City of Muscatine
Art Center & Museum

Muscatine, IA

Energy Conservation Study

A&J #201310.00

RECOMMENDATIONS

- The variable refrigerant flow (VRF) system (Option 1BB) is recommended for implementation at the Art Center/Museum.
- **VRF heat pump** system is coupled with a geothermal loop heat exchanger.
- **Geothermal** loop field heat exchanger located on site. More than enough space at Art Center & Museum site for geothermal field to be located.
- Sophisticated **humidity control** system (**± 5% RH majority**).
- **Window** replacement/upgrade for Art Center **only**.
- The Musser House windows **do not** require window upgrade/replacement.

DISCUSSION

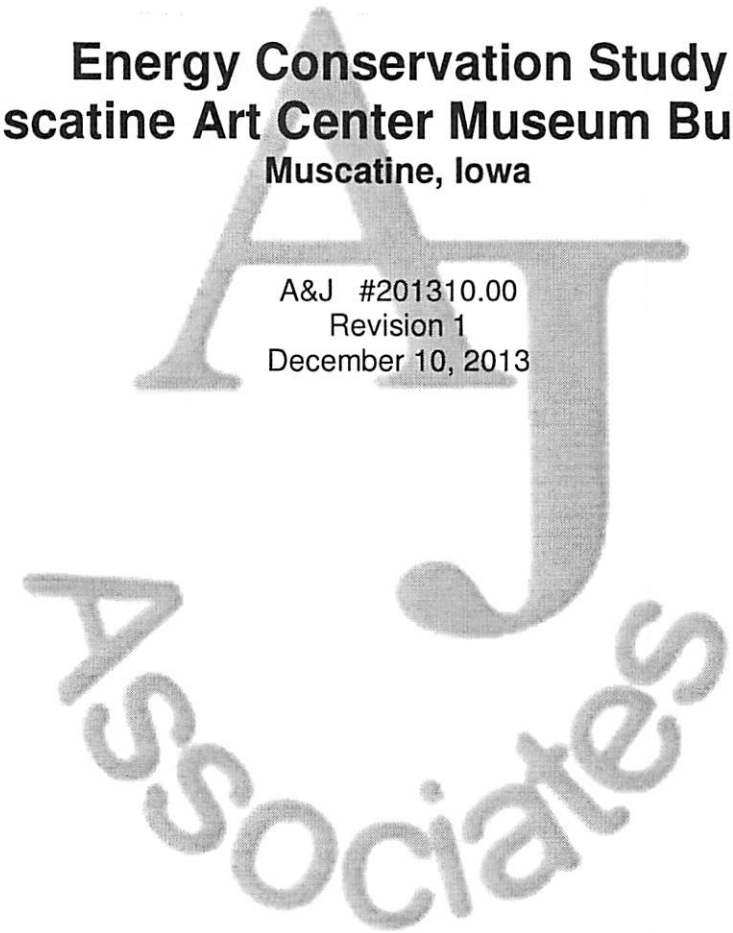
- Art Center/Museum is **not** eligible for Historic Preservation tax credits.
- **Projects** can be **phased** over a period of time or completed under **separate contracts**. Recommended upgrades do not need to be completed simultaneously to be effective. For example, the Art Center window replacement and HVAC upgrades could be done as separate projects at separate times.
- **Upgraded HVAC** system will utilize and **connect** with existing/recently installed heating hot water **boiler system**.
- Outside weather conditions will limit when the windows can be replaced.
- The outside geothermal loop field can only be installed when the outside temperature is above freezing for long periods.
- The inside VRF system can be installed any time during the year and while the facility is occupied.

COST PROJECTIONS

- High Cost of Range $ 1,721,000.00
- Median Cost of Range $ 1,324,000.00
- Low Cost of Range $ 927,000.00

Energy Conservation Study
Muscatine Art Center Museum Building
Muscatine, Iowa

A&J #201310.00
Revision 1
December 10, 2013



I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Licensed Professional Engineer under the laws of the State of Iowa.

Printed or typed name
Victor Amoroso Jr.
Discipline - Mechanical Engineer
Reg. No. 10536 IA

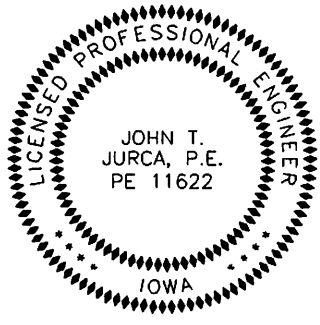
Victor Amoroso Jr.
Signature

My license renewal date is December 31, 2013.

Pages or sheets covered by this seal:
Entire Study

Date issued: Dec. 10, 2013

I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Licensed Professional Engineer under the laws of the State of Iowa.



Printed or typed name
John Jurca
Discipline - Electrical Engineer
Reg. No. 11622 IA

Signature

My license renewal date is December 31, 2014.

Pages or sheets covered by this seal:
Electrical Portions

Date issued: Dec. 10, 2013

STUDY

EXECUTIVE SUMMARY

A. The Energy Conservation Study completed for the City of Muscatine Art Center/Museum (Musser House) compiled several HVAC system options that would increase overall energy efficiency and create an environment that has stable humidity levels necessary for storage of moisture sensitive pieces of art or other artifacts.

B. Two basic options were compiled with variations of the options also evaluated. The options are as follows:

1. Option 1 is a variable refrigerant flow (VRF) system with humidifiers, dehumidifiers, new ventilation air system/energy recovery system. This system would tie into the existing heating hot water boiler system installed in the last 2 years. The variations of Option 1 were broken down into 1A, 1AA, 1B and 1BB.

    a. Option 1A is the VRF system that is air-cooled and located on the roof or on grade, with a sophisticated building wide humidity control system implemented.

    b. Option 1AA is the same as Option 1A with the exception that the humidity control system would be minimized in scope. The humidity control would be relegated to a small area where artwork would be stored.

    c. Option 1B is the VRF system connected with a new geothermal loop field heat exchanger system, with a sophisticated building wide humidity control system.

    d. Option 1BB is the same as Option 1B with the exception that the humidity control system would be minimized in scope. The humidity control would be relegated to a small area where artwork would be stored.

2. Option 2 is a terminal heat pump system with humidifiers, dehumidifiers, new ventilation air system/energy recovery system. This system would also tie into the existing heating hot water boiler system installed in the last 2 years. Option 2 is broken down into 2A and 2B.

    a. Option 2A is a terminal heat pump system connected to a roof or grade mounted evaporative cooler, which would supply heat pump loop water to the terminal heat pumps located in various spaces. A humidity control system would be implemented.

    b. Option 2B is a terminal heat pump system connected to a geothermal loop field heat exchanger system with a humidity control system implemented.

    c. We did not evaluate reduced cost options for a smaller area of humidity control for the heat pump options since that is done only for reducing costs.

