Kent County PUBLIC LIBRARY

HVAC Feasibility Study

Gipe Associates, Inc.
CONSULTING ENGINEERS
Mechanical | Electrical | Plumbing
8719 Brooks Drive
Post Office Box 1147
Easton, Maryland 21601
(410) 822-8688

November 14, 2016
W.O.#: 16084

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November 14, 2016

Mr. Jim Wright, P.E.
Kent County Public Library
408 High Street
Chestertown, MD 21601

Project: Kent County Public Library – Chestertown Maryland
Reference: HVAC Feasibility Study

Dear Mr. Wright:

We are pleased to provide you with this Feasibility Study regarding the replacement of the existing HVAC (Heating, Ventilating, and Air Conditioning) systems, and supporting electrical systems serving the Kent County Public Library located at 408 High Street in Chestertown, Maryland.

On September 9, 2016, we performed field observations and investigations of the existing HVAC and supporting electrical systems. The HVAC system was installed approximately 40 years ago (circa 1976), and has reached the end of its useful life. We've analyzed the systems serving the Library and have included our findings in this Report. Our Report is based on review of existing drawings, field observations, and discussions with the owner and staff of the Kent County Public Library. The Library is approximately 11,000 square feet, and includes collection/book stack areas, offices, meeting room, bathrooms, and other general areas. The following are our observations of the existing HVAC systems and supporting electrical systems.

EXISTING MECHANICAL SYSTEMS

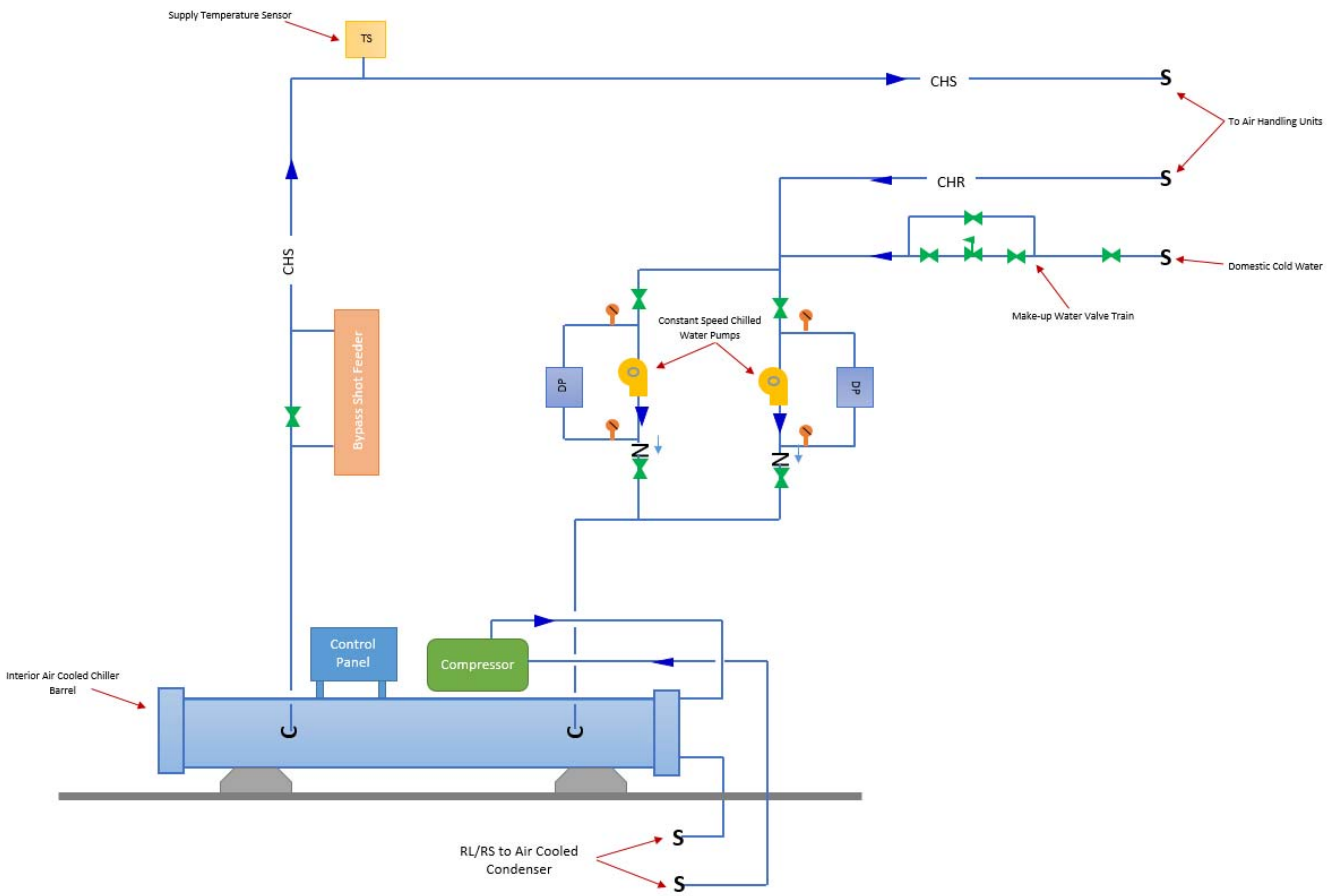
The existing HVAC (Heating, Ventilating, and Air Conditioning) system, and supporting electrical system were surveyed to determine code compliance and age/condition.

The existing HVAC system serving the Library consists of the following components:

- Split System Air Cooled Chiller
- Chilled Water System
- Central Station Air Handling Units
- Electric Heating Coils
- Electric Steam Boiler
- Humidifier
- Exhaust Fan
- Automatic Temperature Control System
- Electric Fin Tube Radiators

CHILLED WATER SYSTEM

The cooling for the facility is provided by an air cooled chiller with a remote condenser. Mechanical Figure #1 illustrates the basic components of the existing chilled water system.



Mechanical Figure #1 – Existing Chilled Water System

The chilled water system provides chilled water to three air handling units.

AIR-COOLED CHILLER

The air cooled chiller is located in the Library's Main Equipment Room. Photograph #1 shows the existing air cooled chiller serving the air handling units.

Photograph #1 – Air Cooled Chiller

See Table #1 below for the performance data and characteristics of the air cooled chiller.

Manufacturer	McQuay-Perfex Inc.
Model #	3GJ00249 06
Serial #	WHR030B3
Unit Electrical Characteristics	208 volt/3 phase/60 hz
Total Full Load Amps	116
Comp. Motor Circuit #1 Electrical Characteristics	208 volt/3 phase/60 hz
Refrigerant Type	R-22
Capacity	360,000 btu/hr (30 Tons)
Flow Rate (GPM)	72.0 GPM

Table #1 - Existing Air Cooled Chiller Unit Performance/Characteristics

The air cooled chiller is original to the building and has served beyond its useful life.

Another thing to consider with the condensing unit and air cooled chiller is the type of refrigerant being utilized. The refrigerant currently utilized is R-22. R-22 refrigerant is labeled as an ozone depleting hydrochlorofluorocarbon (HFCF), and is currently being phased out.

Two in-line pumps circulate the chilled water between the chiller and air handling units cooling coils. As you can see in Photograph #2, the pipe and pumps are in poor shape and in need of replacement.

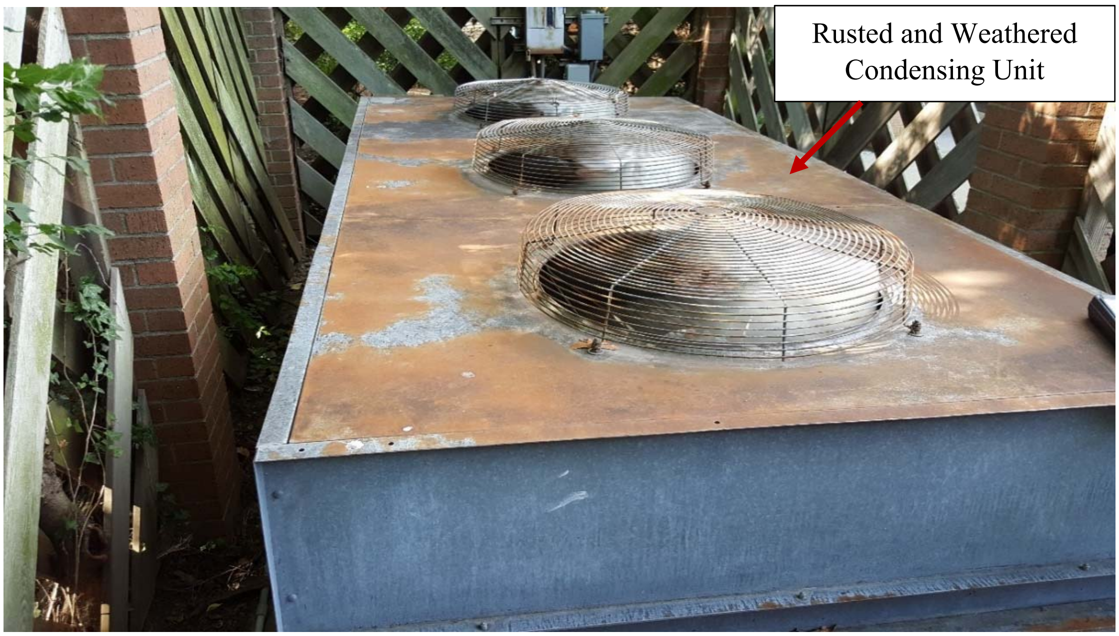
Photograph #2 – Chilled Water Piping and In-line Pumps

Based on its age and condition, we have determined that the existing central chilled water system has reached the end of its useful service life and should be replaced.

Now we will review the Condensing Unit.

CONDENSING UNIT

The existing Condensing Unit located outside, is the original unit installed forty (40) years ago, and is also at the end of its useful life. Photograph #3 shows the existing condensing unit serving the air-cooled chiller.



Photograph #3 – Existing Condensing Unit

The condensing unit is connected to the chiller via refrigerant piping installed below grade.

See Table #2 below for the data we were able to get from the condensing unit nameplate and the original mechanical schedule.

Manufacturer	McQuay-Perfex Inc.
Model #	APD-045B-V-12
Serial #	4-GH00260-06
Unit Electrical Characteristics	208 volt/3 phase/60 hz
Total Airflow Rate	39,000 cfm
Fan Motor Horsepower	1.0 HP (Typical of 3)
Fan Electrical Characteristics	120 volt/1 phase/
Heat Rejection	432,000 btuh/hr (36 tons)
Refrigerant Temperature DB. (R-22 Refrigerant)	115°F
Ambient Temperature DB.	95°F

Table #2 - Existing Air Cooled Condensing Unit Performance/Characteristics

As shown in Photograph #4, the refrigerant piping insulation is missing from the condensing unit, which will result in reductions in performance and efficiency of the unit.

Photograph #4 – Refrigerant Piping from Condensing Unit

Based on our survey and the age/condition of the equipment, the existing condensing unit has reached the end of its useful service life and should be replaced.

Next, we will review the existing Air Handling Units.

AIR HANDLING UNITS

There are three (3) central station chilled water air handling units serving 3 main zones within the Library. See Mechanical Figure #2 for a keyplan showing the locations of the air handling units and the areas they serve.

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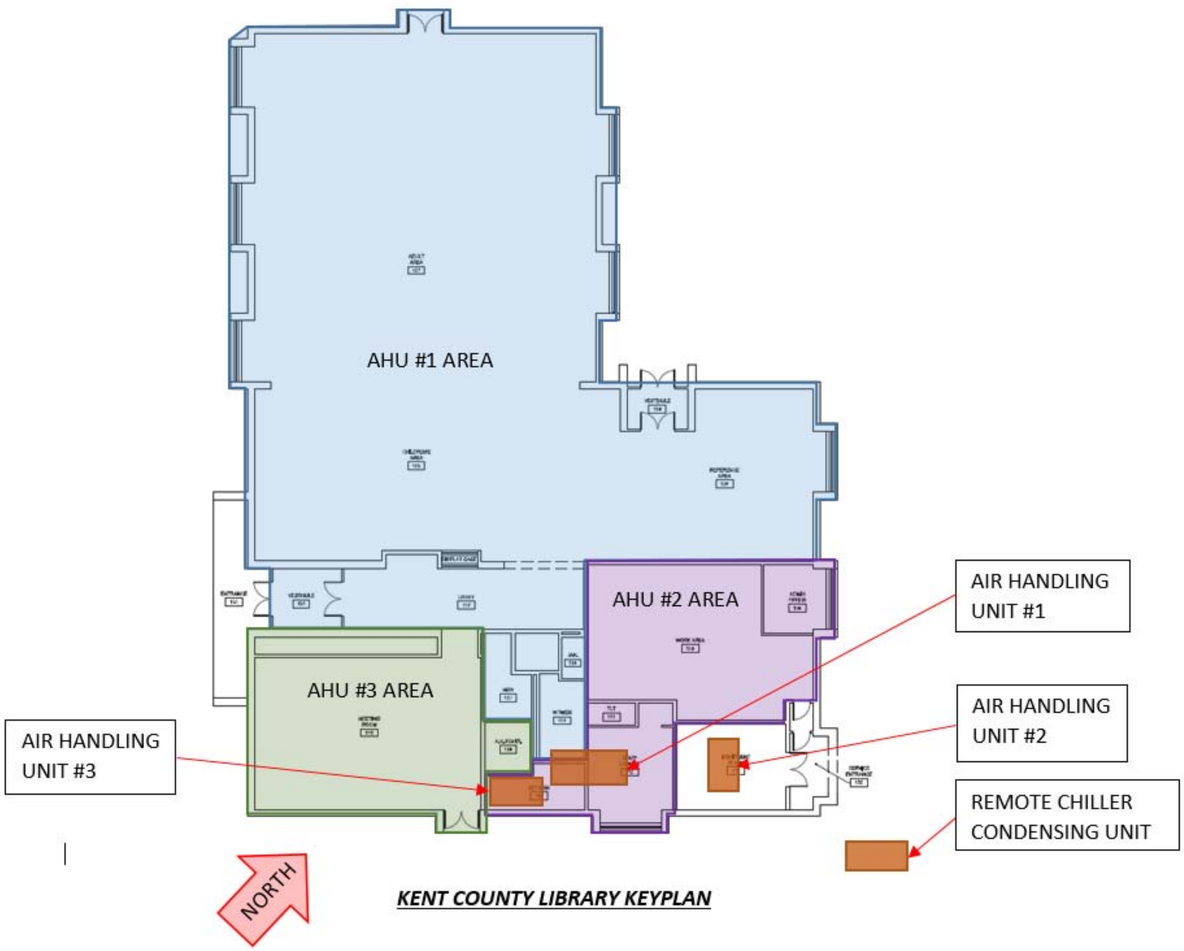
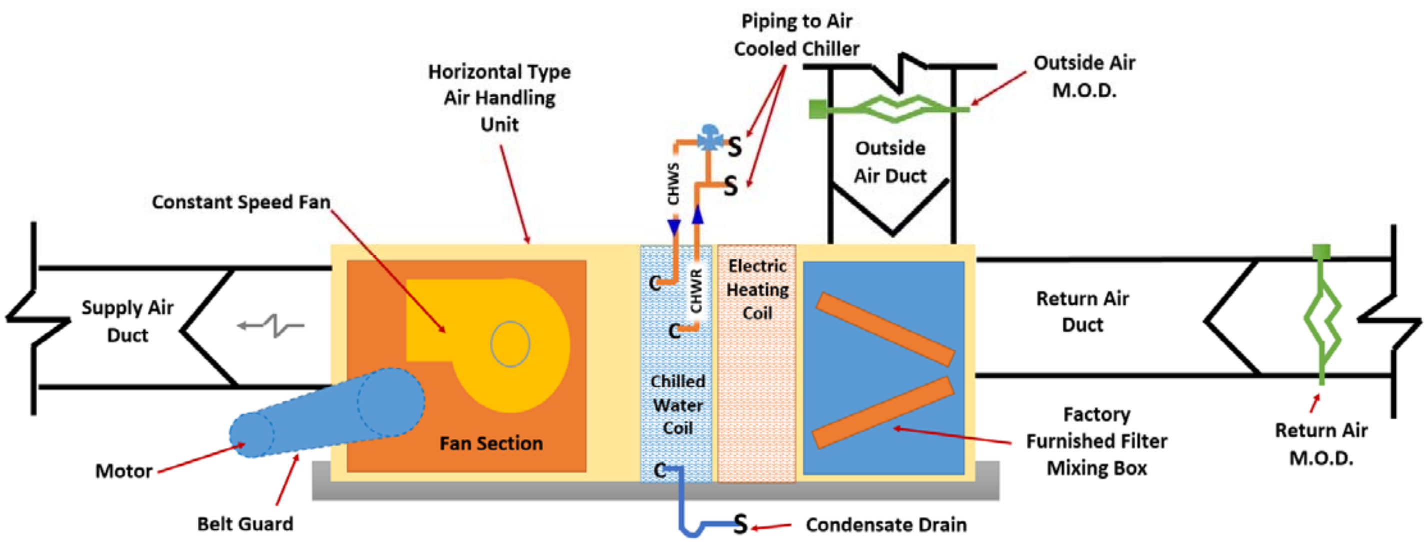


Mechanical Figure #2 – Kent County Public Library – Keyplan (No Scale)

The air handling units are located in the Main Mechanical Room, and in the adjacent equipment mezzanine accessible through the mechanical room. The existing air handling units are chilled water air handling units with electric heat. There is one thermostat located in each of the 3 zones of the Library. The air handling units provide heating or cooling to the zone to satisfy the thermostat in their zone. Ventilation air (outside air) is provided through each air handling unit. The air handling units are constant volume airflow units and modulate the temperature of the supply air to satisfy the heating or cooling load. Mechanical Figure #3 indicates the existing components of the central station air handling units.

