single

Direct Fired Combustion Air Handling Unit Schedule

Mark	Location	Service	CFM	BHP	ESP [in wg]	Max. RMP	HP	EAT	LAT	MBH	Gas Pressure	Type	PD Air [in wg]	EFF.
DF-3 & DF-4	Boiler Room Mer.	Boiler Combustion	21,000	22.2	0.5	865	30	-10	55	1,550	6 oz	2" TA	0.2	30%

Coil Pump Schedule

Unit	Service	Location	Casing Type	Fluid		GPM	NPSHR [ft]	Heat [ft]	Impeller Size [in]	Working Press [psig]	Pump [rpm]	BHP	Motor HP
				Type	Temp [°F]								
CCP	AHU	AHU Room	In-Line	Water	42/56	120	8	20	5.25	125	1750	1	1.5

APPENDIX B – LEED™ EVALUATION

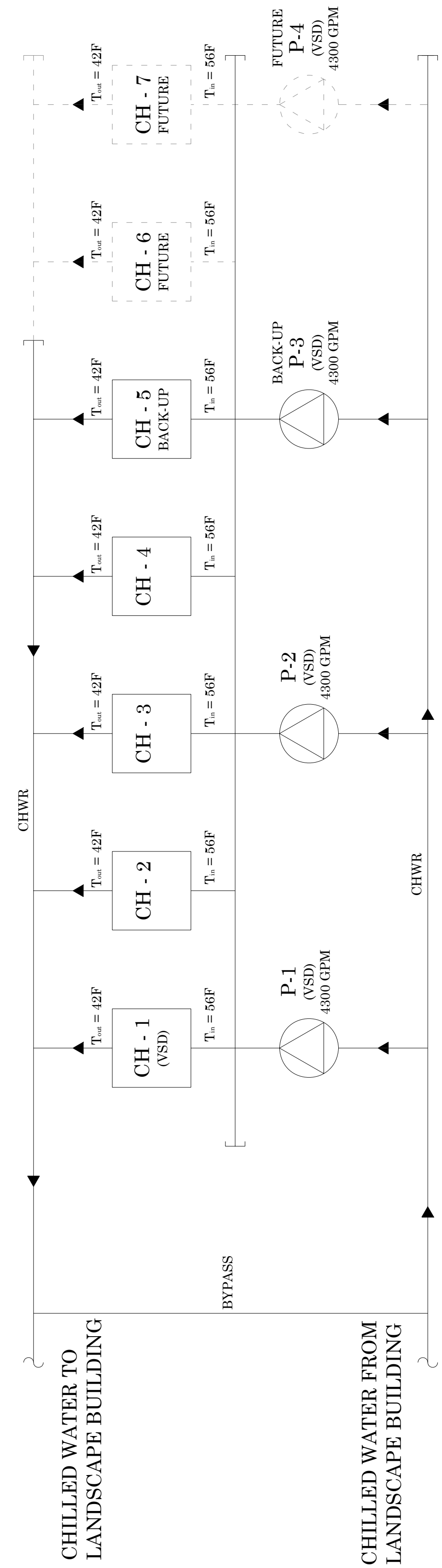
UPDATED FROM TECH TWO

After completed technical assignment two, the mechanical engineer provided a more complete LEED evaluation than was previously known. HHMI stressed obtaining gold status in part through the use of innovative mechanical design. Although the building never tired to be rated, the design was in part driven by the need to create a green building.