C. All of the Options were evaluated on construction costs (with a ±30% range for unforeseen construction challenges or unforeseen conditions), energy savings and life cycle costs for a 25 year time frame. Energy cost savings ($) were estimated because the City of Muscatine does not pay for energy use. Each option's energy usage (kW-hr)

was compared to the others to determine the cost savings based on an average utility cost for Eastern Iowa. This approach monetized the projected savings for comparisons sake.

D. A ±30% cost range was used to achieve a realistic view of costs that could be seen on bids for a project of this nature due to unforeseen conditions, difficulty of construction to maintain historic relevance and it is difficult to anticipate labor charges that contractor's include in bids.

E. The humidity control system consisting of dehumidifiers and humidifiers, whether the building-wide (sophisticated) or the reduced scope humidity control (relegated to a small area), shall be able to control the relative humidity to a ±5% range for a majority of the year to maintain permanent and traveling art exhibits in the building. For special cases where tighter humidity control would be required, the system shall allow for a reduced range of relative humidity to a ±2% spread. A relative humidity of 45% would be the target for winter months (heating season) and 55% for summer months (cooling season) and the ability to eliminate rapid spikes in relative humidity are the key objectives.

F. The HVAC upgrade options can be phased over a period of years to "stretch out" payments for the upgrades and to allow for the continued partial operation of the Art Center Museum areas where no construction is occurring. The phased construction approach can either be handled as one project with a multi-year schedule or as several consecutive separate projects. Both approaches have positive and negative aspects.

G. Currently, the Art Center Museum is <u>not</u> listed nor determined to be eligible for listing on the National Register. However, the work on the "new" addition is <u>not</u> eligible. The potential for historic preservation tax credits is <u>not</u> high.

H. Following is a summary of the different options with estimated costs ranges, and projects life cycle costs:

1. Option 1A is an air-cooled variable refrigerant flow (VRF) system with building wide humidity control with a 30% cost range of $934,000 to $1,734,000 with a median cost estimate of $1,334,000.
2. Option 1AA is the same as Option 1A with the exception of a reduced scope humidity control system for storage areas only. The cost estimate has a 30% range from $783,000 to $1,454,000 with a median cost estimate of $1,118,000.
3. Option 1B is a variable refrigerant flow (VRF) system connected with a geothermal loop field heat exchanger with building wide humidity control system. The cost estimate has a 30% range from $1,063,000 to $1,974,000 with a median cost estimate of $1,519,000.
4. Option 1BB is the same as Option 1B with the exception of a reduced scope humidity control system for storage areas only. The cost estimate has a 30% range from $927,000 to $1,721,000 with a median cost estimate of $1,324,000.
5. Option 2A is a terminal heat pump option with an air-cooled condensing unit providing the heat pump loop water with a building wide humidity control system. The

cost estimate has a 30% range from $931,000 to $1,730,000 with a median cost estimate of $1,331,000.

6. Option 2B is a terminal heat pump option connected with a geothermal loop field heat exchanger with a building wide humidity control system. The cost estimate has a 30% range from $1,046,000 to $1,943,000 with a median cost estimate of $1,495,000.

I. Option 1B or 1BB, the variable refrigerant flow (VRF) system option coupled with the geothermal is recommended. The selection of 1B or 1BB is dependent on the choice to narrow or expand the "tight" humidity level controls.

I. OBJECTIVES

A. Review existing heating, ventilation and air conditioning (HVAC) systems to determine what system modifications and upgrades would enhance system efficiencies and reliability of operation.

B. Evaluate different options using an American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Modified BIN Analysis and Life Cycle Cost Analysis techniques.

C. Currently, the Art Center and Museum Building have several isolated and separate air conditioning systems that provide cooling and some de-humidification during the spring, summer and fall cooling seasons. A new hot water heating system including boilers, pumps and controls was installed in 2012 for the Museum. The cooling system does not provide Museum and Art Center required environmental control stability.

D. The Muscatine Art Center Museum Building is located in the Mississippi River Valley in southeast Iowa. During the cooling season the normal high relative humidity levels in the locale cause very uncomfortable conditions for the building occupants, and result in high and unstable humidity conditions for the Exhibits and the Museum collections. Also the de-centralized air conditioning systems have experienced component failures leading to short term total loss of control of the humidity and temperature.

E. The purposes of this study are the following.

1. Evaluate the potential and feasibility of adding geothermal heat pump system capability to the Art Center Museum Building or adding an enhancement to the recently installed hot water heating system that would provide Museum grade control of temperature and humidity levels. Review both maintaining the entire facilities at stable humidity levels and only segregated separate areas at stable conditions.

2. If the addition of geothermal is feasible provide a concept opinion of estimated costs for implementing the conversion of the existing HVAC systems to a geothermal heat pump system.

3. Because of the current natural gas costs and future expectation of higher costs the City of Muscatine desires to switch to a non-gas based heating system as much as possible. However, any new HVAC system must utilize the high efficiency gas-fired hot water heating system installed in 2012.

4. Also the City of Muscatine benefits positively because the City is the municipal utility supplying electricity to the Art Center Museum.

5. Soil boring test and heat transfer tests need to be done to determine the viability of installing a geothermal loop field before proceeding with any of the geothermal loop options.

6. The humidity control system consisting of dehumidifiers and humidifiers, whether the building-wide (sophisticated) or the reduced scope humidity control (relegated to a small area), shall be able to control the relative humidity to a ±5% range for a majority of the year to maintain permanent and traveling art exhibits in the building.

For special cases where tighter humidity control would be required, the system shall allow for a reduced range of relative humidity to a ±2% spread. A relative humidity of 45% would be the target for winter months (heating season) and 55% for summer months (cooling season) and the ability to eliminate rapid spikes in relative humidity are the key objectives.

F. Provide description of alternative HVAC concepts that could be used in lieu of the geothermal loop system if the geothermal loop system is not viable.

G. Review building envelope replacement or upgrades.

1. Primary focus is the exploration of the window rehabilitation or replacement to repair leaking and failing window and to return the historic character to the building façade.
2. Secondary focus is the exploration of the window rehabilitation to enhance energy conservation.

II. EXISTING CONDITIONS

A. The Art Center Museum Building is located at 1314 Mulberry Avenue in Muscatine, Iowa. The Musser House (Museum) was constructed circa 1908 and is in very good condition. The "new addition" or Art Center circa 1970 construction. Several windows in the new addition were found to be in a state of disrepair.