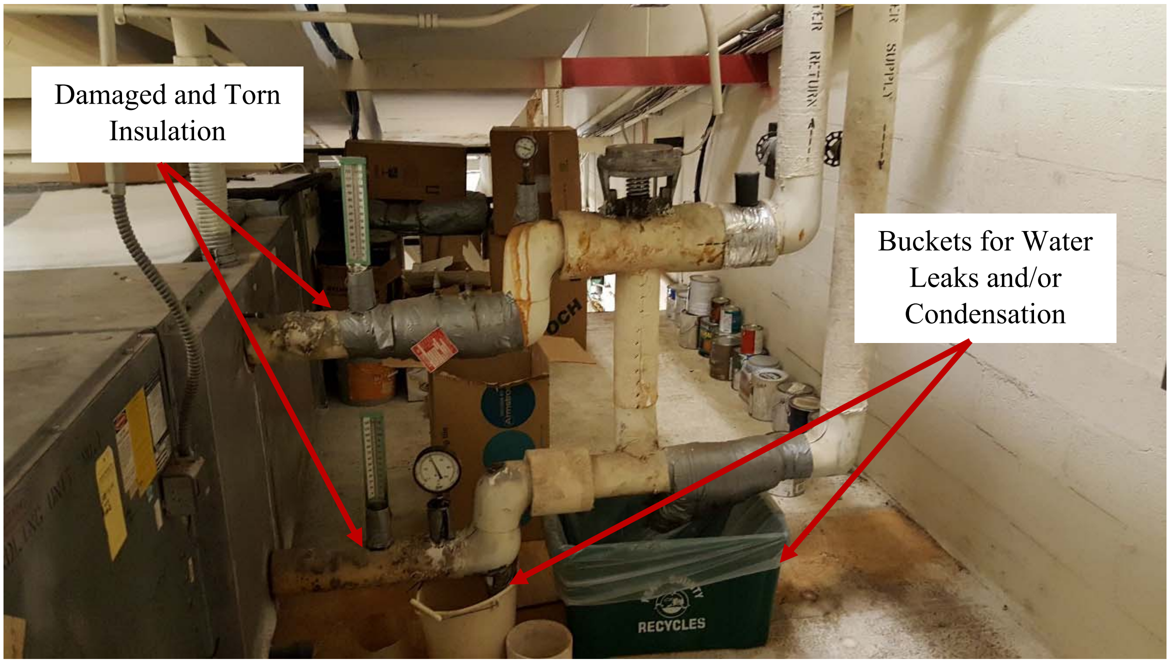


Mechanical Figure #3 – Chilled Water Air Handling Unit

Photograph #4 shows Air Handling Unit #1 (AHU-1), which is located on the equipment mezzanine (above the Faculty Lounge). Air Handling Unit #1 is the largest air handler, and serves the Adult/Child Reading Areas, and the Lobby/Reference Center.

Photograph #4 – Air Handling Unit #1

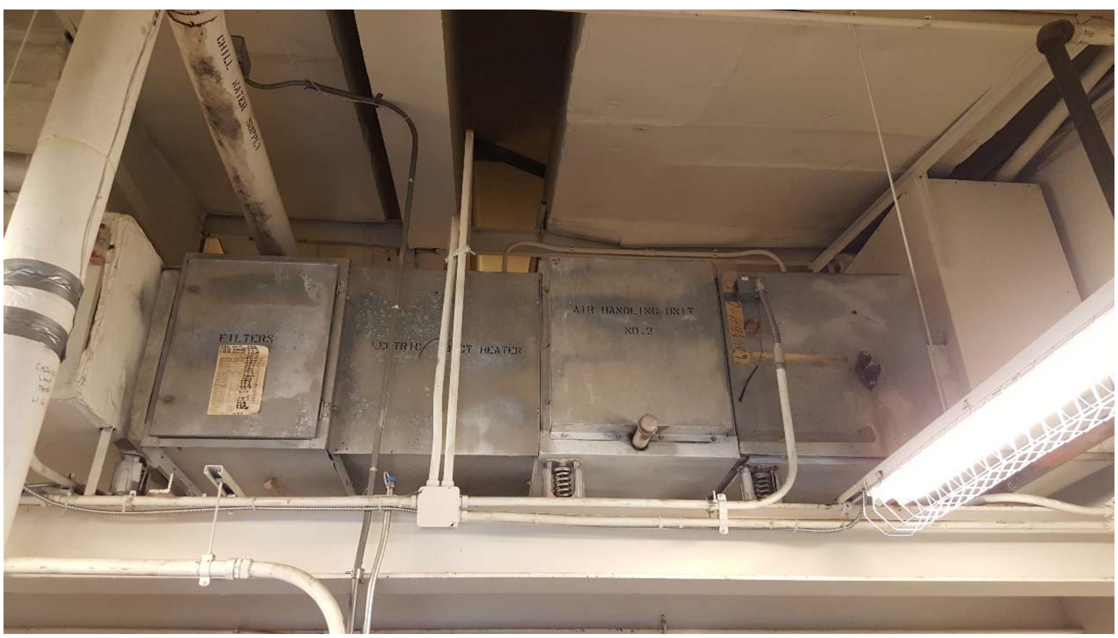
The air handling unit provides heat through an electric resistance coil, and provides cooling through a chilled water coil. Photograph #5 shows the chilled water supply/return piping serving Air Handler Unit #1.



Photograph #5 – Chilled Water Piping Serving AHU-1

As you can see in the picture above, the piping and insulation are showing signs of their age. There are leaks in the piping, and insulation is wet and in need of replacement. Air Handling Unit #1 is provided with a return air fan for economizer operation. AHU-1 is also provided with a steam humidifier located in the ductwork. The humidifier will be discussed later in the Report.

Photograph #6 shows Air Handling Unit #2 (AHU-2), located in the Mechanical Room. Air Handling Unit #2 serves the Work Area, Admin Office, Staff Lounge, and Kitchen.

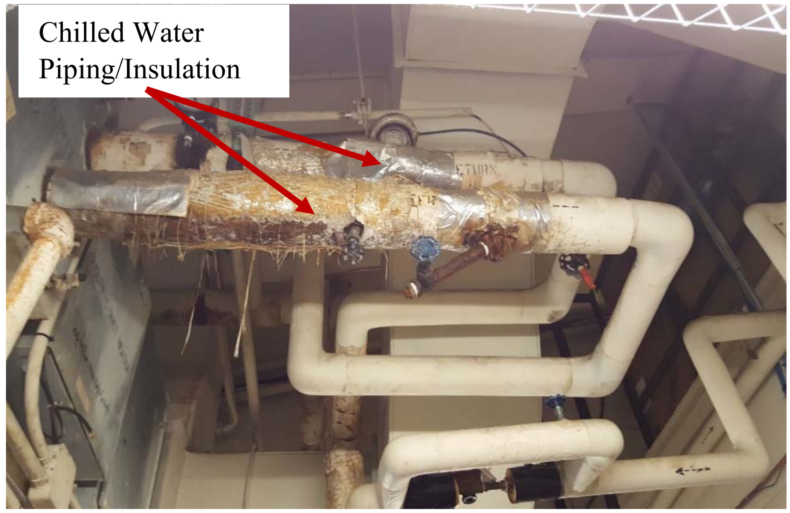


Photograph #6 – Air Handling Unit #2

Photograph #7 shows the Chilled Water Supply and Return Piping serving Air Handler Unit #2.

Due to age and condition, we would recommend replacement of Air Handling Unit #2.

Air Handling Unit #3 (AHU-3) is the final air handling unit serving the Library and is located in the equipment mezzanine with AHU-1. Air Handling Unit #3 serves the Meeting Room and A/V Equipment Closet. See Photograph #8 below for a picture of Air Handling Unit #3.



Photograph #7 – Chilled Water Piping Serving AHU-2

Air handling unit #3 along with the chilled water piping serving it have reached the end of their useful service life and the same should be replaced.

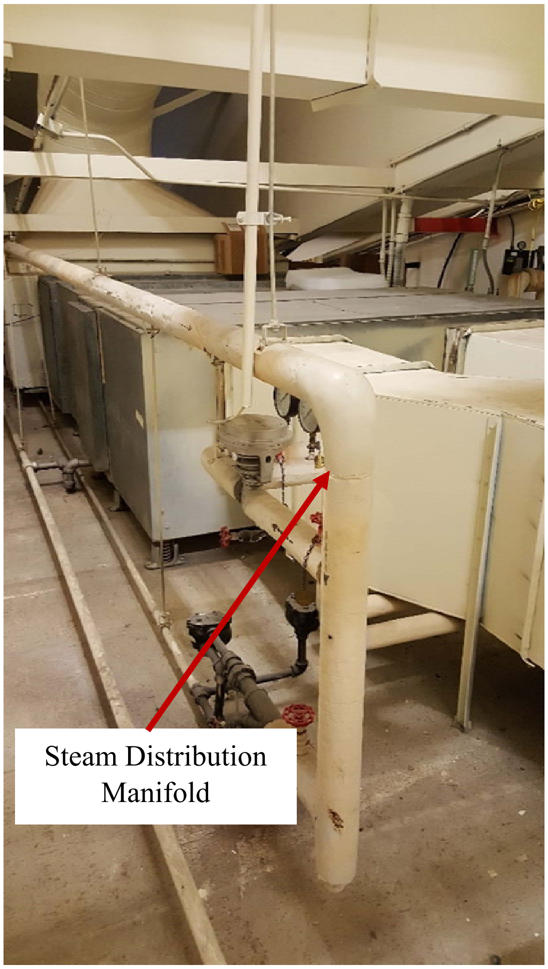
The ductwork for all three air handling units appears to be in fair condition. Due to age we would recommend replacement, however this would require demolition and replacement of ceilings in the Library. This will be discussed later in the report.

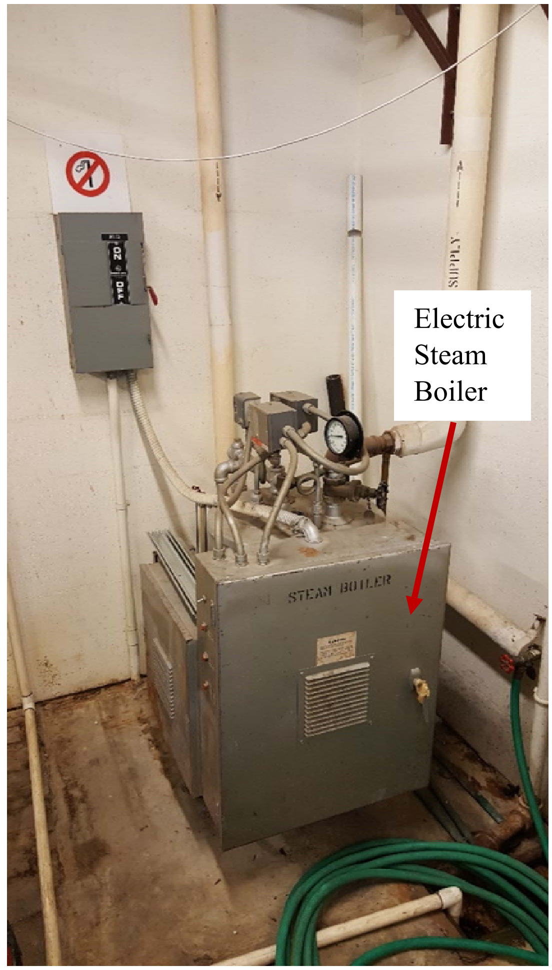
Next we will review the Steam Humidifier and Steam Boiler.

STEAM HUMIDIFIER AND STEAM BOILER

Air Handling Unit #1 is equipped with a steam humidifier. A Steam Humidifier is used during the winter months when the air handling unit is in heating mode to add moisture to the airflow, and prevent low space relative humidity. Low space relative humidity can damage the collections held in the Library. The steam humidifier is located in the supply duct at the discharge of the air handling unit. The steam humidifier is connected to a Steam Boiler located in the equipment room. The Steam Boiler is an electric steam boiler. Please see Photograph #9 & #10 below for pictures of the Steam Humidifier and Steam Boiler respectively.

Photograph #8 – Air Handling Unit #3





Photograph #9 – Steam Humidifier ***Photograph #10 – Steam Boiler***

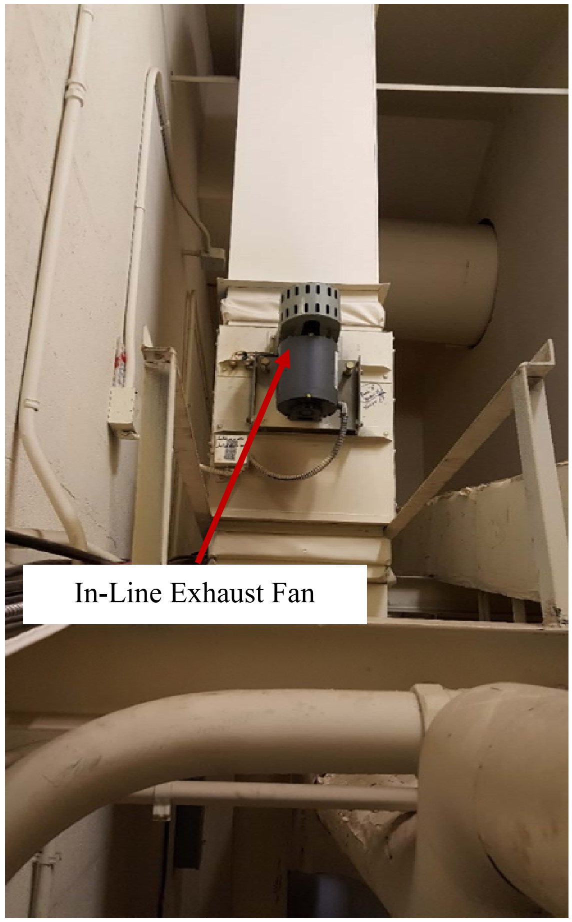
The existing Steam Boiler is disconnected and not currently being utilized (has been de-energized). We recommend removing the existing Steam Boiler and Steam Humidifier and replacing with a new Packaged Electric Steam Humidifier.

The following section will review the exhaust fan serving the building.