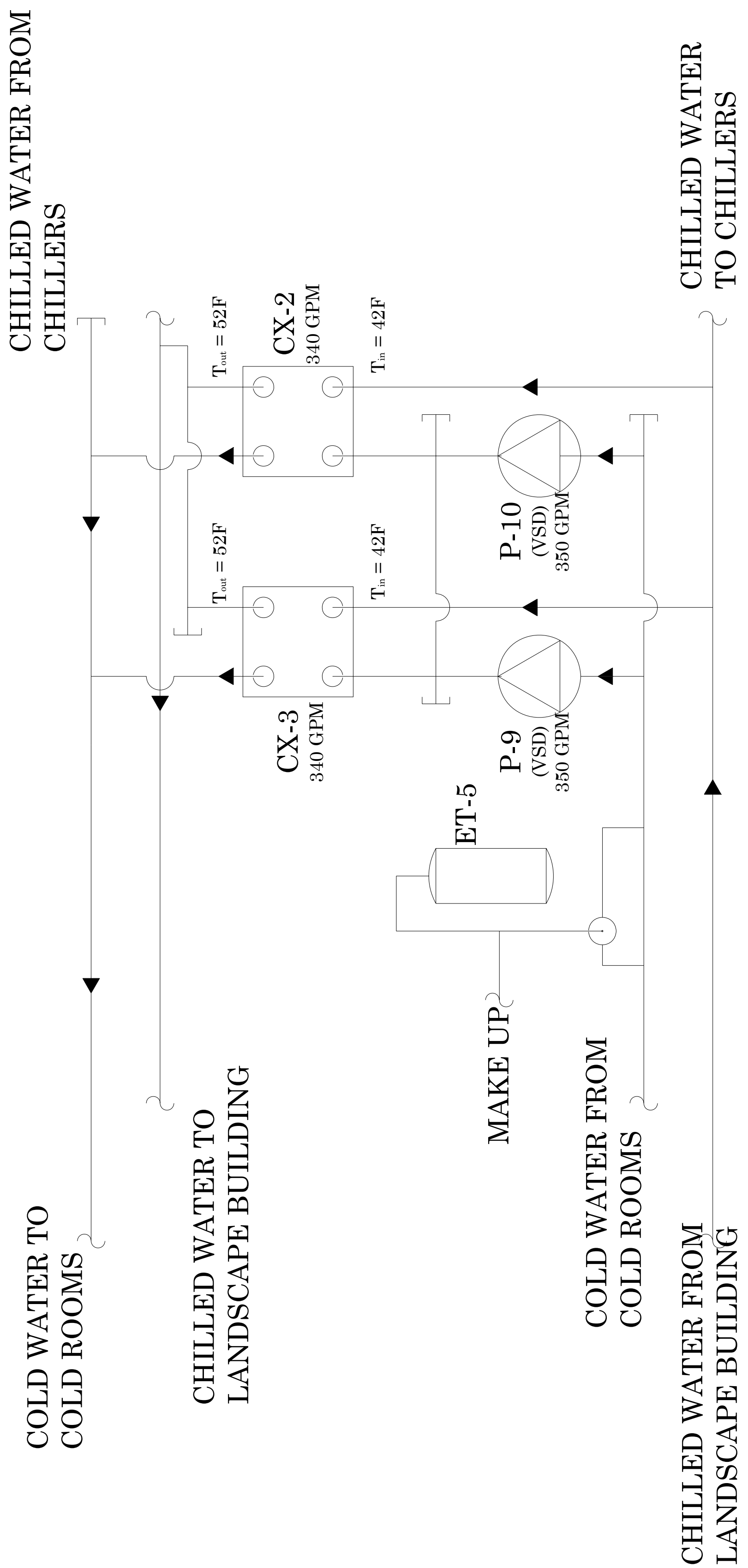
APPENDIX C – SHEMACTICS

PROVIDED BY PROJECT MANAGER

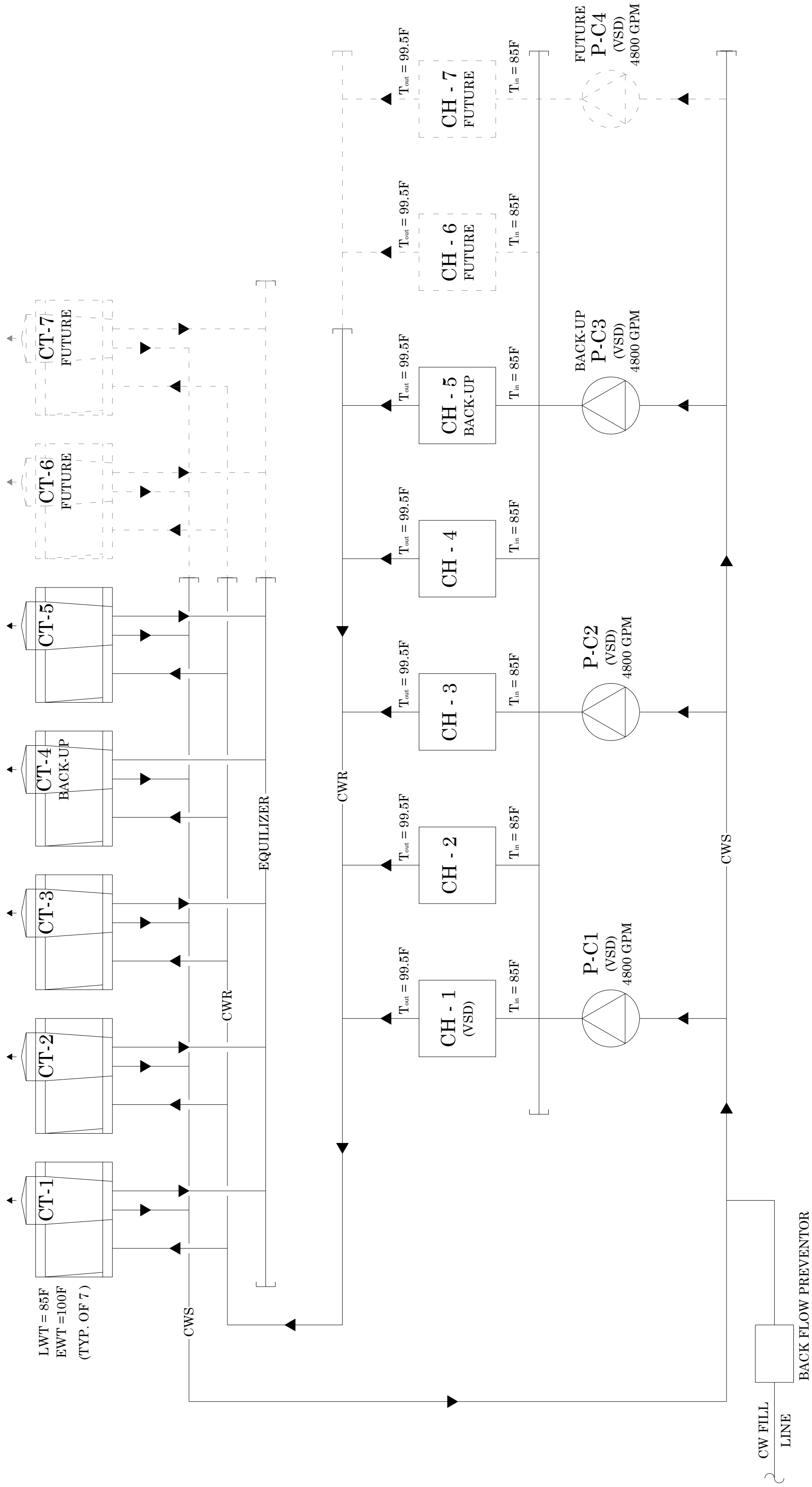
The schematics on the following pages are replicas of schematics provided by the project manager. The first three represent the chilled diagram, the chilled water plate and frame heat exchanger schematic, and condenser water schematic. The last one is the riser diagram of the supply air ductwork from Room D-73 which is a mechanical room on Level One. The drawings have been simplified and only show major equipment and call out important information. Smaller components such as valves and filters have been omitted.