B. Currently, there is no overall building wide temperature and humidity control system for the Art Center Museum. Separate direct expansion cooling units provide very local heating and cooling, not building wide control. Consequently, humidity levels inside the facility vary from space to space and are not maintained at stable levels within each zone or building wide. Refer to the emails and relative humidity readings contained in the Appendix to the study. Humidity levels have been recorded in all parts of the building at lower than 45% RH and higher than 55% RH. Also, the rate of humidity changes is too abrupt for the collections.

C. Some outside air ventilation is provided either by opening windows in the individual rooms or spaces, or through the existing localized air conditioning systems.

D. A new high efficient gas fired boiler and variable speed pumping heating system was installed during the summer of 2012 for the Museum portion of the facility. The system used the existing cast iron radiators and convection type heaters for heating. The Museum section is supplied heating from a mechanical room located in the lower level. The boiler and pumps are located in this basement room.

E. The Art Center (new addition) is heated by the separate gas fired air conditioning systems.

F. Lighting and Lighting Control:

1. No lighting change out or lighting control upgrades were evaluated in this study.

G. Domestic water heating:

1. Existing inefficient electric and gas-fired water heater replacements were included with each option.

H. The building occupancy is the normal 8:00 a.m. to 5:00 p.m. six days per week for visitors. Refer to the Study's Appendix for the projected hours of use for the Art Center and Museum.

I. Historic Perspective

1. Currently the Art Center Museum (aka Peter and Laura Musser House) is not listed, nor determined to be eligible for listing on the National Register.
2. The "historic" Musser House (Museum portion) is eligible for listing on the National Register. The work in the "new" addition is not eligible.
3. Work on the addition could jeopardize the potential for listing the Musser House portion on the National Register.
4. The study will refer to new addition as the Art Center, and historic Musser House as the Museum.

J. The windows of the Museum portion (Musser House) have been well maintained by the City staff. There is no need for any upgrades of the historically relevant windows.

K. The windows of the new addition or Art Center have failed to some extent by being leak prone and not energy efficient. Replacement of the malfunctioning windows should be considered.

III. CODES, STANDARDS, GOOD PRACTICES

A. The following partial listing of codes and standards applies currently to the building HVAC and plumbing systems.

1. International Energy Conservation Code, 2012. (IECC)
2. International Mechanical Code, 2012. (IMC)
3. Uniform Plumbing Code, 2012. (State of Iowa Code) (UPC)
4. American Society of Heating, Refrigeration and Air Conditioning Engineers, Standards. (ASHRAE)
   a. ASHRAE standard 90.1-2012, Energy Standard for Buildings Except Low Rise Residential Buildings.
   b. ASHRAE Standard 2001, Humidity Control Design Guide for Institutional Buildings.
5. National Fire Protection Association, Standards. (NFPA)
6. International Fire Code, 2012. (IFC)
7. National Electric Code, 2012 (NEC)
8. NFPA 90A – Standard for Installation of Air Conditioning and Ventilation Systems.


Mulberry Ave

9. Sheet Metal and Air Conditioning Contractors National Association, Standards. (SMACNA)
10. Iowa State Fire Marshal's Rules and Regulations (Smoke and Fire Detection)
11. USEPA Prohibitions on Certain Refrigerants.
12. International Ground Source Heat Pump Association. (IGSHPA)
13. International Building Code, 2012 (IBC)
14. United States Secretary of Interior's Standards of Rehabilitation
15. National Park Service Preservation Briefs
16. State of Iowa Historic Preservation and Cultural & Entertainment District Tax Credit Program

B. Following items that appear to be out of the prescribed limits of the applicable codes listed above.

1. Minimum ventilation is not provided to the different areas of Art Center and Museum Building. Minimum ventilation is required per IMC 2012 for any HVAC upgrade.
2. The hot water heating system installed during 2012 in the Museum portion of the facility does meet the Energy Code requirements. No changes or upgrades are required.

C. Following are items that do not appear to follow what we consider good engineering practice for HVAC systems for Museums, Libraries and Archives per the ASHRAE Humidity Control Design Guide.

1. There are insufficient HVAC control zones to provide overall satisfactory and stable building temperature and humidity control in each zone and from zone to zone.
   a. Only individual radiator control valves provide heating control, or one thermostat provides temperature control for an entire group of rooms in the Museum.
   b. The Art Center is served by three separate gas-fired furnaces with direct expansion cooling. The limited zone control is not adequate for stable temperature and humidity control.
2. The Art Center Museum HVAC systems do not provide stable humidity and temperature control on a consistent basis because of the system limitations and failing components. Any new system shall be designed to provide the following.
   a. Avoid large temperature differences to better control the relative humidity ranges.
   b. Continuously circulate air throughout all of the spaces to promote more evenly distributed and equalized temperatures and humidity levels. Do not operate fans in an "on/off" cycle.
   c. Avoid intermittent cold and hot spots throughout the facility by providing more and smaller zones.

d. Override cooling and heating for temperature control if stable humidity is threatened. Maintain relative humidity at 50% RH plus or minus 5% RH. Some special exhibits may require more stringent humidity control of ±2% RH.

e. Provide daily and week-long graphic records of relative humidity for critical spaces.

f. Ensure even control of humidifiers and de-humidifiers to provide more stable humidity levels and "slow" changes in humidity levels.

g. Provide dedicated de-humidification systems for different areas that have special environmental requirements.

h. Avoid outdoor air economizers to minimize the extra humidity load swing caused by outside air in winter and summer seasons. Ventilation air is the single largest factor that causes wide variations in relative humidity levels.

IV. BUILDING ENVELOPE UPGRADE OPTIONS

A. Refer to the "full" historic preservation study prepared by historic preservation architect Douglas Steinmetz, AIA. The historic preservation study is included in the Appendix to this study.

B. Envelope Upgrade Changes for the Art Center

1. Replace existing windows

a. Glass for windows must meet overall aesthetic criteria before it meets energy conservation criteria.

b. With the exception of required exist windows (if any), new replacement windows will not be operable.

c. Replacement or repair of some interior wood trim will be required to facilitate the replacement windows.

d. Because of the special requirements for the windows, the windows may be made outside of Muscatine County and perhaps the State of Iowa.

C. Refer to cost estimates, life cycle cost projections and projected energy savings of the different envelope upgrade options.

D. The City of Muscatine has done a very good job of maintaining the Musser House (Museum) windows in a good state of repair. Douglas Steinmetz AIA feels no further construction is required or recommended for the Musser House historic windows.