EXHAUST AIR FAN

Exhaust air from the Bathrooms and Janitor's Closet are ducted to the equipment mezzanine, where an in-line exhaust air fan discharges the air through a louver to the outside. See Photograph #11 for a picture of the existing in-line exhaust fan.

The exhaust air fan's condition is appropriate for its age. We would recommend replacement of the same.



Photograph #11 – In-line Exhaust Fan

Next we will review the Automatic Temperature Control System.

AUTOMATIC TEMPERATURE CONTROL SYSTEM

The automatic temperature controls system (ATC) is a combination pneumatic and direct digital system manufactured by Johnson Controls. Photograph #12 shows the existing ATC control panel.

Photograph #12 – ATC Control Panel

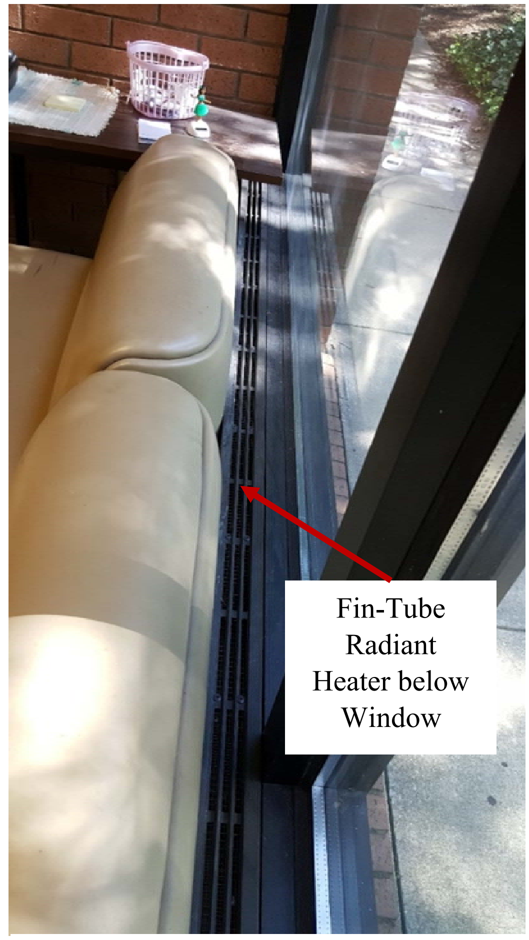
The digital components were added circa 1993. We would recommend a new digital control system for the proposed HVAC Systems.

Finally, we will review the electric finned tube radiators.

FIN TUBE RADIATION HEATERS

There are electric Finned Tube Radiators (FTR) heaters located throughout the Library below the windows. See Photograph #13 for a picture of the FTR Heater in the Staff Lounge.

The FTR Heaters in the Library are all located at the base of the Library's windows. This is to help prevent condensation on the windows during cold weather, and reduce cold surfaces/radiant cooling in the winter season. The FTR Heaters are currently not being utilized due to temperature control issues. Per our discussion with the owner, the heaters have caused a few windows to crack, and have been disabled.
We would recommend new finned tube radiator heaters and controls.



Photograph #13 – Fin Tube Radiant Heater in Employee Lounge

An additional building observation that will affect the performance of the HVAC System is the height of the existing ceilings in the occupied areas. The existing ceiling heights range from 10 to 21 feet high. Although high ceilings are aesthetically pleasing, they create issues with heating season HVAC System performance. The heating season issues are a result of warm air being trapped at the top of the space due to stratification. This heat could be utilized at the lower level of the space where the occupants are located. We would recommend that ceiling fans be installed within the Library to allow for better heat distribution, and reduced heating energy costs. Ceiling fans will also benefit the facility in cooling season by providing air movement and allowing higher space temperature set points while maintaining occupant comfort.

Next, we will review our calculations performed regarding the existing HVAC systems.

ENGINEERING CALCULATIONS

Prior to making recommendations for the replacement of the existing HVAC System, it is critical to calculate the heating, cooling, and ventilation requirements for the facility.

Ventilation Calculations

Due to its contribution to the heating/cooling load calculations and the health/well-being of the Library occupants, we performed a ventilation (or fresh air) calculation to determine the minimum amount of fresh air required by ASHRAE Standard 62.1 – Ventilation for Acceptable Indoor Air Quality. See Table #3 for the results of our calculations.

AHU	Existing Scheduled Ventilation Air Flow Rate (CFM)	Calculated Ventilation Air Flow Rate (CFM)	Difference
AHU #1	1390	1585	-195
AHU #2	350	240	110
AHU #3	675	334	341

Table #3 - Ventilation Air Flow Rate Summary

(Refer to Appendix M-1 for Ventilation Airflow Calculations)

As indicated in Table #3, the existing scheduled ventilation air flow rates are close to or slightly higher than the calculated values. Please note that we did not have a Test and Balance Report to verify the scheduled outside airflow rates were being provided. Therefore, we utilized the calculated ventilation airflow rates for our heating/cooling load calculations presented in the next section of the Report.

Heating and Cooling Load Calculations

Based on the previous ventilation calculations and the building envelope components, we performed space by space load calculations. The existing wall and roof U-values utilized for our heating/cooling load calculations for the Kent County Public Library are based on the existing architectural documents and our field survey, and are as follows:

- Existing Masonry wall U-value = 0.225 BTU/hr/°F/ft^2 (approximate R-value of R-4.44)
- Asphalt shingles roof U-value = 0.067 BTU/hr/°F/ft^2 (approximate R-value of R-15)

We utilized the following U-value and shading coefficient for the windows in our load calculation:

- Window U-value = 0.826 BTU/hr/°F/ft^2
- Shading coefficient = 0.683

Based on the following assumptions and ambient outside air conditions/interior conditions, we calculated the heating and cooling loads for the Kent Count Public Library:

- Summer interior design conditions = 75°F Dry Bulb, and maximum 60% relative humidity
- Summer ambient design conditions = 95°F Dry Bulb and 78°F
- Winter interior design conditions = 72°F Dry Bulb, and minimum 30% relative humidity
- Winter ambient design conditions = 10°F Dry Bulb
- Lighting power density average = 1.0 watt/ ft^2
- Interior plug load average density = 0.5 watt/ ft^2
- Infiltration air flow rate = 0.1 CFM/ ft^2

Based on the above assumptions, the heating/cooling load calculations were performed and compared to the scheduled loads from the original mechanical contract drawings.

	Heating Capacity	Cooling Sensible Capacity	Cooling Total Capacity	Supply Air Flow Rate	Outside Air (Ventilation)
AHU #1	275,100 btu/hr	232,200 btu/hr	310,000 btu/hr	8,824 cfm	1585 cfm
AHU #2	53,400 btu/hr	53,200 btu/hr	66,300 btu/hr	2,212 cfm	240 cfm
AHU #3	47,600 btu/hr	38,900 btu/hr	60,100 btu/hr	1,508 cfm	334 cfm

Table #4 - Heating/Cooling Load Calculation Summary

(***Refer to Appendix M-2 for Heating & Cooling Load Calculations)***

	Heating Capacity	Cooling Sensible Capacity	Cooling Total Capacity	Supply Air Flow Rate
AHU #1	230,000 btu/hr	206,142 btu/hr	268,000 btu/hr	9,640 cfm
AHU #2	50,000 btu/hr	47,628 btuh/hr	63,000 btu/hr	2,100 cfm
AHU #3	60,000 btu/hr	46,786 btuh/hr	82,000 btu/hr	1,900 cfm

Table #5 - Existing Scheduled Heating/Cooling Loads Summary

Based on our calculations, the existing equipment appears to have been reasonably sized. The cooling loads we calculated are higher than the existing system capacities due to our lower coil leaving air conditions in cooling mode. The original AHU schedule indicated a cooling coil leaving air temperature of 60°F. This relatively high leaving air temperature will result in poor humidity control. We utilized a leaving air temperature of 55°F to allow proper moisture removal of the supply air.

Next, we will review the existing electrical systems serving the Library.

EXISTING ELECTRICAL SYSTEM

Electrical energy is provided to the Kent County Library at 208Y/120-volts AC, three-phase, from a 150 kVA oil-filled transformer, shown in Photograph #14, which is owned by Delmarva Power. The transformer and electrical service were installed in 1976. The electrical service is metered via two current transformer meters in a metering enclosure located adjacent to the utility transformer, shown in Photograph #15. This transformer is located at the southeast corner of the parking lot and has two different sets of conductors from the transformer to the building. One of the meters is a general service meter and the second meter is a heat meter. With the heat meter there is not a demand charge from Delmarva Power which benefits the library with lower overall operating costs.

Photograph #14 – Delmarva Power Pad-Mounted Transformer

Photograph #15 – Metering Cabinet Containing Two Meters

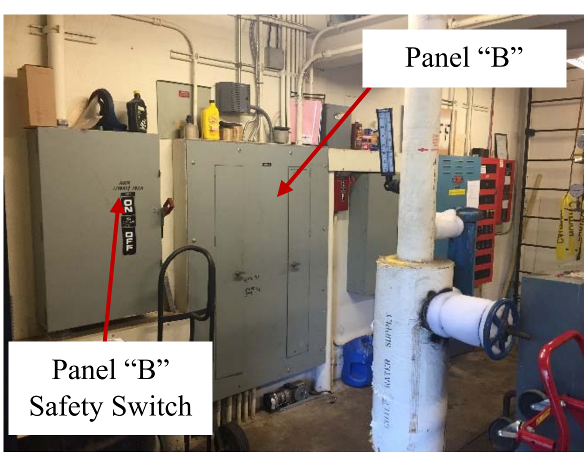
Photograph #16 – Panel "A" Fire Alarm and Disconnect Switch

The conductors from the transformer serving the general service meter go to a wire trough located in the Library's Main Equipment Room that serves two safety switches as shown in Photograph #16. Based on the existing drawing the wire trough is fed by four (4) 250 kcmil conductors in a 2-1/2" conduit. Based on Electrical Table 310.15 of the National Electrical Code, 250 kcmil copper has an ampacity of 255 amperes. One of the safety switches is a 400A switch that has 250A fuses that serve a 400A panelboard labeled as Panel “A” and located in Work Area 108. Panel “A” contains various circuit breakers to serve lighting and receptacle branch circuits throughout the library. The second safety switch is a 30A, 208V, single-phase, switch that is labeled as emergency and feeds the building fire alarm system, as shown in Photographs #17 and #18.

__Photograph #17 – Disconnect to Serve Fire Alarm System__

__Photograph #18 – Fire Alarm System and Abandoned Emergency Lighting System__

The conductors from the transformer for the heat service meter go to a wire trough located in the Library’s Main Equipment Room that serves one safety switch and a 400A panelboard labeled as Panel “B”, shown in Photograph #19. Based on the existing drawings the wire trough is fed by two sets of three (3) 500 kcmil conductors in 3-1/2” conduit. Based on Electrical Table 310.15 of the National Electrical Code, 500 kcmil copper has an ampacity of 380 amperes, so the two sets of 500 kcmil in parallel would have an ampacity of 760 amperes. The 400A safety switch located above the wire trough has 300A fuses installed and serves the 70kW electric heat coil for the air handling unit (AHU) #1. Panel “B”, shown in Photograph #20 is a 400A, 208Y/120V, 3 phase, 3 wire panelboard with a 400A main circuit breaker that serves the remainder of the HVAC equipment serving the Library. Based on the existing drawings of the building and our field observations, it appears that the panelboards and majority of the HVAC safety switches/disconnects were installed in 1976 and are in fair to poor condition. Based on the condition of the equipment and the fact that the equipment has exceeded its useful life, we would recommend that the existing panelboards, safety switches, and HVAC disconnect switches be replaced.



__Photograph #19 – AHU#1 Electric Heat Safety Switch and Panel “B”__

__Photograph #20 – Panelboard “B”__

Next, we will review potential HVAC System replacement options.

<u>HVAC SYSTEM OPTIONS</u>

The Library's existing HVAC system is the original system installed approximately 40 years ago when the Library was constructed. Due to its age, condition, and inefficiency, the existing HVAC system has reached the end of its useful life and we would recommend replacement of the same. There are several potential new HVAC systems, but to be of maximum benefit to the Library, any new system must meet the following criteria:

1. High energy efficiency.
2. Must be easy to maintain and service.
3. Must provide ventilation airflow for people and spaces.
4. Have the capability to maintain temperature and humidity levels in the space required for comfort and maintain good indoor air quality.
5. Minimize the required alterations to the existing architecture and structure.
6. Be quiet and produce low noise levels.

We have evaluated four (4) HVAC systems based on the following criteria:

- Availability of cooling/heating energy sources.
- Required mechanical room/ceiling space.
- Service and maintenance costs.
- Annual operating costs.
- Maintenance involvement.
- Utility costs.
- Noise levels.

Based on the following criteria, the following four (4) systems were analyzed in a Life Cycle Cost Analysis for the building. They are as follows:

System #1. Air Cooled Split System Chiller, Serving Chilled Water Air Handling Units with Electric Heat. (Similar to Existing System)

System #2. Ground Source Heat Pump with Packaged Energy Recovery Ventilator (ERV).

System #3. Air Cooled Variable Refrigerant Volume (VRV) System with Decoupled Air Side Heat Pump and Energy Recovery Ventilator (ERV).

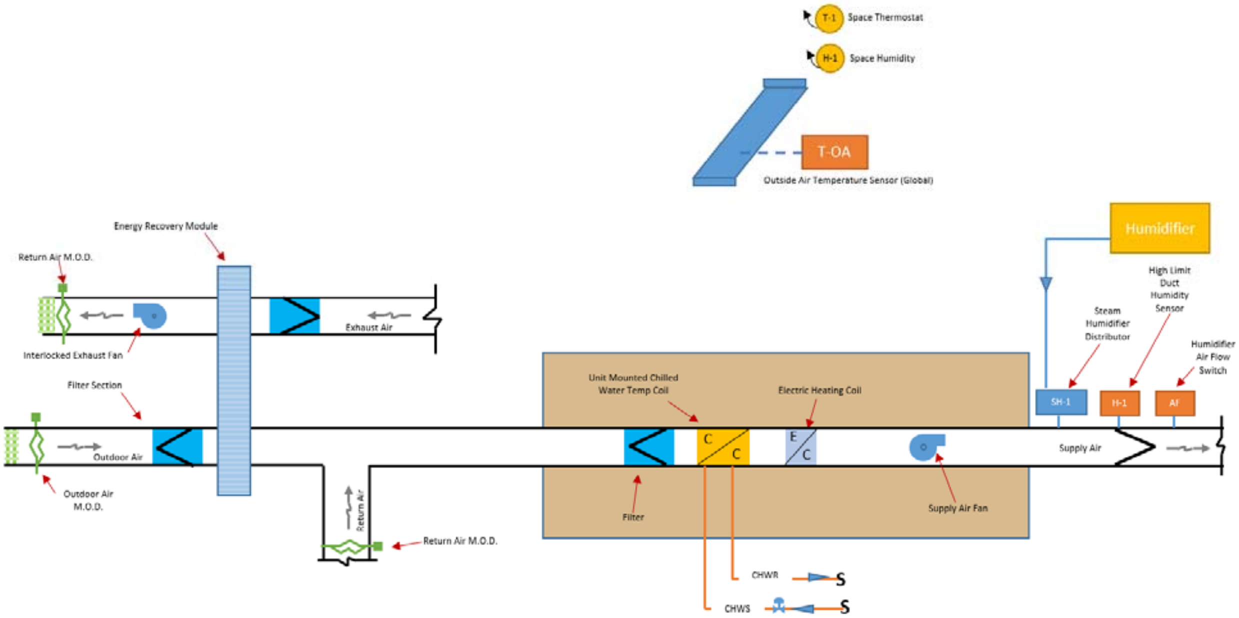
System #4. Air Side Heat Pump System with Packaged Energy Recovery Ventilator (ERV).

The following sections will outline the basic elements of each system.

System #1 (Air Cooled Split System Chiller & Electric Heat)

This Chilled water air handling unit, shown below in Mechanical Figure #4, is very similar to the existing HVAC system, however the following enhancements will be added.