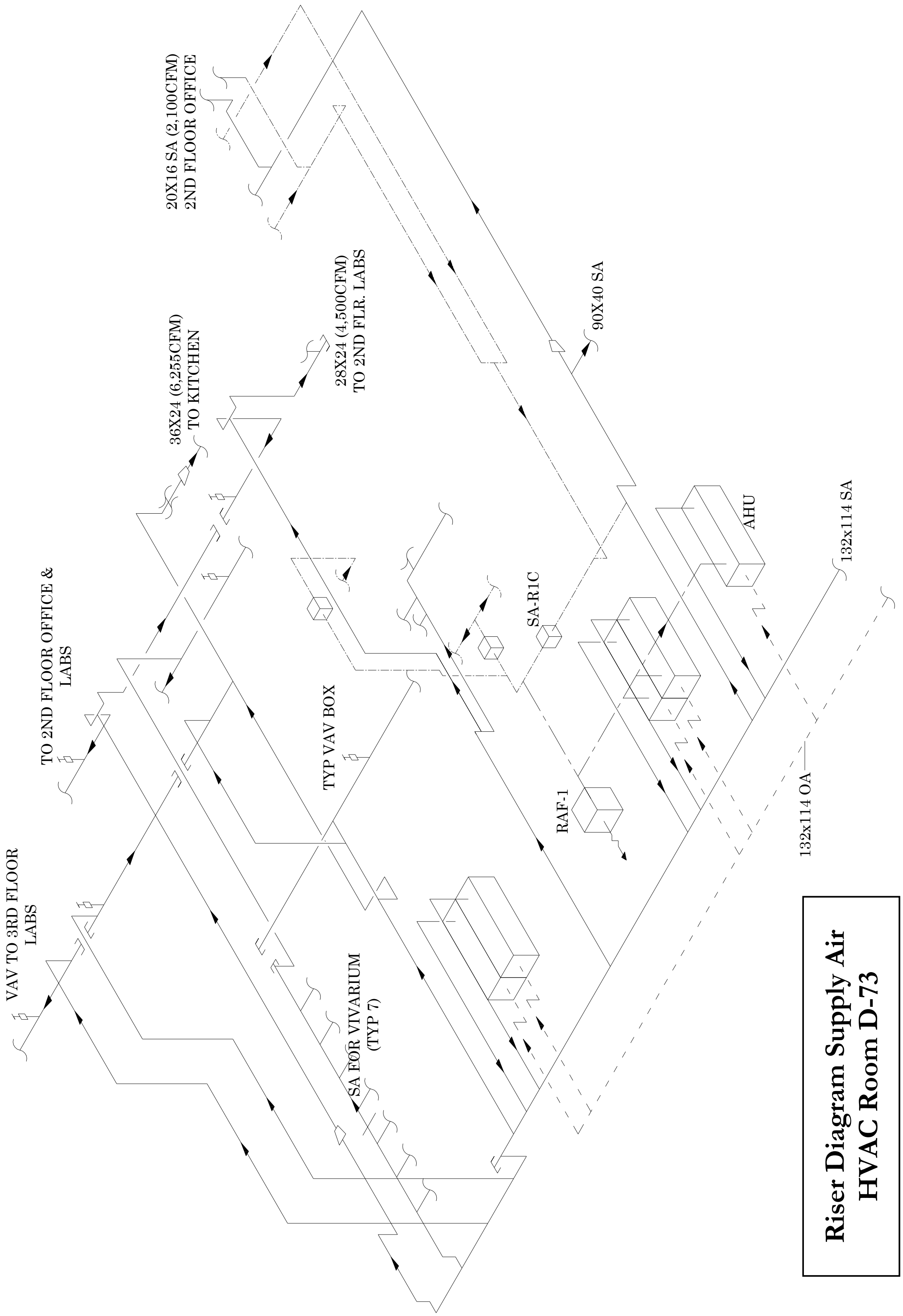
Chilled Water Flow Diagram



Chilled Water with Heat Exchangers Flow Diagram



Condenser Water Flow Diagram



Riser Diagram Supply Air
HVAC Room D-73