E. Windows in the 1970 Addition shall be replaced with efficient new windows.

V. HVAC SYSTEM RECOMMENDATIONS

A. Iowa Department of Natural Resources (IADNR) "Life Cycle Cost Analysis Guidelines" 2008 requires evaluation of HVAC system options against "baseline" HVAC system per IECC specification.

B. The new HVAC systems should meet the following criteria.

1. Individual room or zone temperature control, and humidity control.
2. Dedicated humidification and de-humidification systems to stabilize humidity levels for different areas.
3. Both heating and cooling capability at all times.
4. Controlled outside air for ventilation to aid in humidity control. Minimize the negative effects the amount of outside air has on stable humidity control by letting humidity level control override ventilation controls. Eliminate free cooling control for the sensitive areas.
5. Be energy efficient.
6. System installation should not require significant changes to the building's "historic" character of the Museum portion of the building. Any HVAC upgrade to the Art Center (new addition) should not compromise the eligibility of the Musser House for the National Register.
7. Rely on "large" air volume and low temperature and humidity ranges to control temperatures and humidity in a more stable and steady manner.
8. Maintain the architectural character of the circa 1970 Art Center.

C. Other concepts considered but not evaluated further include because they did not meet all criteria specified above in Item B.

1. Two pipe hot/chilled fan coil system.
2. Four pipe hot chilled fan coil system.
3. Four pipe radiant panel cooling and heating system.
4. Small air handling units dispersed throughout the facilities.

D. The Art Center Museum Building is an irregular shaped facility that includes several different buildings with different shapes and levels that are connected together.

E. A&J estimates that approximately 30 tons of cooling capacity (temperature and humidity control) will be required to handle both the individual room cooling requirements and the minimum outside air ventilation requirements for the entire facility, the Musser House and new addition Art Center.

F. The existing facility does not currently have building wide air conditioning or overall control system so the existing electrical system is not sized to allow just plugging in a

new air conditioning system meeting the new requirements. Additions and upgrades will be required for the electrical system to handle the air conditioning system.

G. Following is the specific description of options considered.

1. Option 1A – Variable Refrigerant Flow System (VRF) *Without* Geothermal Loop System

   a. The Mitsubishi VRF system was used as the study bases because *in* our experience the Mitsubishi two-pipe VRF has been the most cost competitive of the different VRF systems available in the market place. A&J has recent design and construction experience with installing the VRF system in historic buildings. The VRF system is a very efficient HVAC system that uses a high efficient "change of state" mechanism for energy transfer.

   b. Three of the Mitsubishi Outdoor R2-Series 10 ton grade mounted heat exchangers for heat rejection or heat sink for the variable refrigerant flow system.

   c. Heating and cooling would be provided by refrigerant piping distributing two phase gas/liquid to terminal units.

   d. Low ambient temperature backup heating should be provided by two existing half capacity high efficiency gas fired boilers and hot water terminal heating units already operational for the Museum. These terminal heating units provide backup heat at outside air temperatures below 20°F which is the efficiency crossover temperature and also backup heat at temperatures below minus 13°F. The low ambient temperature limit for the Mitsubishi VRF system is minus 13°F. At temperatures below that limit the VRF loses the capacity to effectively draw heat from the "cold" outside air. The existing backup hot water heating boilers and pumps are located in the Museum basement. Hot water heating terminal units in the Museum are the existing cast iron radiators or fin tube convectors in the Museum/Musser House.

   e. Energy recovery and makeup air units will provide conditioned (temperature and humidity controlled) makeup air to the spaces for ventilation during occupied periods. One energy recovery unit will be provided for the Museum (Musser House) and one will be provided for the Art Center.

   f. Provide a new building wide digital control system to interface with the VRF HVAC controls and to incorporate the recently installed hot water heating controls in the Museum.

   g. Provide new ductwork to supply the required ventilation air only to the spaces. Do not use the central air system to heat or cool the spaces. The ductwork will also provide for de-humidification and humidification in the areas.

   h. Individual VRF units located in each zone will circulate cooling or heating air within each zone. An individual VRF unit will be set up to continually circulate air in the zones to stabilize the environment. The VRF system will have a

dehumidification mode where air is circulated at a "low" rate so moisture is continuously removed from the affected spaces.

i. Terminal VRF units will be encased with casework to match the existing woodwork as closely as is reasonable from a cost standpoint.

j. Option 1AA would be the same system as Option 1A except the Museum grade environmental control capability and capacity would be limited to a small area of the Art Center where art and artifacts are stored, not the entire Art Center.

k. Provide new building wide digital control system that incorporate recently installed controls for the hot water heating system.

2. Option 1B – (similar to Option 1A but with geothermal loop field heat exchanger)

   a. The main VRF heat exchangers and condensing units will be water cooled by the geothermal loop and not be air cooled as specified by Option 1A.

   b. The geothermal loop heat exchanger will be installed under the Art Center Museum grounds using horizontal borings to minimize the landscape damage and resultant repairs.

   c. The existing facility landscape appears to be adequate in size to accommodate the 30 tons estimated to be needed for the Art Center Museum.

   d. However, prior to committing to the geothermal loop options a soil conductivity test and boring feasibility test must be completed to determine the actual viability of the geothermal loop system. Historically, these tests have cost between $7,000 and $8,000. Half of the cost is for test loops and can be recovered if the geothermal system is used.

   e. The geothermal loop system will provide the heat rejection and absorption source for the building HVAC systems. The geothermal system will be coupled with the recently installed boiler hot water heating system to form a hybrid cooling and heating system. No glycol will be required for freeze protection.

   f. Option 1BB would be the same system as Option 1B except the Museum grade environmental control capability and capacity would be limited to a small area of the Art Center where art and artifacts are stored, not the entire Art Center.

3. Option 2A – Water to Air Heat Pumps with Heating Boilers and Rooftop Evaporative Cooler, without geothermal loop:

   a. Use of the recently installed boiler and pumping capacity in the Museum by tying into existing closed circuit hot water heating boilers to heat the closed loop supplying the new water source heat pumps.

   b. Provide a new grade mounted evaporative cooler or cooling tower and heat exchanger to provide heat absorption for the heat pump loop heat rejection.

c. Energy recovery and makeup air units shall provide conditioned makeup air to the office for ventilation as needed depending on time of year. Provide one unit for the Museum and one unit for the Art Center.

d. The existing hot water heating system shall provide heating source for the heat pump system.

e. Option 2A is a water source heat pump system that relies on distributed heating and cooling units.

f. The new heat pumps would be encased in wooden case work to match the existing woodwork to the extent economically feasible.

g. Provide a new building wide digital control system that incorporates the recently installed controls for the hot water heating system.