- Exhaust air energy recovery for AHU-1
- Variable speed compressor for improved temperature control (in chiller)
- Variable speed supply fans.



<u>**Mechanical Figure #4 – Chilled Water Air Handling Unit**</u>

The air handling units would be served by the central chilled water system. Electric heating coils would provide heat in winter and reheat in summer for dehumidification. Due to cost/construction issues with replacing existing ductwork, the existing ductwork shall be re-utilized.

The following are the advantages/disadvantages of this system:

Advantages:

1. Similar to the existing system
2. Library will be able to remain open during construction.
3. Existing ductwork above ceilings can be re-utilized.
4. System is familiar to current maintenance staff.
5. Lowest first cost option.
6. Does not require any type of antifreeze.

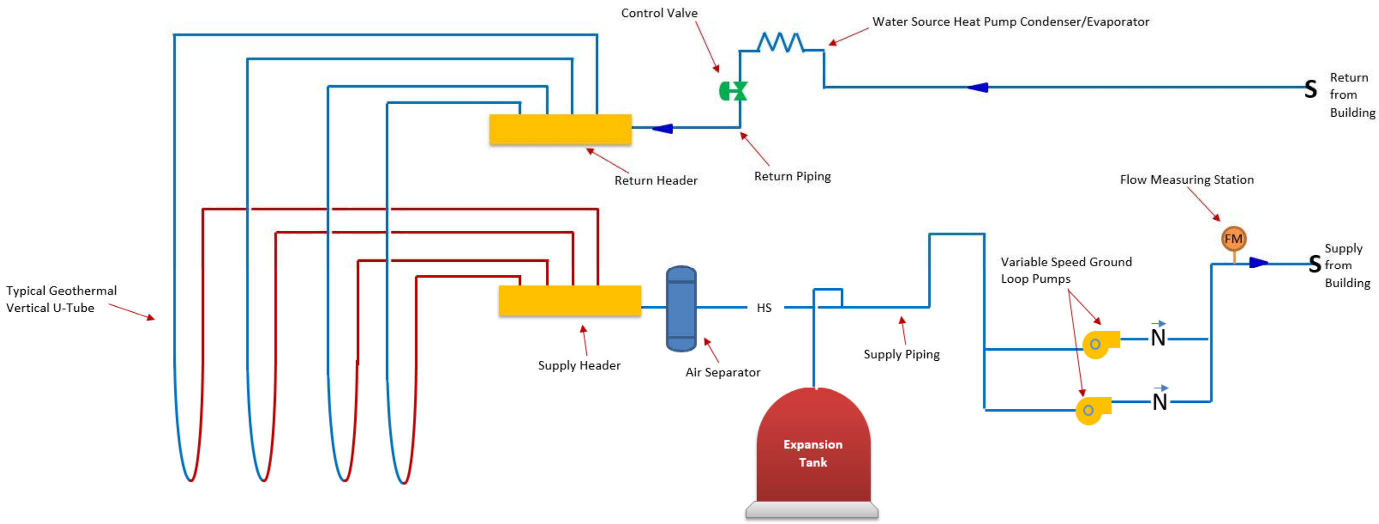
Disadvantages:

1. Heating will be done through electric resistance heaters.
2. Utilizes electric re-heat for dehumidification.

3. Higher operating costs when compared to Systems #2, #3, and #4.

System #2 (Ground Source Heat Pump with Packaged ERV)

The proposed geothermal system would utilize packaged geothermal heat pumps ducted to each zone to provide heating and cooling. An energy recovery ventilator (ERV) would provide decoupled ventilation airflow to each space. The ERV unit would be connected to the geothermal water loop. See Mechanical Figure #5 for a basic layout of this system.



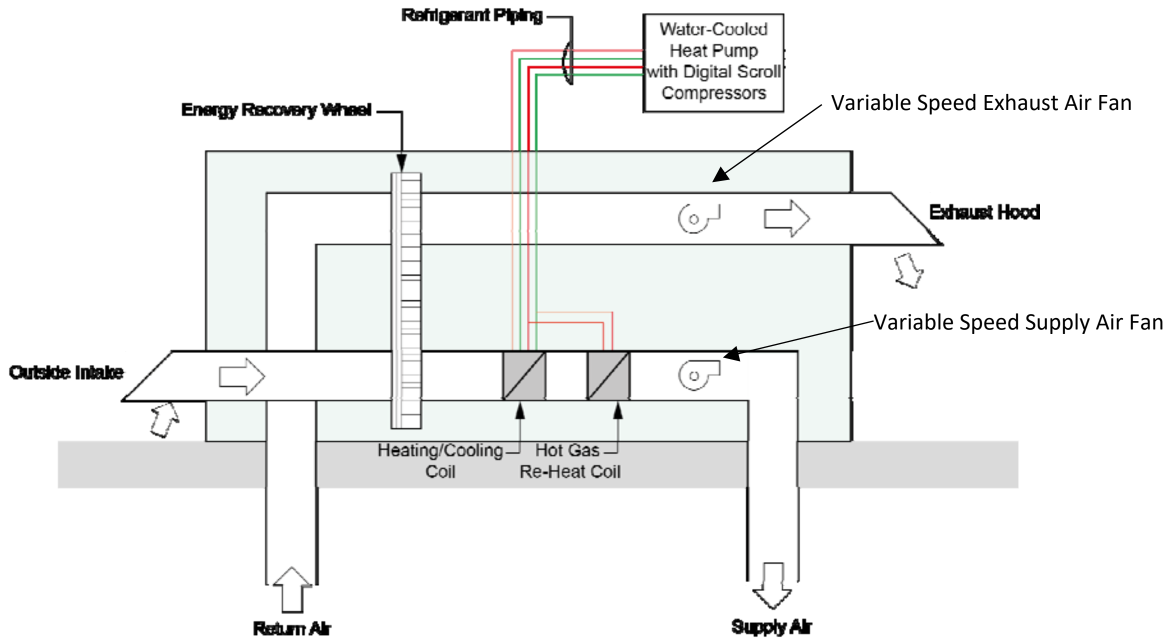
Mechanical Figure #5 – Closed Loop Geothermal System

Digital scroll compressors are utilized in the energy recovery ventilator to provide better performance at part load and varying outdoor air conditions.

To meet current requirements and to reduce the potential for indoor air quality problems from high relative humidity in the spaces, we recommend an energy recovery ventilator with packaged total energy recovery wheels. This approach will ensure that the proper amount of outside air is introduced into the space and it will help minimize the heating and cooling loads on the system by the incoming air.

These energy recovery ventilators (ERV) would be provided with variable speed drives for the supply and exhaust fans. This would permit the unit to operate with a demand controlled ventilation feature. This feature monitors carbon dioxide levels in the spaces and allows the ERV to reduce airflows to the minimum levels required to adequately ventilate the building. An energy recovery ventilator as indicated in Mechanical Figure #5 above utilizes a desiccant wheel to transfer heat (both sensible and latent) from exhaust air to supply air and vice-versa, to reduce heating and cooling loads associated with outside ventilation air.

The Energy Recovery Ventilators will be packaged water cooled units as indicated in Mechanical Figure #6 below.



Mechanical Figure #6 - Typical Energy Recovery Ventilator

Once conditioned, ventilation air would be distributed throughout the building via ductwork mounted above the ceilings. The use of an energy recovery ventilator will reduce the energy costs associated with conditioning outside air and also reduce the installed tonnage of heating/cooling equipment.

Ground source water cooled heat pumps and energy recovery ventilator system will provide cooling/heating and code required amount of ventilation air respectively. The water source heat pumps can provide simultaneous heating and cooling throughout the zones as needed.

As each water source heat pump unit will have its own thermostat, flexibility of control is greatly enhanced. However, the installation would require all new ductwork above the ceilings. This would require removal and replacement of ceilings along with a shutdown of the Library. The Library parking lot would also need to be removed and replaced to allow for the geothermal bore holes to be installed, which would increase construction costs drastically.

The following are the advantages/disadvantages of this system:

Advantages:

1. Minimal central equipment to maintain.
2. Lowest operating cost.
3. ERVs maintain constant ventilation of the occupied spaces.
4. Longer useful service life, approximately 30-35 years.
5. Equipment efficiency remains more consistent for life of system versus air cooled systems.
6. Decoupled ERV can utilize demand controlled ventilation.

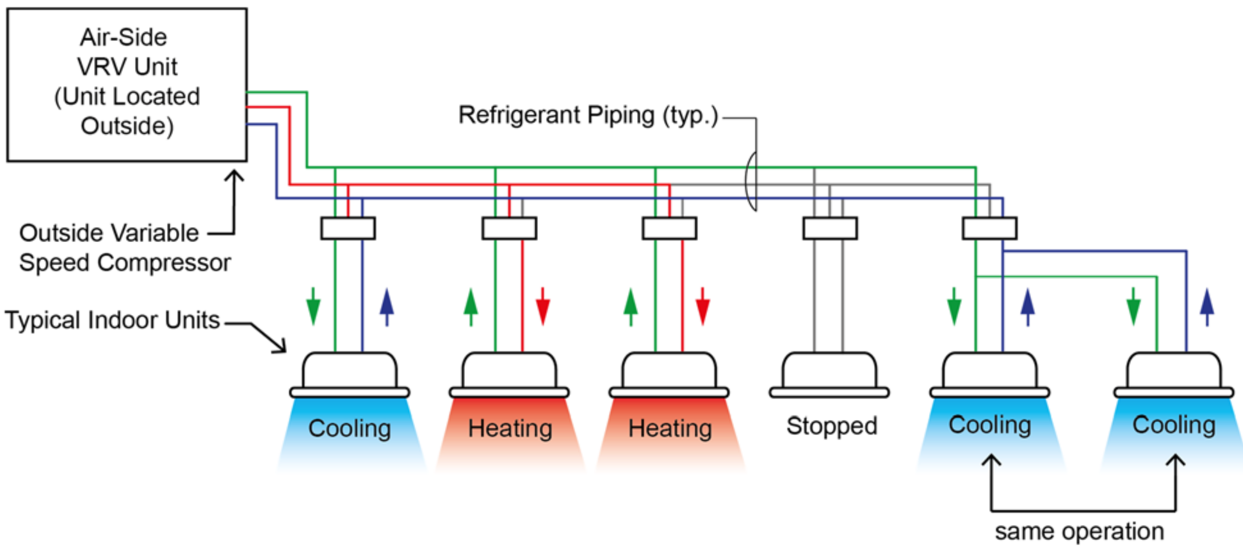
Disadvantages:

1. High initial cost when compared to other systems.
2. Library parking lot would need to be removed and replaced.

3. New ductwork and ceilings would be required.
4. Shut down of Library would be required.

System #3 (Air Cooled Variable Refrigerant Volume System w/ Decoupled Air Side Heat Pump ERV)

This system would include an air cooled variable refrigerant volume system for heating and cooling, along with a decoupled energy recovery ventilator. See Mechanical Figure #7 below for the basic layout of the VRV System.



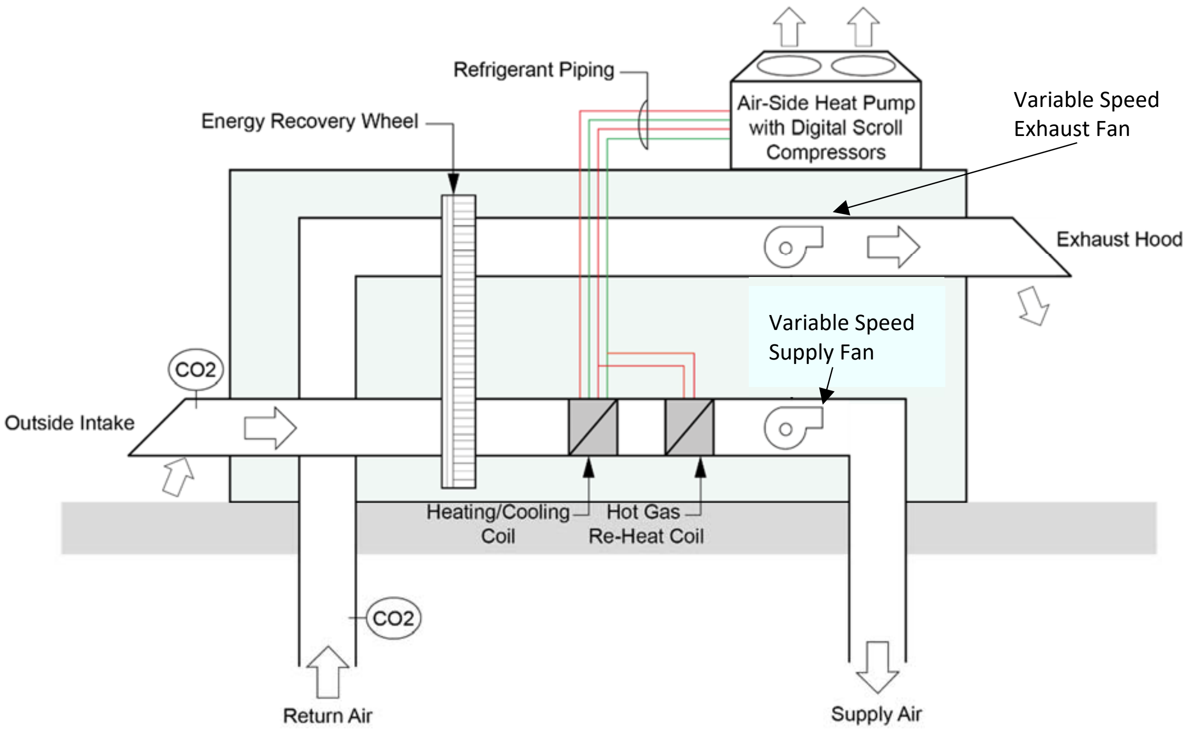
<u>Mechanical Figure #7 - Air Cooled Variable Refrigerant Volume System</u>

This air cooled VRV (heat pumps) and ventilator system will provide heating/cooling and the required amount of ventilation respectively. The variable refrigerant volume system allows simultaneous heating and cooling throughout zones by utilizing individual ductless or ducted heat pump units. The VRV system is a ductless multi-split system which uses a single air-cooled remote compressor unit which houses a variable speed compressor unit in conjunction with multiple inside heat pump units. The compressor unit has a reversing valve and performs as a conventional heat pump to provide both heating and cooling in the system. Digital scroll compressors are utilized in both the VRV heat pump compressor unit and the energy recovery ventilator. The digital scroll compressors provide energy efficient operation at full load and part load.

As shown in Figure #7 above, the VRV system can eliminate most of the required ductwork as the individual indoor units can be small wall, floor, or ceiling mounted ductless units for each space where possible. As each indoor unit will have its own thermostat, flexibility of control is greatly enhanced. Ducted units would be utilized for the large spaces with high ceilings where ductless is not appropriate. The installation requires new ductwork, and refrigerant piping to be routed throughout the facility.

To perform the task of conditioning the outside air, a dedicated Energy Recovery Ventilator (ERV) would be provided for the building. This approach is referred to as "de-coupling". This would require new ceilings and a shutdown of the Library to install. By de-coupling the two systems, constant ventilation airflow can be maintained without affecting the space temperature.

The ERV unit would be provided with variable speed drives for the supply and exhaust fans. This would permit the unit to operate with a demand control ventilation feature. This feature monitors carbon dioxide levels in the spaces and allows the ERV to reduce airflows to the minimum levels required to adequately ventilate the building. An energy recovery ventilator as indicated in Mechanical Figure #8 utilizes a desiccant wheel to transfer heat from exhaust air to supply air and vice-a-versa, which will drastically reduce heating and cooling loads associated with outside ventilation air.



Mechanical Figure #8 – Energy Recovery Ventilator

The following are the advantages/disadvantages of this system.

Advantages:

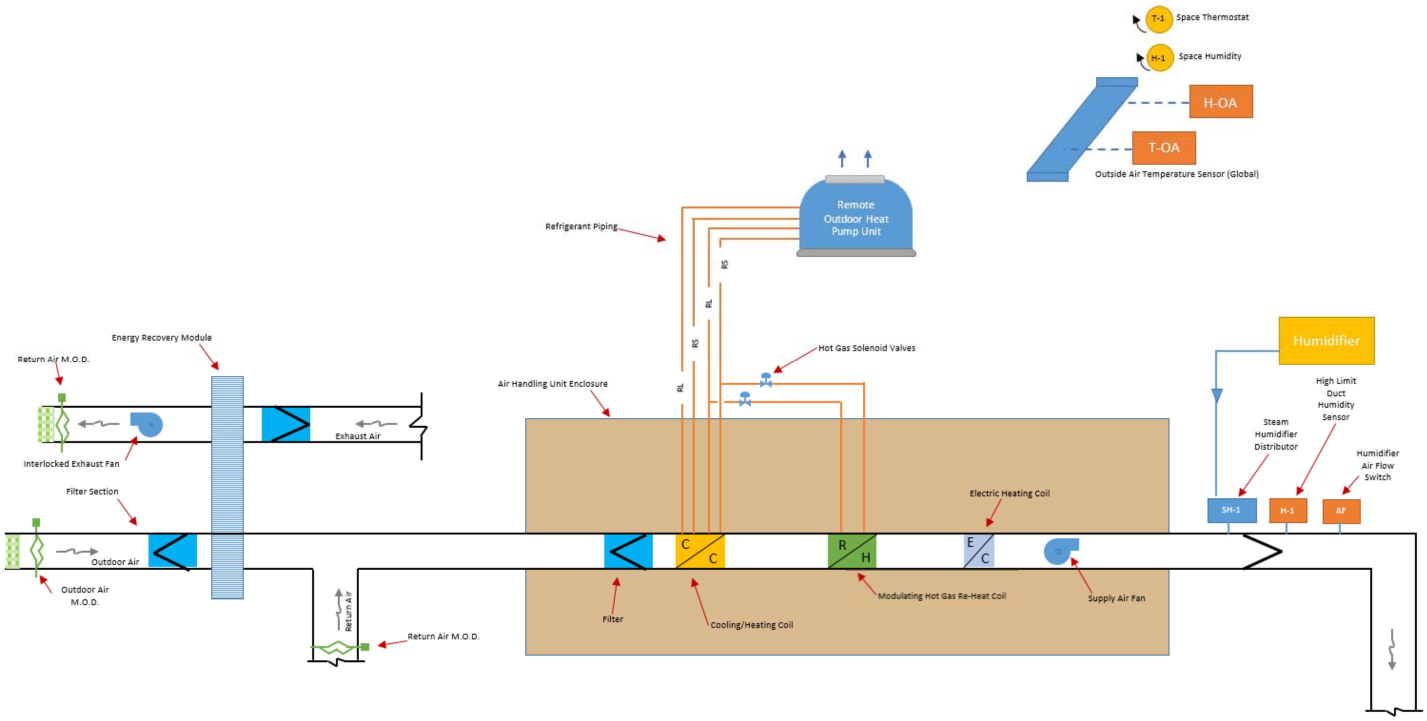
1. More zones (thermostats) for control when compared to existing system.
2. Inherent energy recovery.
3. Decoupled ERV can utilize demand controlled ventilation.

Disadvantages:

1. Second most expensive system indicated.
2. Library ceilings would need to be removed for installation of ductless units, ductwork, and refrigerant piping.
3. Library would need to be closed for renovations.

System #4 (Air Side Split System Heat Pumps)

Split system heat pump units would be provided to serve the Library with a ducted distribution system, and re-use existing ductwork. See Mechanical Figure #9 for a basic layout of the system.



<u>Mechanical Figure #9 – Air Side Split System Heat Pump</u>

Digital scroll compressors are utilized in the exterior heat pump to provide better performance at part load and varying outdoor air conditions. The heat pumps are an improvement over straight electric heat. Exhaust air energy recovery would be utilized for pre-treatment of outside air on AHU-1 (highest outside air requirement). Hot gas reheat coils shall allow dehumidification without electric reheat coils.

The following are the advantages/disadvantages of this system:

Advantages:

1. Digital scroll technology provides reduced operating power at part load.
2. The majority of existing ductwork will be re-utilized.
3. Library will be able to stay operational during renovations.
4. Lower operating cost due to hot gas re-heat coil when compared to Option #1.

Disadvantages:

1. Higher operating cost than Systems #2 & #3.
2. Reduced service life for air cooled equipment. (compared to system #2)
3. Equipment efficiency is not consistent for life of system due to the compressor units being located outside.
4. The need to find exterior location for large exterior heat pump units.
5. Increased exterior noise due to compressors being located outside.

Next we will review our Life Cycle Cost Analysis.

LIFE CYLCE COST ANALYSIS

To avoid comparing systems exclusively based on their advantages/disadvantages, we performed a life cycle cost analysis on each system. The life cycle cost analysis (LCCA) evaluates initial costs, operating costs, and service/maintenance costs associated with each system over a 30 year period. The summary of the life cycle cost analysis is contained in the tables below. For the detailed analysis, refer to Appendix M-3.

The initial mechanical installation costs for the four (4) systems are listed below in Table #7.

SYSTEM	Mechanical Construction Cost	$/ FT^2
System #1: Air Cooled Split System Chiller, Air Handling Units and Electric Heat	$380,600	$34.60
System #2: Ground Source Heat Pump with Packaged Energy Recovery Ventilator (ERV)	$673,300	$61.21
System #3: Air Cooled Variable Refrigerant Volume (VRV) System with Decoupled Air Side Heat Pump and Energy Recovery Ventilator (ERV)	$507,350	$46.12
System #4: Air Side Split System Heat Pumps	$418,900	$38.08

Notes:

1. **Total Initial cost does not include plumbing costs.**
2. **Total initial cost does NOT include cost associated with architectural, civil or electrical system construction costs.**
3. **Total initial cost does NOT include bonds, insurance, general conditions, or design contingency.**
4. **System #2 Initial cost includes an additional $150,000 for additional incremental architectural and structural components for the demolition and replacement of ceilings and parking lot.**
5. **System #2 Initial cost includes an additional $25,000 for additional incremental cost of electrical components.**
6. **System #3 Initial cost includes an additional $50,000 for additional incremental architectural and structural components for the demolition and replacement of ceilings.**
7. **System #3 Initial cost includes an additional $30,000 for additional incremental cost of electrical components.**
8. **System #4 Initial cost includes an additional $20,000 for additional incremental architectural and structural components for the heat pump enclosures.**
9. **System #4 Initial cost includes an additional $15,000 for additional incremental cost of electrical components.**
10. **Present Worth Factor utilizes an escalation rate of .05 and discount rate of .04.**

Table #6 – Estimated Mechanical Installation Costs
(***Refer to Appendix M-3 for Life Cycle Cost Analysis)***

The next step in the life cycle cost analysis was to identify the annual operating cost based on energy, service, and maintenance costs. The estimated costs for each of these are summarized below in Table #8.

SYSTEM	Annual Energy Cost ($)	Annual Service Cost ($)	Annual Maintenance Cost ($)	Total Annual Operating Cost ($)
System #1: Air Cooled Split System Chiller, Air Handling Units and Electric Heat	$7,924	$1,850	$1,950	$11,724
System #2: Ground Source Heat Pump with Packaged Energy Recovery Ventilator (ERV)	$4,933	$1,350	$1,450	$7,733
System #3: Air Cooled Variable Refrigerant Volume (VRV) System with Decoupled Air Side Heat Pump and Energy Recovery Ventilator (ERV)	$5,976	$1,400	$1,500	$8,876
System #4: Air Side Split System Heat Pumps	$6,254	$2,200	$2,300	$10,754

Table #7 - Estimated Annual Operating Costs
(***Refer to Appendix M-3 for Life Cycle Cost Analysis)***

The final step in the life cycle cost analysis is to apply a present worth factor to these costs as appropriate for a 30-year cost. This factor accounts for escalation in cost of utilities and discount (interest rate) over a 30-year period. Applying the factor to the costs summarized previously yields a total estimated life cycle cost for each system as summarized below.

The total 30-year life cycle cost for all systems are as follows.

- System #1 – 30 year life cycle cost = $789,958
- System #2 – 30 year life cycle cost = $943,307
- System #3 – 30 year life cycle cost = $817,226
- System #4 – 30 year life cycle cost = $794,389

From this data, the recommended system based on a life cycle cost analysis is the Air Cooled Split System Chiller, Air Handling Units and Electric Heat (System #1). Systems #2 & #3 have lower annual operating costs, but the initial cost of installation makes these options not feasible. System #4 is a close 2nd when compared to System #1. However, the longer useful service life of the chiller, and reduced exterior work (required for the enclosure) make System #1 the best option. The Life Cycle Cost Analysis results were a surprise since the system with electric heat had the best Life Cycle Cost Analysis. However, the use of electric heat was found to be competitive because the heat meter provided an overall competitive cost per unit of electricity.

ELECTRICAL RECOMMENDATIONS

Due to the age and condition of the existing electrical distribution equipment, we would recommend the same be replaced as well as new HVAC disconnect switches be provided for all HVAC equipment being replaced for this project. As noted in the existing conditions of this report, there are two separate services to the library from the utility transformer. We would recommend the following upgrades for the general electrical service:

1. Remove the conductors from the conduit that goes from the transformer to the wire trough serving the safety switch feeding Panelboard “A”.

2. Remove the existing wire trough, and two safety switches located below the wire trough.

3. Retain all wiring on the load side of the safety switches for reconnection.

4. Cut conduit back to 1’ AFF in Library Equipment Room, retain the conduit for reuse.

5. Provide new four (4) sets of 500 kcmil (CU) conductors from the utility transformer to the Library Equipment room via existing conduit.

6. Provide new 6”x6” NEMA 1 wireway and connect to top of existing conduit.

7. Provide a new 400A, 208, 3 phase, 4 wire, distribution panelboard equal to Square D I-Line panelboard HCM with 400A main circuit breaker that is capable of having a 225A branch breaker installed in panelboard above the new wireway and connect the 4 sets of 500kcmil to the 400A main breaker via the wireway.

8. Provide a new 225A, 3 pole breaker in the distribution panelboard and terminate the existing wiring to panelboard “A” to the new breaker and provide a new 20A, 1 pole breaker in the distribution panel and connect existing wiring to the fire alarm panel to the new breaker.

In the library work room, we would recommend that the two section panelboard “A” be replaced with a 72 circuit, 208/120V, 3 phase, two section panelboard installed in the same location and all of the existing branch circuit wiring be terminated at new circuit breakers to match existing. The existing panelboard “A” has (54) 1 pole 20A circuit breakers, (1) 3 pole/20A circuit breaker, (1) 2 pole/30A circuit breaker and (1) 2 pole/50A circuit breaker. The remaining spaces shall receive 20A/1 pole circuit breakers and be labeled as “spare”.

We have calculated the new heating load for the entire building to be 183kW or 636A at 208V, 3 phase, based on the scheduled values of existing equipment that is remaining and assuming that recommended mechanical option number 1 is accepted. We would recommend the following upgrades to the heating service which currently serves the building’s HVAC equipment:

1. The existing two (2) sets of (3) 500kcmil conductors be removed, however the two 3-1/2” conduits shall remain.

2. The existing wire trough, safety switch for AHU #1 electric heat coil, and panelboard “B” shall be removed.

3. Under the proposed mechanical recommendations, AHU #1, 2, 3, chiller, condensing unit, and electric steam boiler are all being replaced so all the branch circuit wiring and associated disconnects for these units shall be removed.

4. All load side wiring for branch circuits in panelboard "B" for HVAC units that are not being removed shall be retained for termination to new HVAC panelboard.

5. Provide a new 800A, 208V, 3 phase, 4 wire, distribution panelboard equal to Square D I-Line Combo with 800A main breaker and 42 circuit 225A, 208V, 3 phase, branch circuit panelboard in one enclosure in equipment room.

6. Two (2) sets of 500kcmil (CU) conductors shall be provided from the transformer to the new 800A panelboard via the existing two (2) 3-1/2" conduits in the equipment room. The proposed two sets of 500kcmil conductors have a continuous load ampacity of 760A.

7. Terminate the new conductors on the main circuit breaker in the new distribution panel.

8. New disconnects, wiring and breakers would be provided in the new distribution panelboard.

9. All circuits 60A or larger would be installed in the new I-Line section of the distribution panelboard while the existing heater circuits and any other new circuits smaller than 60A can be installed in the branch circuit panelboard.

10. All new disconnects and wiring shall be sized to comply with the National Electrical Code (NEC).

Additional information is provided in the single line diagrams found in Appendix E-1 of the Report. The estimated construction costs associated with the above electrical recommendations $101,429. (Refer to Appendix M-4 for the breakdown on the construction cost estimate.)

SUMMARY AND RECOMMENDATIONS

The existing HVAC system located at the Kent County Public Library has served its useful life, and is in need of replacement. The fact that the existing HVAC system has operated for 40 years is a testament to the care, service, and maintenance provided for the system over its useful service life. Based on our analysis we have determined that best option for addressing the Kent County Public Library HVAC System deficiencies is System #1 (Air Cooled Split System Chiller, Air Handling units, and Electric Heat). System #1 has the lowest initial cost, and has reasonable operating/maintenance costs. Also with System #1, the Library would be able to remain operational during the HVAC replacements, and a majority of the existing ductwork would be able to remain and be reused.

System enhancements include energy recovery, variable speed supply fans, and digital scroll compressors.

The existing electrical distribution system in the Kent County Public Library has exceeded its useful life and is in need of replacement. We would recommend replacing both the general electrical service and the space heating service in their entirety, including service laterals, panelboards, safety switches, etc.

We would recommend maintaining the two electrical services since the utility company does not apply a demand change for the space heating service. The proposed HVAC system equipment would be served from the new heating service distribution panelboard as outlined in this Report.

Finally we produced an overall project cost estimate that includes all recommendations (mechanical and electrical), supporting architectural costs, supporting structural costs and other costs associated with construction bonds, insurance, general conditions, etc. The total proposed construction cost estimate is $622,449. (Refer the Appendix M-4 for the construction cost estimate.) Please note this does not include costs associated with architectural, structural, or engineering design fees. We fully understand that this cost exceeds your budget and will work diligently with Kent county Government to reduce the same where feasible with alternates during the Bidding phase of the project.

Per your request we have created a design fee proposal for the recommended options listed above. The design fee (fee proposal attached separately from report) is approximately $53,000. **Therefore, the total construction cost estimate and associated MEP design fee is approximately $675,449.**

We hope you will find our Report informative and useful relative to the HVAC system replacement at the Kent County Public Library. Once you have reviewed the report, please feel free to contact our office if you have any questions or comments.

Very truly yours,

Very truly yours,
GIPE ASSOCIATES, INC.