4. Option 2B – Same as Option 2A except with geothermal loop heat exchanger.

a. The evaporative cooler or cooling tower of Option 2A would be replaced by the geothermal loop field heat exchanger.

b. The geothermal loop field would be installed under the building grounds.

c. The viability of the geothermal loop heat exchanger must be determined prior to use of the system. Refer to the discussion under Option 1B for checking out the potential for using the geothermal loop option.

H. Geothermal Loop Options for Inside HVAC system:

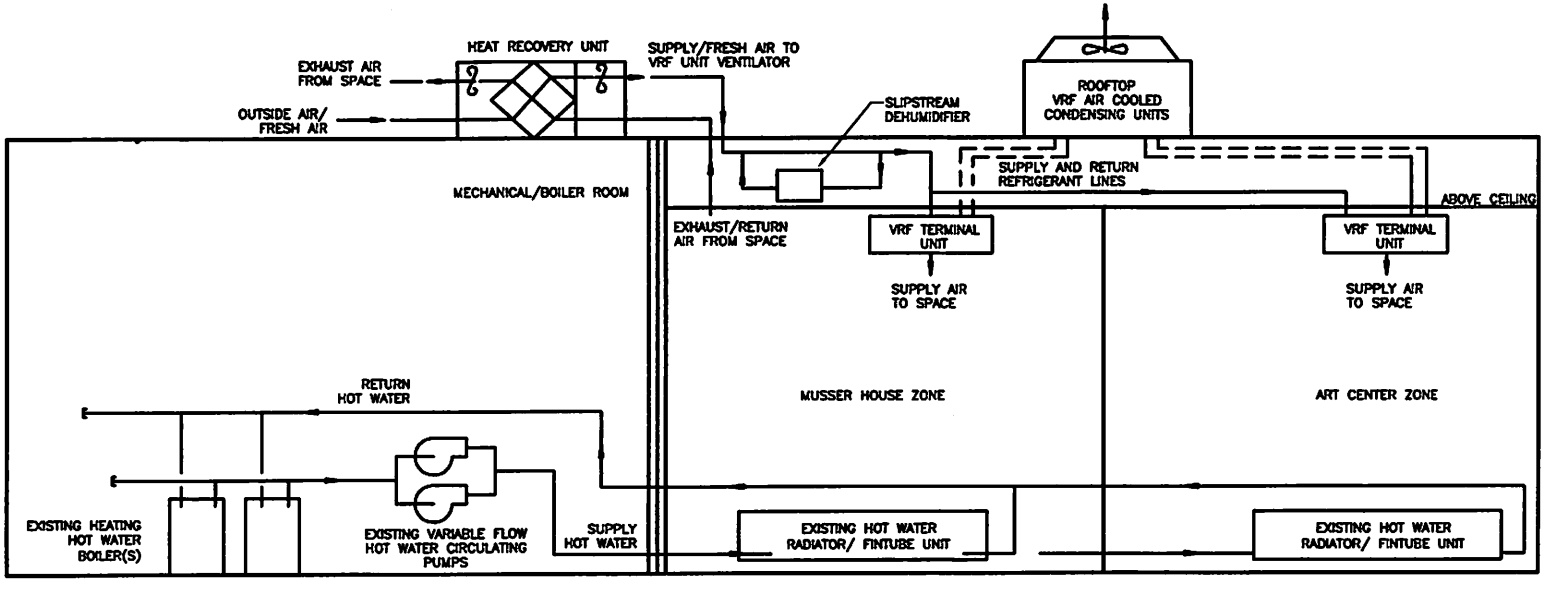
1. A&J evaluated the geothermal loop option with the intent to combine the geothermal loop heat exchanger with either the variable refrigerant flow option or the water source heat pump option (options 1B and 2B above).

2. There appears to be sufficient "real estate" around the building to locate a geothermal loop field.

3. However, soil borings and soils conductivity tests should be performed to confirm the geothermal loop option viability for any HVAC system type.

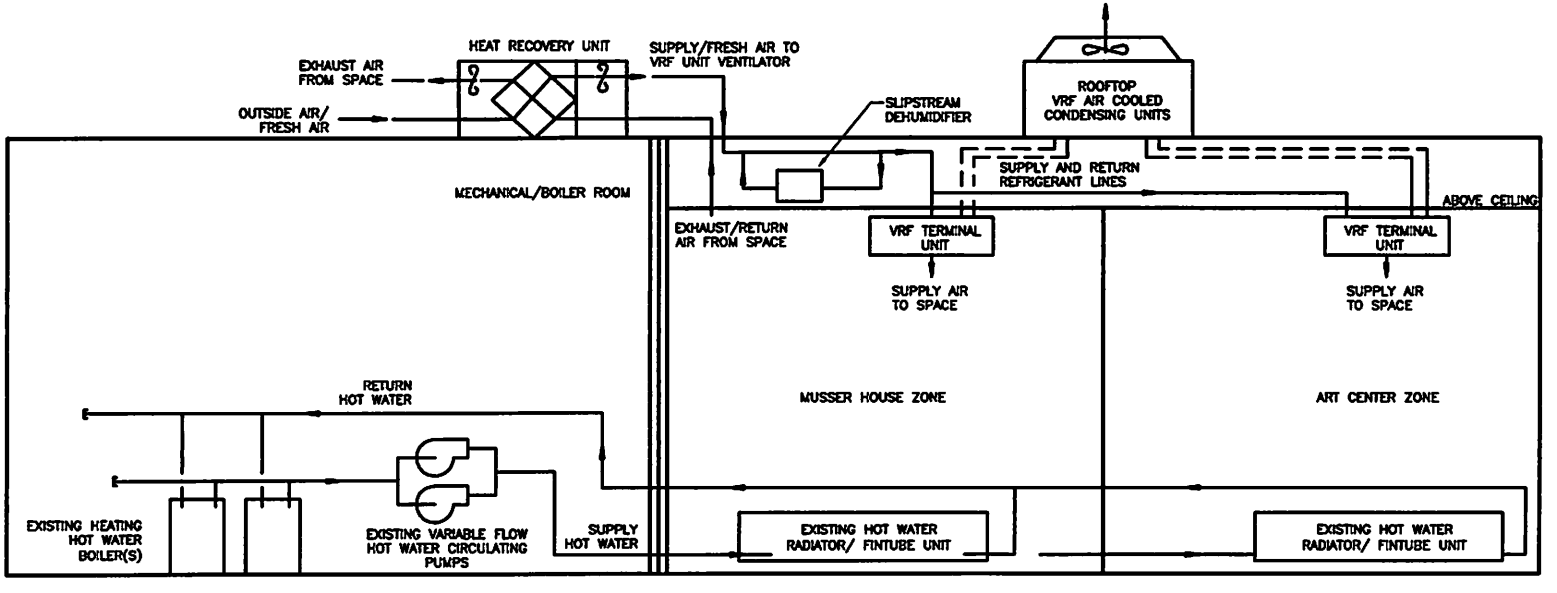
I. Reducing the area of "extreme" or tight humidity control to only a few rooms in the Art Center where exhibits are stored and maintained. This option would be applied to the Option 1A and 1B variable refrigerant flow (VRF) options only since these two options have the lowest opinion of projected costs. This approach is taken only to reduce the total cost of the HVAC system.