Marcus D. Schwarz,
Mechanical Designer

And

R. Adam Kegan, P.E., C.P.D, LEED AP, CxA
Vice President

Appendix:

Appendix M-1: Ventilation Load Calculations
Appendix M-2: Heating & Cooling Load Calculations
Appendix M-3: Life Cycle Cost Analysis
Appendix M-4: Construction Cost Estimates
Appendix E-1: Library Equipment Room – Demolition and New Work Single Line Sketches

Appendix M-1

Ventilation Load Calculations

1. Summary

Ventilation Sizing Method .... **ASHRAE Std 62.1-2010**
Design Condition .... **Minimum flow (heating)**
Occupant Diversity (D) **1.000**
Uncorrected Outdoor Air Intake (Vou) .... **1098** CFM
System Ventilation Efficiency (Ev) **0.693**
Outdoor Air Intake (Vot) .... **1585** CFM

2. Space Ventilation Analysis

Zone Name / Space Name	Mult.	Minimum Supply Air (CFM) (Vpz)	Space Floor Area (ft²) (Az)	Area Outdoor Air Rate (CFM/ft²) (Ra)	Time Averaged Occupancy (Occupants) (Pz)	People Outdoor Air Rate (CFM/person) (Rp)	Air Distribution Effectiveness (Ez)	Space Outdoor Air (CFM) (Voz)	Breathing Zone Outdoor Air (CFM) (Vbz)	Space Ventilation Efficiency (Evz)
Zone 1										
102 Lobby	1	508	639.0	0.06	4.0	5.00	0.80	**73**	*58*	1.106
Zone 2										
103 Children's Area	1	530	1715.0	0.12	6.0	5.00	0.80	**295**	*236*	0.693
Zone 3										
105 Reference Area	1	1095	1257.0	0.12	30.0	5.00	0.80	**376**	*301*	0.906
Zone 4										
107 Adult Area	1	2209	3754.0	0.12	10.0	5.00	0.80	**626**	*500*	0.966
Zone 5										
117 Men	1	23	96.0	0.00	0.0	0.00	0.80	**0**	*0*	1.249
118 Women	1	27	115.0	0.00	0.0	0.00	0.80	**0**	*0*	1.249
119 Jan.	1	7	31.0	0.00	0.0	0.00	0.80	**0**	*0*	1.249
124 Vest.	1	12	50.0	0.06	0.0	0.00	0.80	**4**	*3*	0.933
Totals (incl. Space Multipliers)		**4412**							**1098**	**0.693**

Ventilation Sizing Summary for AHU-2

1. Summary

Ventilation Sizing Method .... **ASHRAE Std 62.1-2010**
Design Condition .... **Minimum flow (heating)**
Occupant Diversity (D) **1.000**
Uncorrected Outdoor Air Intake (Vou) .... **172** CFM
System Ventilation Efficiency (Ev) **0.715**
Outdoor Air Intake (Vot) .... **240** CFM

2. Space Ventilation Analysis

		Minimum Supply Air (CFM)	Space Floor Area (ft²)	Area Outdoor Air Rate (CFM/ft²)	Time Averaged Occupancy (Occupants)	People Outdoor Air Rate (CFM/person)	Air Distribution Effectiveness	Space Outdoor Air (CFM)	Breathing Zone Outdoor Air (CFM)	Space Ventilation Efficiency
Zone Name / Space Name	**Mult.**	**(Vpz)**	**(Az)**	**(Ra)**	**(Pz)**	**(Rp)**	**(Ez)**	**(Voz)**	**(Vbz)**	**(Evz)**
Zone 1										
108 Work Area	1	615	887.0	0.06	7.0	5.00	0.80	**110**	*88*	0.975
Zone 2										
109 Admin Office	1	168	129.0	0.06	2.0	5.00	0.80	**22**	*18*	1.023
Zone 3										
112 Staff Lounge	1	235	264.0	0.06	4.0	5.00	0.80	**45**	*36*	0.964
113 TLT	1	8	33.0	0.00	0.0	0.00	0.80	**0**	*0*	1.155
114 Kitchen	1	85	123.0	0.12	2.0	7.50	0.80	**37**	*30*	0.715
Totals (incl. Space Multipliers)		**1110**							**172**	**0.715**

Ventilation Sizing Summary for AHU-3

1. Summary

Ventilation Sizing Method .... **ASHRAE Std 62.1-2010**
Design Condition .... **Minimum flow (heating)**
Occupant Diversity (D) **1.000**
Uncorrected Outdoor Air Intake (Vou) .... **299** CFM
System Ventilation Efficiency (Ev) **0.897**
Outdoor Air Intake (Vot) .... **334** CFM

2. Space Ventilation Analysis

Zone Name / Space Name	Mult.	Minimum Supply Air (CFM) (Vpz)	Space Floor Area (ft²) (Az)	Area Outdoor Air Rate (CFM/ft²) (Ra)	Time Averaged Occupancy (Occupants) (Pz)	People Outdoor Air Rate (CFM/person) (Rp)	Air Distribution Effectiveness (Ez)	Space Outdoor Air (CFM) (Voz)	Breathing Zone Outdoor Air (CFM) (Vbz)	Space Ventilation Efficiency (Evz)
Zone 1										
115 Meeting Room	1	738	1169.0	0.06	45.0	5.00	0.80	**369**	*295*	0.897
116 A.V. Equip.	1	17	72.0	0.06	0.0	0.00	0.80	**5**	*4*	1.081
Totals (incl. Space Multipliers)		**755**							**299**	**0.897**

Appendix M-2

Heating & Cooling Load Calculations

Air System Information

Air System Name	**AHU-1**		Number of zones	**5**	
Equipment Class	**CW AHU**		Floor Area	**7657.0**	ft²
Air System Type	**VAV**		Location	**Salisbury, Maryland**	

Sizing Calculation Information

Calculation Months	**Jan to Dec**	Zone CFM Sizing	**Peak zone sensible load**
Sizing Data	**Calculated**	Space CFM Sizing	**Individual peak space loads**

Central Cooling Coil Sizing Data

Total coil load	**25.8**	Tons	Load occurs at	**Jul 1600**	
Total coil load	**310.0**	MBH	OA DB / WB	**94.4 / 77.9**	°F
Sensible coil load	**232.2**	MBH	Entering DB / WB	**80.0 / 65.5**	°F
Coil CFM at Jul 1600	**8218**	CFM	Leaving DB / WB	**53.8 / 52.6**	°F
Max block CFM at Jul 1600	**8725**	CFM	Coil ADP	**50.9**	°F
Sum of peak zone CFM	**8824**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.749**		Resulting RH	**45**	%
ft²/Ton	**296.4**		Design supply temp.	**55.0**	°F
BTU/(hr·ft²)	**40.5**		Zone T-stat Check	**5 of 5**	OK
Water flow @ 10.0 °F rise	**62.03**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

No heating coil loads occurred during this calculation.

Supply Fan Sizing Data

Actual max CFM at Jul 1600	**8725**	CFM	Fan motor BHP	**8.06**	BHP
Standard CFM	**8708**	CFM	Fan motor kW	**6.40**	kW
Actual max CFM/ft²	**1.14**	CFM/ft²	Fan static	**3.00**	in wg

Return Fan Sizing Data

Actual max CFM at Jul 1600	**8725**	CFM	Fan motor BHP	**1.99**	BHP
Standard CFM	**8708**	CFM	Fan motor kW	**1.57**	kW
Actual max CFM/ft²	**1.14**	CFM/ft²	Fan static	**1.00**	in wg

Outdoor Ventilation Air Data

Design airflow CFM	**1585**	CFM	CFM/person	**31.70**	CFM/person
CFM/ft²	**0.21**	CFM/ft²			

Air System Information

Air System Name **AHU-1**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **5**
Floor Area .... **7657.0** ft²
Location .... **Salisbury, Maryland**

Sizing Calculation Information

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone CFM Sizing .... **Peak zone sensible load**
Space CFM Sizing .... **Individual peak space loads**

Zone Terminal Sizing Data

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	1017	508	1.59	24.4	-	0.0	0.00	0
Zone 2	1060	530	0.62	26.0	-	0.0	0.00	0
Zone 3	2190	1095	1.74	51.8	-	0.0	0.00	0
Zone 4	4418	2209	1.18	145.0	-	0.0	0.00	0
Zone 5	139	69	0.48	2.6	-	0.0	0.00	0

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
Zone 1	21.9	Sep 1500	15.1	639.0
Zone 2	22.9	Jul 1500	16.3	1715.0
Zone 3	47.2	Jul 1600	31.8	1257.0
Zone 4	95.3	Aug 1500	104.5	3754.0
Zone 5	3.0	Jul 1400	1.3	292.0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Peak Sensible Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
102 Lobby	1	21.9	Sep 1500	1017	15.1	639.0	1.59
Zone 2							
103 Children's Area	1	22.9	Jul 1500	1060	16.3	1715.0	0.62
Zone 3							
105 Reference Area	1	47.2	Jul 1600	2190	31.8	1257.0	1.74
Zone 4							
107 Adult Area	1	95.3	Aug 1500	4418	104.5	3754.0	1.18
Zone 5							
117 Men	1	1.0	Jul 1400	46	0.4	96.0	0.48
118 Women	1	1.2	Jul 1400	55	0.5	115.0	0.48
119 Jan.	1	0.3	Jul 1400	15	0.1	31.0	0.48
124 Vest.	1	0.5	Jul 1400	24	0.2	50.0	0.48

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1600 COOLING OA DB / WB 94.4 °F / 77.9 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 10.0 °F / 8.0 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	954 ft²	41887	-	954 ft²	-	-
Wall Transmission	2550 ft²	15592	-	2550 ft²	35638	-
Roof Transmission	7657 ft²	35410	-	7657 ft²	31618	-
Window Transmission	954 ft²	12992	-	954 ft²	48853	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	126 ft²	8710	-	126 ft²	4531	-
Floor Transmission	7657 ft²	0	-	7657 ft²	8699	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	7657 W	26125	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	3829 W	13063	-	0	0	-
People	50	11500	6000	0	0	0
Infiltration	-	7607	14036	-	24261	0
Miscellaneous	-	15213	0	-	0	0
Safety Factor	0% / 0%	0	0	10%	15360	0
>> Total Zone Loads	**-**	**188099**	**20036**	**-**	**168961**	**0**
Zone Conditioning	-	180283	20036	-	165973	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	8218 CFM	4655	-	4412 CFM	-1374	-
Ventilation Load	1493 CFM	28373	57731	801 CFM	52723	0
Supply Fan Load	8218 CFM	18912	-	4412 CFM	-5582	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**232223**	**77767**	**-**	**211740**	**0**
Central Cooling Coil	-	232223	77778	-	0	0
Preheat Coil	-	0	-	-	0	-
Terminal Reheat Coils	-	0	-	-	211732	-
>> Total Conditioning	**-**	**232223**	**77778**	**-**	**211732**	**0**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Air System Information

Air System Name	**AHU-2**		Number of zones	**3**	
Equipment Class	**CW AHU**		Floor Area	**1436.0**	ft²
Air System Type	**VAV**		Location	**Salisbury, Maryland**	

Sizing Calculation Information

Calculation Months	**Jan to Dec**	Zone CFM Sizing	**Peak zone sensible load**
Sizing Data	**Calculated**	Space CFM Sizing	**Individual peak space loads**

Central Cooling Coil Sizing Data

Total coil load	**5.5**	Tons	Load occurs at	**Jul 1400**	
Total coil load	**66.3**	MBH	OA DB / WB	**94.4 / 77.9**	°F
Sensible coil load	**53.2**	MBH	Entering DB / WB	**78.6 / 64.2**	°F
Coil CFM at Jul 1400	**2002**	CFM	Leaving DB / WB	**54.0 / 52.7**	°F
Max block CFM at Jul 1400	**2193**	CFM	Coil ADP	**51.3**	°F
Sum of peak zone CFM	**2212**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.803**		Resulting RH	**45**	%
ft²/Ton	**260.0**		Design supply temp.	**55.0**	°F
BTU/(hr·ft²)	**46.2**		Zone T-stat Check	**3 of 3**	OK
Water flow @ 10.0 °F rise	**13.26**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

No heating coil loads occurred during this calculation.

Supply Fan Sizing Data

Actual max CFM at Jul 1400	**2193**	CFM	Fan motor BHP	**1.00**	BHP
Standard CFM	**2189**	CFM	Fan motor kW	**0.79**	kW
Actual max CFM/ft²	**1.53**	CFM/ft²	Fan static	**2.00**	in wg

Return Fan Sizing Data

Actual max CFM at Jul 1400	**2193**	CFM	Fan motor BHP	**0.50**	BHP
Standard CFM	**2189**	CFM	Fan motor kW	**0.40**	kW
Actual max CFM/ft²	**1.53**	CFM/ft²	Fan static	**1.00**	in wg

Outdoor Ventilation Air Data

Design airflow CFM	**240**	CFM	CFM/person	**15.99**	CFM/person
CFM/ft²	**0.17**	CFM/ft²			

Air System Information

Air System Name **AHU-2**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **3**
Floor Area .... **1436.0** ft²
Location .... **Salisbury, Maryland**

Sizing Calculation Information

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone CFM Sizing .... **Peak zone sensible load**
Space CFM Sizing .... **Individual peak space loads**

Zone Terminal Sizing Data

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	1229	615	1.39	24.4	-	0.0	0.00	0
Zone 2	336	168	2.61	10.8	-	0.0	0.00	0
Zone 3	647	323	1.54	21.3	-	0.0	0.00	0

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
Zone 1	26.5	Jul 1400	13.2	887.0
Zone 2	7.2	Jul 1400	7.7	129.0
Zone 3	13.9	Aug 1400	15.4	420.0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Peak Sensible Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
108 Work Area	1	26.5	Jul 1400	1229	13.2	887.0	1.39
Zone 2							
109 Admin Office	1	7.2	Jul 1400	336	7.7	129.0	2.61
Zone 3							
112 Staff Lounge	1	10.1	Aug 1100	470	10.3	264.0	1.78
113 TLT	1	0.3	Jul 1400	16	0.1	33.0	0.48
114 Kitchen	1	3.7	Aug 1500	169	4.9	123.0	1.38

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1400 COOLING OA DB / WB 94.4 °F / 77.9 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 10.0 °F / 8.0 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	282 ft²	9083	-	282 ft²	-	-
Wall Transmission	453 ft²	3243	-	453 ft²	6331	-
Roof Transmission	1436 ft²	7360	-	1436 ft²	5930	-
Window Transmission	282 ft²	3737	-	282 ft²	14441	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	1436 ft²	0	-	1436 ft²	1363	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1436 W	4900	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	718 W	2450	-	0	0	-
People	15	3450	1800	0	0	0
Infiltration	-	1540	2839	-	4912	0
Miscellaneous	-	11527	0	-	0	0
Safety Factor	0% / 0%	0	0	10%	3298	0
>> Total Zone Loads	**-**	**47290**	**4639**	**-**	**36275**	**0**
Zone Conditioning	-	45762	4639	-	35535	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	2002 CFM	1080	-	1106 CFM	-343	-
Ventilation Load	219 CFM	4186	8448	121 CFM	7932	0
Supply Fan Load	2002 CFM	2161	-	1106 CFM	-687	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**53189**	**13087**	**-**	**42436**	**0**
Central Cooling Coil	-	53189	13085	-	-11657	0
Preheat Coil	-	0	-	-	0	-
Terminal Reheat Coils	-	0	-	-	54093	-
>> Total Conditioning	**-**	**53189**	**13085**	**-**	**42436**	**0**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Air System Information

Air System Name	**AHU-3**		Number of zones	**1**	
Equipment Class	**CW AHU**		Floor Area	**1241.0**	ft²
Air System Type	**VAV**		Location	**Salisbury, Maryland**	

Sizing Calculation Information

Calculation Months	**Jan to Dec**	Zone CFM Sizing	**Peak zone sensible load**
Sizing Data	**Calculated**	Space CFM Sizing	**Individual peak space loads**

Central Cooling Coil Sizing Data

Total coil load	**5.0**	Tons	Load occurs at	**Aug 1500**	
Total coil load	**60.1**	MBH	OA DB / WB	**95.0 / 78.0**	°F
Sensible coil load	**38.9**	MBH	Entering DB / WB	**80.4 / 67.7**	°F
Coil CFM at Aug 1500	**1369**	CFM	Leaving DB / WB	**54.0 / 53.0**	°F
Max block CFM at Aug 1500	**1508**	CFM	Coil ADP	**51.1**	°F
Sum of peak zone CFM	**1508**	CFM	Bypass Factor	**0.100**	
Sensible heat ratio	**0.648**		Resulting RH	**52**	%
ft²/Ton	**247.9**		Design supply temp.	**55.0**	°F
BTU/(hr·ft²)	**48.4**		Zone T-stat Check	**1 of 1**	OK
Water flow @ 10.0 °F rise	**12.02**	gpm	Max zone temperature deviation	**0.0**	°F

Preheat Coil Sizing Data

No heating coil loads occurred during this calculation.

Supply Fan Sizing Data

Actual max CFM at Aug 1500	**1508**	CFM	Fan motor BHP	**0.69**	BHP
Standard CFM	**1505**	CFM	Fan motor kW	**0.54**	kW
Actual max CFM/ft²	**1.22**	CFM/ft²	Fan static	**2.00**	in wg

Outdoor Ventilation Air Data

Design airflow CFM	**334**	CFM	CFM/person	**7.42**	CFM/person
CFM/ft²	**0.27**	CFM/ft²			

Air System Information

Air System Name **AHU-3**
Equipment Class .... **CW AHU**
Air System Type .... **VAV**

Number of zones **1**
Floor Area .... **1241.0** ft²
Location .... **Salisbury, Maryland**

Sizing Calculation Information

Calculation Months .... **Jan to Dec**
Sizing Data .... **Calculated**

Zone CFM Sizing .... **Peak zone sensible load**
Space CFM Sizing .... **Individual peak space loads**

Zone Terminal Sizing Data

Zone Name	Design Supply Airflow (CFM)	Minimum Supply Airflow (CFM)	Zone CFM/ft²	Reheat Coil Load (MBH)	Reheat Coil Water gpm @ 20.0 °F	Zone Htg Unit Coil Load (MBH)	Zone Htg Unit Water gpm @ 20.0 °F	Mixing Box Fan Airflow (CFM)
Zone 1	1508	754	1.22	39.0	-	0.0	0.00	0

Zone Peak Sensible Loads

Zone Name	Zone Cooling Sensible (MBH)	Time of Peak Sensible Cooling Load	Zone Heating Load (MBH)	Zone Floor Area (ft²)
Zone 1	32.5	Aug 1500	25.2	1241.0

Space Loads and Airflows

Zone Name / Space Name	Mult.	Cooling Sensible (MBH)	Time of Peak Sensible Load	Air Flow (CFM)	Heating Load (MBH)	Floor Area (ft²)	Space CFM/ft²
Zone 1							
115 Meeting Room	1	31.8	Aug 1500	1476	24.9	1169.0	1.26
116 A.V. Equip.	1	0.7	Jul 1400	34	0.3	72.0	0.48

Air System Design Load Summary for AHU-3

Project Name: 16084 - Kent County Library Study — 09/21/2016

Prepared by: Gipe Associates, Inc. — 10:18AM

	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1500 COOLING OA DB / WB 95.0 °F / 78.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 10.0 °F / 8.0 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	0 ft²	0	-	0 ft²	-	-
Wall Transmission	693 ft²	5249	-	693 ft²	9685	-
Roof Transmission	1241 ft²	5794	-	1241 ft²	5124	-
Window Transmission	0 ft²	0	-	0 ft²	0	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	42 ft²	2514	-	42 ft²	1510	-
Floor Transmission	1241 ft²	0	-	1241 ft²	1698	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1241 W	4234	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	621 W	2117	-	0	0	-
People	45	11025	9225	0	0	0
Infiltration	-	1585	2332	-	4912	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	10%	2293	0
>> Total Zone Loads	**-**	**32517**	**11557**	**-**	**25224**	**0**
Zone Conditioning	-	31294	11557	-	24708	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Return Fan Load	1369 CFM	0	-	754 CFM	0	-
Ventilation Load	303 CFM	6141	9617	167 CFM	10902	0
Supply Fan Load	1369 CFM	1463	-	754 CFM	-464	-
Space Fan Coil Fans	-	0	-	-	0	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	**-**	**38899**	**21174**	**-**	**35145**	**0**
Central Cooling Coil	-	38899	21175	-	-2215	0
Preheat Coil	-	0	-	-	0	-
Terminal Reheat Coils	-	0	-	-	37360	-
>> Total Conditioning	**-**	**38899**	**21175**	**-**	**35145**	**0**
Key:	**Positive values are clg loads Negative values are htg loads**			**Positive values are htg loads Negative values are clg loads**		

Appendix M-3

Life Cycle Cost Estimate

IV. LIFE CYCLE COST ANALYSIS - SYSTEM DESCRIPTION

PROJECT: KENT COUNTY LIBRARY HVAC ANALYSIS LOCATION: CHESTERTOWN, MARYLAND	USING AGENCY KENT CO. MD	DATE: 9/15/2016

BY: MARCUS SCHWARZ

SYSTEM DESCRIPTION

BASE SYSTEM (SYSTEM #1)

Air Cooled Split System Chiller, Chilled water air handling units, and electric heat.

Central station air handling units shall provide heating, cooling and ventilation airflow to the various areas served by the same.

New exhaust fans shall be provided for bathroom areas.

Existing ductwork shall be re-utilized for new HVAC systems to avoid demolition of the ceilings.

SYSTEM #2

Ground Source heat pump system with packaged Energy Recovery Ventilator (ERV). Water source heat pumps are connected to the ground loop condenser water system. The geothermal heat pumps shall be packaged type and will be ducted to serve the individual zones throughout the library. Decoupled energy recovery ventilators would provide both the building exhaust and ventilation airflow. ERV units shall utilize enthalpy wheels and demand cotrolled ventilation components.

SYSTEM #3

Air Cooled Variable Refrigerant Volume system with decoupled air side heat pump energy recovery ventilator (ERV).

A combination of ducted and ductless terminal equipment will serve the various zones throughout the library.

The energy recovery ventilator shall provide both the building exhaust and ventilation airflow (similar to option #2).

ERV units shall utilize enthalpy wheels and demand controlled ventilation components.

SYSTEM #4

Air Side Heat pump system with packaged Energy Recovery Ventilator (ERV).

V. ENERGY COST ESTIMATE:

A. COST OF ENERGY

ENERGY TYPE	ESTIMATED AVERAGE UNIT COST	ESCALATION RATE
ELECTRIC ENERGY CHARGE	**0.02** $ PER KWH (All year Peak) **0.02** $ PER KWH (All year Off-Peak)	____ ____
ELECTRIC DEMAND CHARGE	**3.51** $ PER KW (winter) **3.51** $ PER KW (summer)	____ ____
STEAM ENERGY CHARGE	____ $ PER MLB (winter) ____ $ PER MLB (summer)	____ ____
STEAM DEMAND CHARGE	____ $ PER MLB (winter) ____ $ PER MLB (summer)	____ ____
LP-GAS (PROPANE)	**0** $ PER THERM	____
FUEL OIL	____ $ PER THERM	____
COAL	____ $ PER TON	____
OTHERS	____ $ PER ____ ____ $ PER ____	____ ____

UTILITY SUMMER RATE MONTHS: **June** TO **August**

UTILITY WINTER RATE MONTHS: **September** TO **May**

USEFUL EQUIPMENT LIFE: **30** YEARS (N)

DISCOUNT RATE: **0.04** (D)
ESCALATION RATE: **0.05** (E)
PRESENT WORTH FACTOR: 34.92 PW

$$PW = \frac{1+E}{D-E} \times \left(\left(\frac{1+E}{1+D} \right)^N - 1 \right)$$

VI. INITIAL COST ESTIMATE

ITEM	SYSTEM #1 (Split Chiller and Electric Heat)	SYSTEM #2 (Geothermal Heat Pump System)	SYSTEM #3 (Air Side VRV and Air Side ERV's)	SYSTEM #4 (Air Side Heat Pump and ERV)
MECHANICAL INSULATION	$22,000	$35,750	$35,750	$24,750
FIRE PROTECTION	$0	$0	$0	$0
PLUMBING	$0	$0	$0	$0
ROOF DRAINAGE	$0	$0	$0	$0
PLUMBING/PIPING FIXTURES	$0	$0	$0	$0
DOMESTIC WATER HEATERS	$0	$0	$0	$0
CEILING FANS	$22,000	$22,000	$22,000	$22,000
WATER DISTRIBUTION PUMPS	$8,250	$11,000	$0	$0
GAS/FUEL PIPING SYSTEM	$0	$0	$0	$0
HEATING PIPE/SPECIALTIES	$0	$0	$0	$0
DEMOLITION	$5,500	$11,000	$11,000	$5,500
WATER TREATMENT	$3,850	$3,850	$0	$0
REFRIGERATION	$11,000	$0	$55,000	$44,000
CHILLER	$38,500	$0	$0	$0
COOLING PIPE SPECIALTIES	$44,000	$16,500	$0	$0
HEAT EXCHANGERS	$0	$0	$0	$0
AHU, FAN COILS, VAV	$77,000	$0	$0	$143,000
POWER VENTILATORS/ERV MODULE	$11,000	$0	$0	$11,000
DUCTWORK	$66,000	$110,000	$110,000	$66,000
AIR OUTLETS/INLETS	$2,750	$8,250	$8,250	$2,750
ATC CONTROLS	$55,000	$66,000	$71,500	$52,250
TESTING/BALANCING	$13,750	$15,950	$14,850	$12,650
GEOTHERMAL HEAT EXCHANGER	$0	$110,000	$0	$0
HEAT PUMPS/VENTILATORS	$0	$88,000	$99,000	$0
TOTAL	$380,600	$498,300	$427,350	$383,900

TOTALS	**$380,600**	**$498,300**	**$427,350**	**$383,900**

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COST

SYSTEM #: 1

A. ENERGY (TOTAL BUILDING ENERGY)

ENERGY SOURCE	UNIT OF MEASURE	ENERGY CONSUMPTION	ENERGY COST	DEMAND CHARGE	TOTAL ENERGY COST
ELECTRIC (Annual)	KWH	237,844	$4,570	$3,354	$7,924
ELECTRIC (Summer)	KWH				$0
GAS (Annual)	THERM	0	$0		$0
GAS (Summer)	MCF OR THERM				$0
STEAM (Winter)	MLB/HR				$0
STEAM (Summer)	MLB/HR				$0
FUEL OIL	THERM				$0
COAL	TON				$0
OTHERS PROPANE	GALLON				$0

GRAND TOTAL **$7,924**

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COSTS (Cont'd.) **SYSTEM #: 1**

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT		SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
1. CHILLERS		$500	$500	$1,000
2. BOILERS		$0	$0	$0
3. PUMPS		$250	$250	$500
4. AIR HANDLING UNITS		$400	$500	$900
5. FANS:	SUPPLY	$0	$0	$0
	RETURN	$0	$0	$0
	EXHAUST	$100	$100	$200
6. SPLIT & UNITARY EQUIPMENT		$0	$0	$0
7. THRU THE WALL UNITS - PACKAGED TERMINAL AIR CONDITIONING UNITS		$0	$0	$0
8. HEAT PUMPS		$0	$0	$0
9. TERMINAL UNITS (VAV BOXES, FCU, ETC.)		$0	$0	$0
SUBTOTAL		$1,250	$1,350	$2,600

VII. <u>ANNUAL COST</u> (Cont'd.)

SYSTEM #: 1

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT	SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
10. HOT WATER CONVERTORS, FTR, Uhs, CUHs, ETC.	$100	$100	$200
11. COOLING TOWERS			$0
12. DOMESTIC WATER HEATERS	$0	$0	$0
13. TEMPERATURE CONTROL SYSTEM	$500	$500	$1,000
14. MISCELLANEOUS EQUIPMENT	$0	$0	$0
SUBTOTAL	$600	$600	$1,200

GRAND TOTAL **$3,800**

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COST

SYSTEM #: 2

A. ENERGY (TOTAL BUILDING ENERGY USE)

ENERGY SOURCE	UNIT OF MEASURE	ENERGY CONSUMPTION	ENERGY COST	DEMAND CHARGE	TOTAL ENERGY COST
ELECTRIC (Annual)	KWH	150,285	$2,888	$2,045	$4,933
ELECTRIC (Summer)	KWH				$0
GAS (Annual)	THERM	0	$0		$0
GAS (Summer)	MCF OR THERM				$0
STEAM (Winter)	MLB/HR				$0
STEAM (Summer)	MLB/HR				$0
FUEL OIL	THERM				$0
COAL	TON				$0
OTHERS PROPANE	GALLONS				$0

GRAND TOTAL **$4,933**

VII. ANNUAL COSTS (Cont'd.)

SYSTEM #: 2

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT		SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
1. CHILLERS		$0	$0	$0
2. BOILERS		$0	$0	$0
3. PUMPS		$350	$350	$700
4. AIR HANDLING UNITS		$300	$400	$700
5. FANS:	SUPPLY	$0	$0	$0
	RETURN	$0	$0	$0
	EXHAUST	$0	$0	$0
6. SPLIT & UNITARY EQUIPMENT		$0	$0	$0
7. THRU THE WALL UNITS - PACKAGED TERMINAL AIR CONDITIONING UNITS		$0	$0	$0
8. HEAT PUMPS		$100	$100	$200
9. TERMINAL UNITS (VAV BOXES, FCU, ETC.)		$0	$0	$0
SUBTOTAL		$750	$850	$1,600

VII. ANNUAL COST (Cont'd.)

SYSTEM #: 2

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT	SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
10. HOT WATER CONVERTORS, FTR, Uhs, CUHs, ETC.	$100	$100	$200
11. THERMAL STORAGE TANKS			$0
12. DOMESTIC WATER HEATERS	$0	$0	$0
13. TEMPERATURE CONTROL SYSTEM	$500	$500	$1,000
14. MISCELLANEOUS EQUIPMENT	$0	$0	$0
SUBTOTAL	$600	$600	$1,200

GRAND TOTAL $2,800

VII. ANNUAL COST

SYSTEM #: 3

A. ENERGY (TOTAL BUILDING ENERGY USE)

ENERGY SOURCE	UNIT OF MEASURE	ENERGY CONSUMPTION	ENERGY COST	DEMAND CHARGE	TOTAL ENERGY COST
ELECTRIC (Annual)	KWH	170,585	$3,278	$2,698	$5,976
ELECTRIC (Summer)	KWH				$0
GAS (Annual)	THERM	0	$0		$0
GAS (Summer)	MCF OR THERM				$0
STEAM (Winter)	MLB/HR				$0
STEAM (Summer)	MLB/HR				$0
FUEL OIL	GALLONS				$0
COAL	TON				$0
OTHERS					$0

GRAND TOTAL **$5,976**

VII. ANNUAL COSTS (Cont'd.)

SYSTEM #: 3

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT		SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
1. CHILLERS		$0	$0	$0
2. BOILERS		$0	$0	$0
3. PUMPS		$0	$0	$0
4. AIR HANDLING UNITS		$300	$400	$700
5. FANS:	SUPPLY	$0	$0	$0
	RETURN	$0	$0	$0
	EXHAUST	$0	$0	$0
6. SPLIT & UNITARY EQUIPMENT		$0	$0	$0
7. THRU THE WALL UNITS - PACKAGED TERMINAL AIR CONDITIONING UNITS		$0	$0	$0
8. HEAT PUMPS		$500	$500	$1,000
9. TERMINAL UNITS (VAV BOXES, FCU, ETC.)		$0	$0	$0
SUBTOTAL		$800	$900	$1,700

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COST (Cont'd.)

SYSTEM #: 3

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT	SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
10. HOT WATER CONVERTORS, FTR, Uhs, CUHs, ETC.	$100	$100	$200
11. COOLING TOWERS			$0
12. DOMESTIC WATER HEATERS	$0	$0	$0
13. TEMPERATURE CONTROL SYSTEM	$500	$500	$1,000
14. MISCELLANEOUS EQUIPMENT	$0	$0	$0
SUBTOTAL	$600	$600	$1,200

GRAND TOTAL $2,900

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COST

SYSTEM #: 4

A. ENERGY (TOTAL BUILDING ENERGY USE)

ENERGY SOURCE	UNIT OF MEASURE	ENERGY CONSUMPTION	ENERGY COST	DEMAND CHARGE	TOTAL ENERGY COST
ELECTRIC (Annual)	KWH	183,133	$3,519	$2,735	$6,254
ELECTRIC (Summer)	KWH				$0
GAS (Annual)	THERM	0	$0		$0
GAS (Summer)	MCF OR THERM				$0
STEAM (Winter)	MLB/HR				$0
STEAM (Summer)	MLB/HR				$0
FUEL OIL	GALLONS				$0
COAL	TON				$0
OTHERS					$0

GRAND TOTAL **$6,254**

KENT COUNTY LIBRARY HVAC ANALYSIS

VII. ANNUAL COSTS (Cont'd.)

SYSTEM #: 3

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT		SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
1. CHILLERS		$0	$0	$0
2. BOILERS		$0	$0	$0
3. PUMPS		$0	$0	$0
4. AIR HANDLING UNITS		$600	$700	$1,300
5. FANS:	SUPPLY	$0	$0	$0
	RETURN	$0	$0	$0
	EXHAUST	$0	$0	$0
6. SPLIT & UNITARY EQUIPMENT		$0	$0	$0
7. THRU THE WALL UNITS - PACKAGED TERMINAL AIR CONDITIONING UNITS		$0	$0	$0
8. HEAT PUMPS		$1,000	$1,000	$2,000
9. TERMINAL UNITS (VAV BOXES, FCU, ETC.)		$0	$0	$0
SUBTOTAL		$1,600	$1,700	$3,300

VII. ANNUAL COST (Cont'd.)

SYSTEM #: 3

B. SERVICE AND MAINTENANCE COSTS

MAJOR EQUIPMENT	SERVICE COST	MAINTENANCE COST	TOTAL SERVICE AND MAINTENANCE COST
10. HOT WATER CONVERTORS, FTR, Uhs, CUHs, ETC.	$100	$100	$200
11. COOLING TOWERS			$0
12. DOMESTIC WATER HEATERS	$0	$0	$0
13. TEMPERATURE CONTROL SYSTEM	$500	$500	$1,000
14. MISCELLANEOUS EQUIPMENT	$0	$0	$0
SUBTOTAL	$600	$600	$1,200

GRAND TOTAL **$4,500**

KENT COUNTY LIBRARY HVAC ANALYSIS

VIII. SUMMARY

A. LIFE CYCLE COST ANALYSIS

PW FACTOR: 34.92

PROJECT: **KENT COUNTY LIBRARY HVAC ANALYSIS** LOCATION: **CHESTERTOWN, MARYLAND**		USING AGENCY **KENT CO. MD**		DATE: **9/15/2016**
	BASE SYSTEM (CHILLER-ELEC.)	SYSTEM #2 GEOTHERMAL	SYSTEM #3 AIR SIDE VRV	SYSTEM #4 SPLIT HEAT PUMP
INITIAL COST MECHANICAL INSTALLATION	$380,600	$498,300	$427,350	$383,900
INCREMENTAL COST OF ARCHITECTURAL COMPONENTS (+ OR - OVER BASE SYSTEM)		CEILINGS PARKING LOT $150,000	CEILINGS $50,000	HP ENCLOSURE $20,000
INCREMENTAL COST OF STRUCTURAL COMPONENTS (+ OR - OVER BASE SYSTEM)	$0	$0	$0	$0
INCREMENTAL COST OF ELECTRICAL COMPONENTS (+ OR - OVER BASE SYSTEM)	$0	$25,000	$30,000	$15,000
(a) TOTAL INITIAL COST	$380,600	$673,300	$507,350	$418,900
ANNUAL COSTS ENERGY	$7,924	$4,933	$5,976	$6,254
SERVICE	$1,850	$1,350	$1,400	$2,200
ROUTINE MAINTENANCE	$1,950	$1,450	$1,500	$2,300
(b) TOTAL ANNUAL COST	$11,724	$7,733	$8,876	$10,754
(c) PRESENT VALUE OF TOTAL ANNUAL COST: (b) X PW FACTOR	$409,358	$270,007	$309,916	$375,489
TOTAL LIFE CYCLE COST: (a) + (c)	$789,958	$943,307	$817,266	$794,389

RECOMMEND SYSTEM NO. **BASE**

Appendix M-4

Construction Cost Estimates

Gipe Associates, Inc.
CONSULTING ENGINEERS
Mechanical | Electrical | Plumbing

8719 BROOKS DRIVE
EASTON, MARYLAND
PHONE: 410-822-8688
FAX: 410-822-6306

CONSTRUCTION COST ESTIMATE

PROJECT: KENT COUNTY PUBLIC LIBRARY
GAI PROJECT NO: 16084
DATE: 10/13/16
PREPARED BY: RAK

GENERAL PROJECT INFORMATION

PROJECT SQUARE FOOTAGE: 11,000
FACILITY TYPE: PUBLIC LIBRARY
 # OF FLOORS: 1
ARCHITECT: N/A
BASIS FOR ESTIMATE: CODE-A (NO DESIGN COMPLETED)
SUMMARY: SCHEMATIC ESTIMATE FOR REPORT

DESCRIPTION	QUANTITY		MATERIAL		LABOR		TOTAL COST
	NO. OF UNITS	UNIT OF MEASURE	PER UNIT	TOTAL	PER UNIT	TOTAL	
BASE BID COST ESTIMATE							
MECHANICAL COST ESTIMATE (REFER TO DETAILED ESTIMATE IN LCCA)	1.0	LS	$ 380,600.00	$ 380,600.00	$ -	$ -	$ 380,600.00
ELECTRICAL COSTS	1.0	LS	$ 52,459.00	$ 52,459.00	$ 33,315.00	$ 33,315.00	$ 85,774.00
PHASING AND OVERTIME LABOR	1.0			$ -	$ 5,000.00	$ 5,000.00	$ 5,000.00
TEMPORARY HEAT/CONTROLS	1.0		$ 3,500.00	$ 3,500.00	$ 1,500.00	$ 1,500.00	$ 5,000.00
SUPPORTING ARCHITECTURAL PATCH, REPAIR AND REPAINT	1.0		$ 10,000.00	$ 10,000.00	$ 15,000.00	$ 15,000.00	$ 25,000.00
SUPPORTING STRUCTURAL WORK (LINTELS, HOUSEKEEPING PADS, ETC..)	1.0		$ 3,000.00	$ 3,000.00	$ 6,000.00	$ 6,000.00	$ 9,000.00
ALTERNATE #1 - COMMISSIONING							
COMMISSIONING	1.0	LS		$ -	$ 10,000.00	$ 10,000.00	$ 10,000.00
ALTERNATE #2 - NOT USED							

COST ESTIMATE SUMMARY

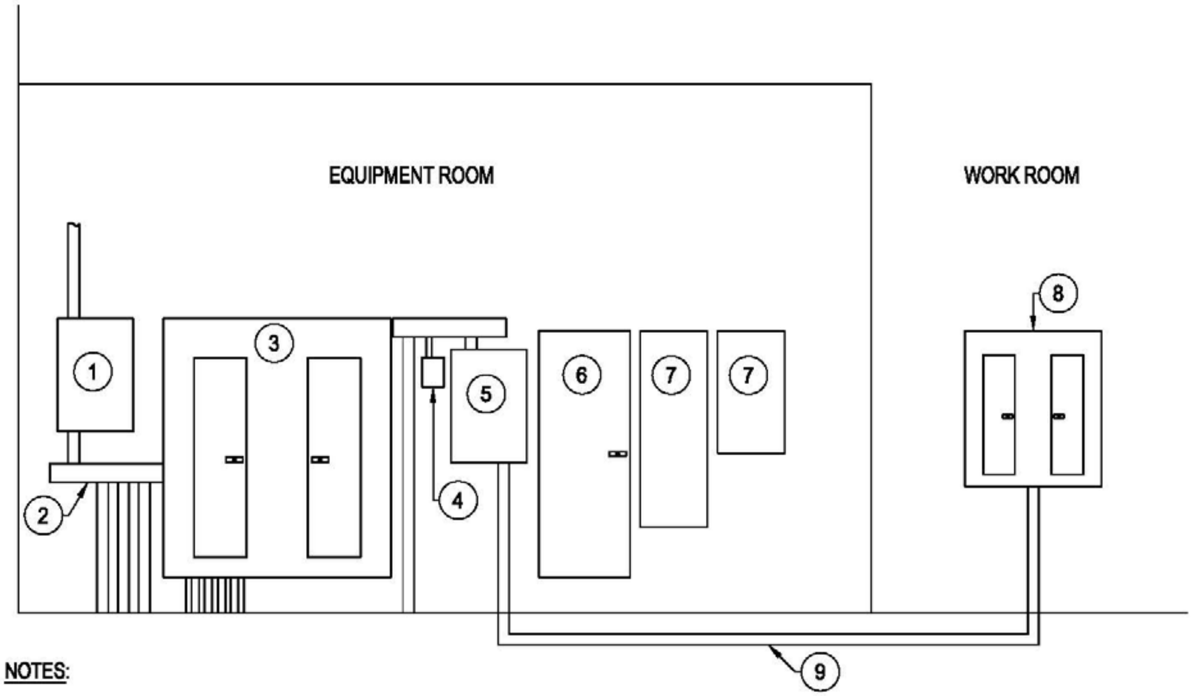
DESCRIPTION	MATERIAL	LABOR	TOTAL
BASE BID TOTAL COST	$ 449,559.00	$ 60,815.00	$ 510,374.00
ALTERNATE #1 TOTAL COST	$ -	$ 10,000.00	$ 10,000.00
ALTERNATE #2 TOTAL COST	$ -	$ -	$ -
TOTAL BASE BID + ALTERNATES:	**$ 449,559.00**	**$ 70,815.00**	**$ 520,374.00**
TOTAL BASE BID + ALT. COST PER SQUARE FOOT:	**$40.87 PER S.F.**	**$6.44 PER S.F.**	**$47.31 PER S.F.**

GRAND TOTAL COST ESTIMATE SUMMARY

ADDITIONAL PROJECT COST ITEM DESCRIPTION (APPLIES TO BASE BID ONLY)	PERCENTAGE (%)	% X TOTAL BASE BID	REMARKS
CONTRACTOR OVERHEAD	3.0%	$ 15,311.22	
CONTRACTOR PROFIT	3.0%	$ 15,311.22	
GENERAL CONDITIONS	3.0%	$ 15,311.22	
BUILDER'S RISK INSURANCE	1.0%	$ 5,103.74	
PERMIT FEES	1.0%	$ 5,103.74	
CONTRACTOR INSURANCE	2.0%	$ 10,207.48	
PAYMENT BOND	1.0%	$ 5,103.74	
PERFORMANCE BOND	1.0%	$ 5,103.74	
DESIGN CONTINGENCY	5.0%	$ 25,518.70	
GIPE MEP DESIGN FEE	**--**	**$ 53,000.00**	
TOTAL ADDITIONAL PROJECT COST ITEMS		**$ 155,074.80**	
GRAND TOTAL CONSTRUCTION COST (BASE BID + ALTERNATES + ADDITIONAL PROJECT COSTS)		**$ 675,448.80**	**$61.40 PER S.F.**

Appendix E-1

Library Equipment Room – Demolition and New Work Single Line Sketches



NOTES:

1. DISCONNECT AND REMOVE EXISTING 400A SAFETY SWITCH AND ASSOCIATED CONDUITS, AND WIRING BACK TO SOURCE.

2. REMOVE WIRE TROUGH AND CUT CONDUITS BACK TO 12" AFF.

3. REMOVE DOUBLE SECTION PANELBOARD "B" AND WIRING AND CONDUIT TO ALL HVAC EQUIPMENT BEING REMOVED AS PART OF THIS PROJECT. KEEP EXISTING BRANCH CIRCUIT FOR ALL HVAC EQUIPMENT THAT IS TO REMAIN FOR RE-TERMINATION UNDER NEW WORK.

4. REMOVE 30A, SAFETY SWITCH AND ASSOCIATED CONDUIT AND WIRING BACK TO SOURCE.

5. REMOVE 400A, SAFETY SWITCH FEEDING PANELBOARD "A". RETAIN ALL FEEDER WIRING TO PANEL A LOCATED IN LIBRARY WORK ROOM.

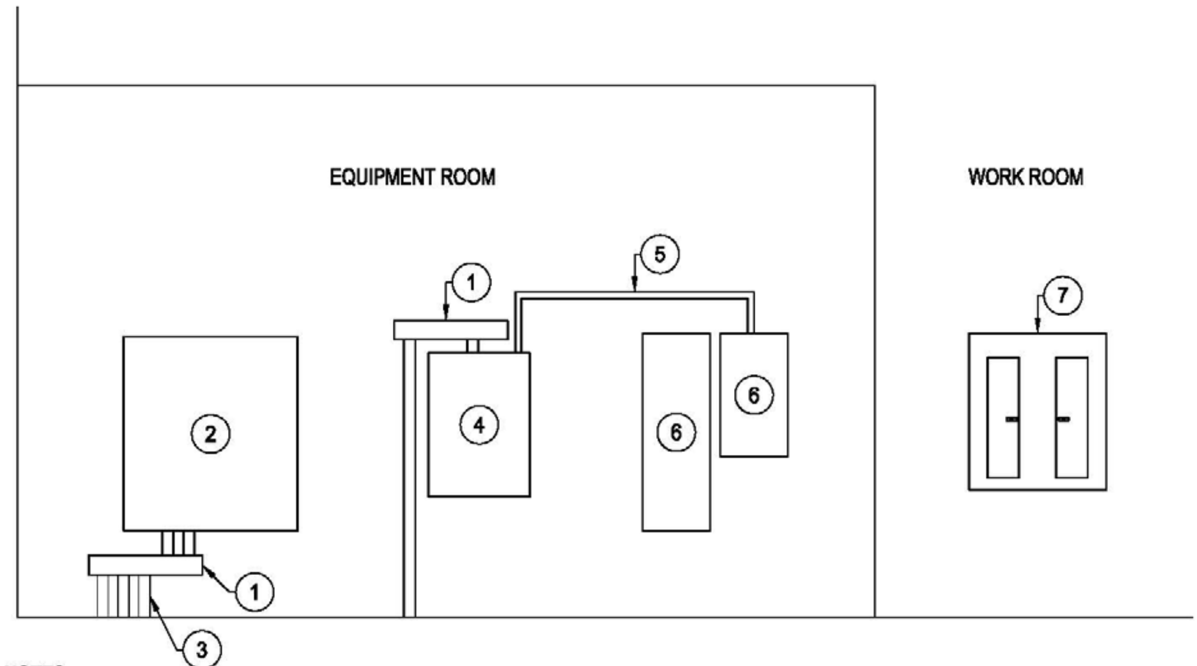
6. REMOVE ABANDONED EMERGENCY LIGHTING PANEL AND ALL ASSOCIATED WIRING AND CONDUIT BACK TO SOURCE.

7. FIRE ALARM PANEL TO REMAIN.

8. REMOVE DOUBLE SECTION PANELBOARD A. AND ASSOCIATED TIME CLOCK INSTALLED WITH THE PANELBOARD. RETAIN ALL BRANCH CIRCUIT WIRING FOR RE-TERMINATION TO NEW PANELBOARD UNDER NEW WORK.

9. CONDUIT AND WIRING TO REMAIN FOR CONNECTION TO BREAKERS IN PANELBOARDS UNDER NEW WORK.

Library Equipment Room Southwest Wall Elevation – Demolition



NOTES:

1. NEW WIRE TROUGH SIZED AS REQUIRED BY NATIONAL ELECTRICAL CODE (NEC), CONNECTED TO EXISTING CONDUITS,
2. 800A, 208V, 3 PHASE, 4 WIRE, I-LINE COMBO PANELBOARD TO SERVE LIBRARY HVAC LOADS.
3. EXISTING CONDUIT TO BE REUSED.
4. PROVIDE 400A, 208V, 3 PHASE, DISTRIBUTION PANELBOARD WITH ONE (1) 225A, 3 POLE, BREAKER TO FEED PANELBOARD A AND ONE (1) 20A, 1 POLE, BREAKER TO FEED FIRE ALARM SYSTEM.
5. CONDUIT AND WIRING TO EXISTING FIRE ALARM SYSTEM.
6. EXISTING FIRE ALARM PANEL.
7. PROVIDE 225A, 208V, 3 PHASE, 4 WIRE, 72 CIRCUIT, BRANCH PANELBOARD WITH 225A MAIN CIRCUIT BREAKER.

Library Equipment Room Southwest Wall Elevation – New Work