J. Any of the HVAC options may be installed in a phased manner either through one contract or through multiple contracts. The phasing would allow for continued operation and use for part of the facility during construction and for delaying expenditures. However, phasing involving separate contracts also risks dealing with separate contractors, project interface difficulty and added project management costs.



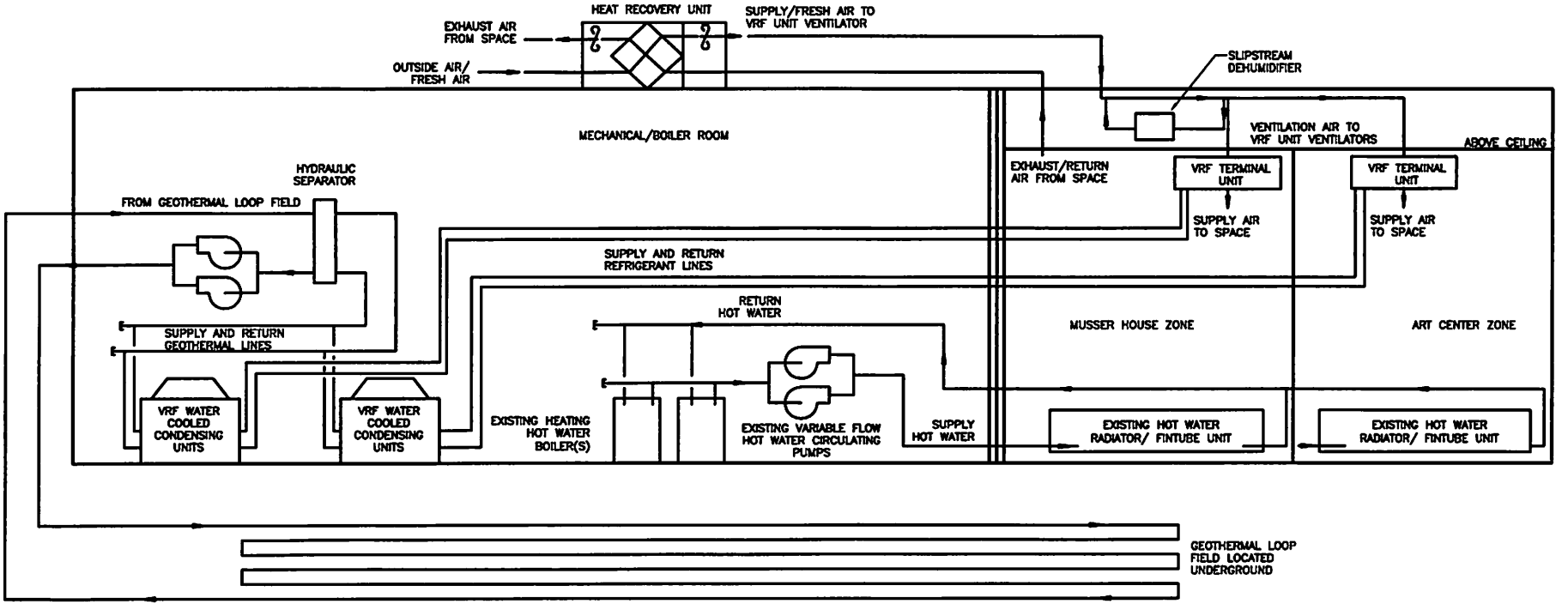
OPTION 1A HEATING, COOLING & VENTILATION AIR:

- VARIABLE REFRIGERANT FLOW WITHOUT GEOTHERMAL LOOP FIELD, ENERGY RECOVERY UNIT, HUMIDIFIERS AND USE OF THE EXISTING PERIMETER HOT WATER HEAT.



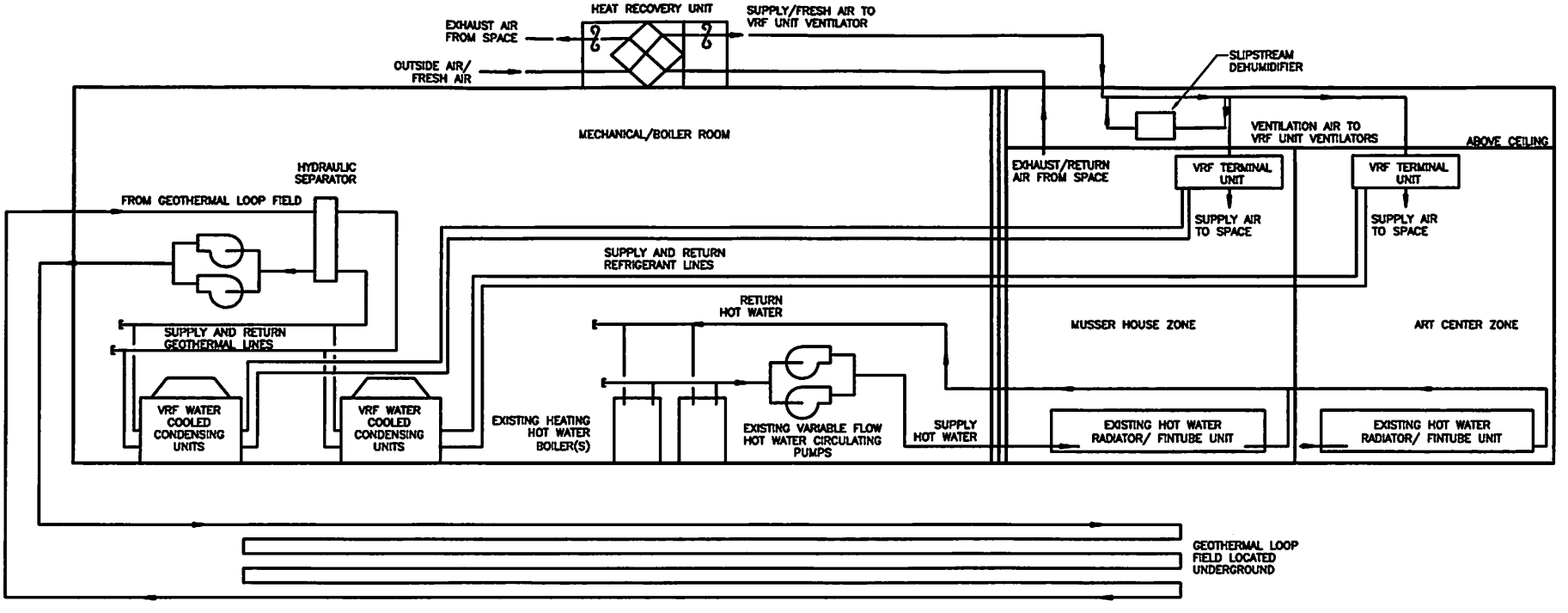
OPTION 1AA HEATING, COOLING & VENTILATION AIR:

- VARIABLE REFRIGERANT FLOW WITHOUT GEOTHERMAL LOOP FIELD, ENERGY RECOVERY UNIT, HUMIDIFIERS AND USE OF THE EXISTING PERIMETER HOT WATER HEAT. OPTION 1AA HAS REDUCED HUMIDITY CONTROL THAN OPTION 1A.



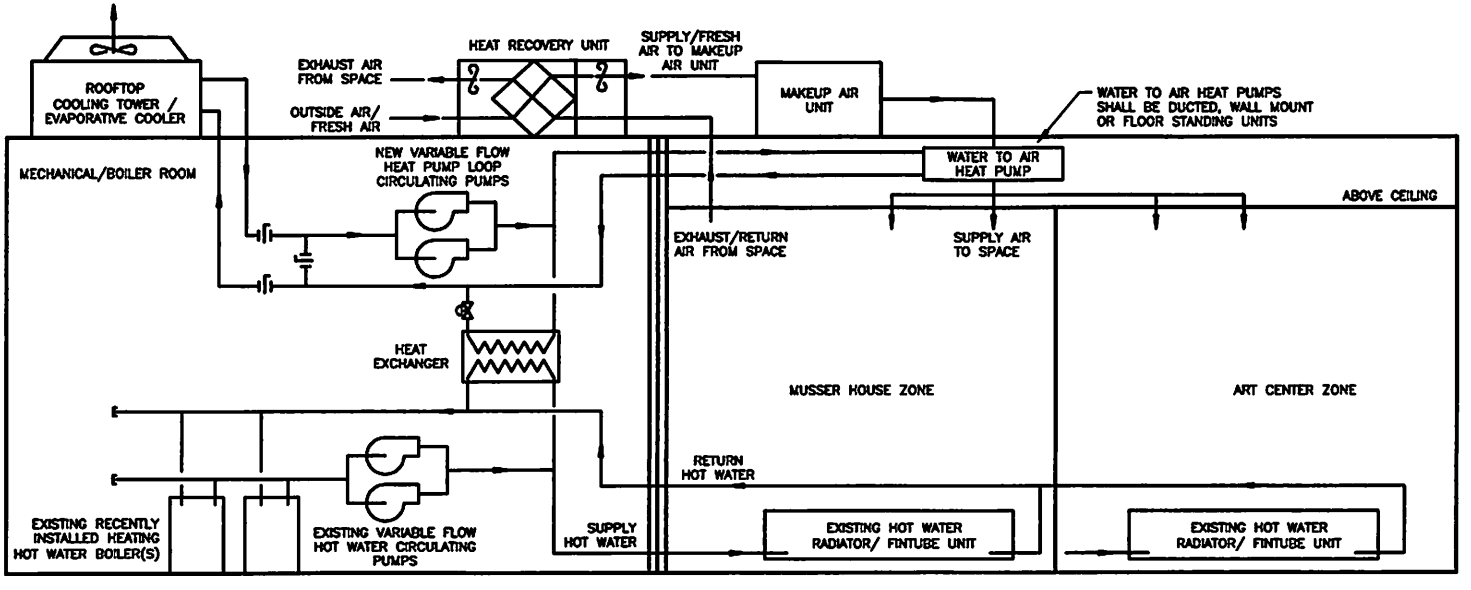
OPTION 1B HEATING, COOLING & VENTILATION AIR:

- VARIABLE REFRIGERANT FLOW WITH GEOTHERMAL LOOP FIELD AS HEAT SINK, ENERGY RECOVERY UNIT, HUMIDIFIERS AND USE OF THE EXISTING PERIMETER HOT WATER HEAT.



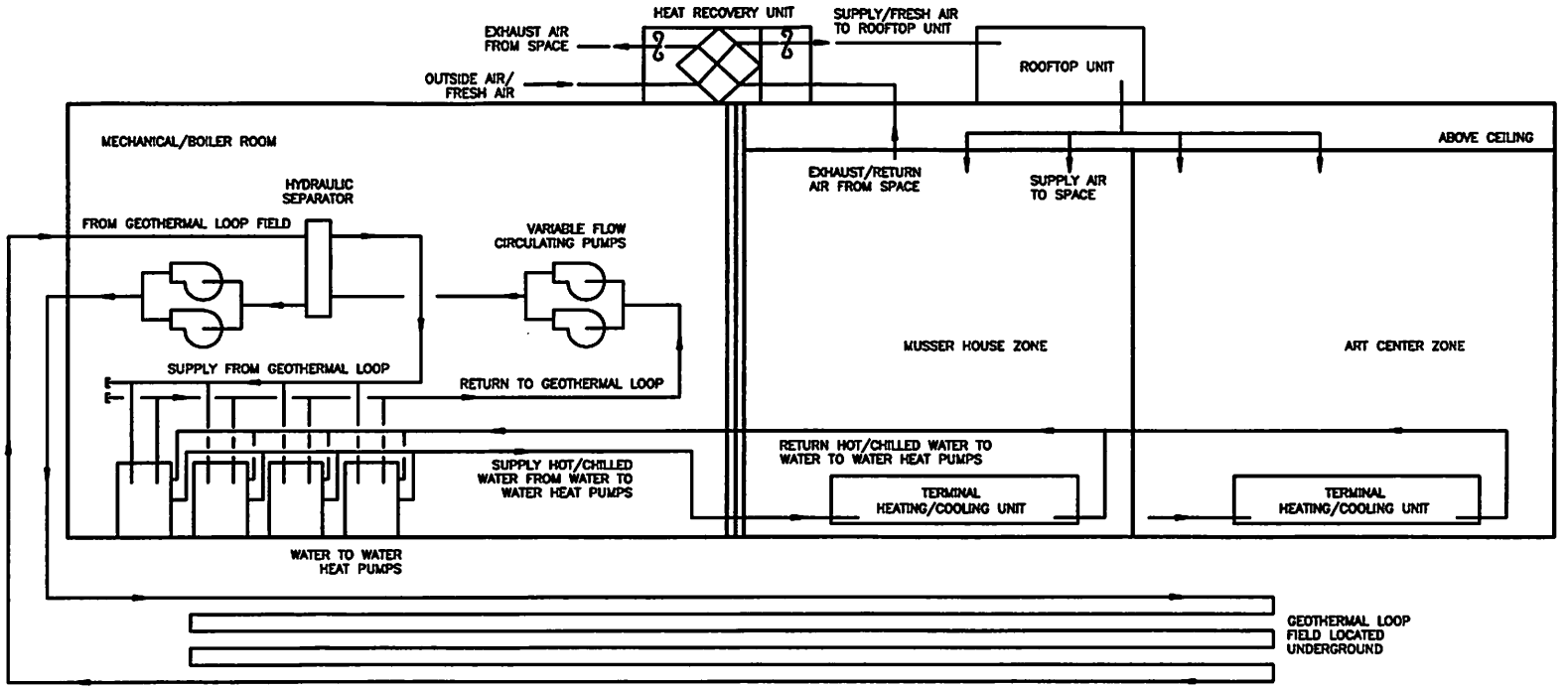
OPTION 1BB HEATING, COOLING & VENTILATION AIR:

- VARIABLE REFRIGERANT FLOW WITH GEOTHERMAL LOOP FIELD AS HEAT SINK, ENERGY RECOVERY UNIT, HUMIDIFIERS AND USE OF THE EXISTING PERIMETER HOT WATER HEAT. OPTION 1BB HAS REDUCED HUMIDITY CONTROL THAN OPTION 1B.



OPTION 2A HEATING, COOLING & VENTILATION AIR:

- COOLING TOWER AND HEAT EXCHANGER, WATER TO AIR PUMPS, ENERGY RECOVERY UNITS, NEW SUPPLY AND RETURN DUCT, DEMOLITION OF EXISTING PERIMETER HOT WATER HEATING AND REUSE OF EXISTING HOT WATER HEATING BOILERS, PUMPS AND CONTROLS.



OPTION 2B GEOTHERMAL HEATING/COOLING:

- STEAM TO HOT WATER CONVERSION, GEOTHERMAL LOOP FIELD, WATER TO WATER HEAT PUMPS, CIRCULATING PUMPS, TERMINAL HEATING/COOLING UNITS IN ROOMS, HEAT RECOVERY UNIT WITH ROOFTOP UNIT FOR VENTILATION AIR

VI. ELECTRICAL UPGRADES

A. Install new 208 volt, 3 phase, and electrical panels in lower level. The new panels will provide 208 volt circuits to power the proposed HVAC systems.

B. Install new 400 amp service from main distribution panel.

C. Install new feeders to equipment located in the mechanical room in the lower level of equipment room.

D. Install new circuits to power proposed heat pump system, or variable refrigerant flow system components. Main runs of new circuits to be run in surface mounted conduits/raceways horizontally along corridor ceilings and individual circuits to heat pumps or variable refrigerant flow system components to be run in surface mounted conduits/raceways horizontally along ceilings into individual rooms

E. Refer to attached plan and site drawings which schematically show the concepts described.

VII. LIGHTING AND LIGHTING CONTROL UPGRADE OPTIONS

A. No lighting upgrades were considered for this study.

VIII. ENVELOPE AND DOMESTIC WATER HEATING UPGRADE

A. The Museum (Musser House) windows are in a good state of repairs. No further work is needed. However, the windows of the new addition or Art Center should be replaced with new energy efficient windows. Refer to the cost estimate for those window replacements.

B. New high efficiency hot water heaters were included with each HVAC option considered to bring that segment up to current plumbing code and energy code requirements.

IX. RECOMMENDATIONS

A. Recommendations are based on the modified BIN analysis and the Life Cycle Cost Analysis of the upgrades. The 25 year gage is one used by the USDOE and the Iowa Office of Economic Development to rate "straight" energy conservation projects. This project will not be typical 25 year payback project, because the new HVAC system will be providing capacity for functions not currently being provided.

B. Options 1A and 1AA upgrade the HVAC to variable refrigerant flow system without a geothermal loop field. Options 1A and 1AA will require supplemental hot water heat at extreme low ambient temperatures. The existing recently installed hot water heating upgrade in the Museum will be used with the new HVAC system to provide this heating capacity at low ambient conditions. The difference in two options 1A and 1AA is the overall cooling capacity.

C. Options 1B and 1BB upgrade the HVAC to variable refrigerant flow with the geothermal loop field and no air-cooled condensers. The recently installed hot water heating components will provide adequate heating capacity to make the system cooling dominant and reduce the geothermal loop size. The boilers will also provide freeze protection for the VRF system. The difference in the two options is the overall cooling capacity.

D. Option 2A upgrades the HVAC system to a water source heat pump system, a grade mounted evaporative cooler and water to air distributed heat pumps.

E. Option 2B upgrades the HVAC to a water source heat pump system with a geothermal loop field heat exchanger. The recently installed hot water heating components will provide freeze protection for the heat pump system and provide low temperature heating for the heat pump loop.

F. All options will have dedicated humidity control apparatuses' (humidifiers/de-humidifiers), but options 1AA and 1BB have reduced humidity control only for a specified storage area.

G. HVAC Option 1A, 1AA, 1B, 1BB, 2A or 2B can be phased to be completed in stages to allow the continued occupancy of the facility, or to stretch out expenditures over a period of years.

H. The attached Life Cycle Cost Analysis and BIN evaluations indicate which operation is preferable from cost outlay standpoints only, from life cycle costs which include initial cost and energy savings payback.

I. The attached estimated costs of Options are based on concepts only and A&J's experience with basic construction cost parameters. Construction cost estimates are **not** guaranteed. Refer to the Appendix for detailed concept cost estimates.

J. Subject to the following qualifications, the modified Life Cycle Cost Analysis and ASHRAE BIN analysis offers predictions of energy savings with estimations as good as any other means available for projecting energy use and future costs for the systems or project that have not been built.

   1. The energy savings results compare relative differences in net energy use for design alternatives. The results are not appropriate for system design and/or equipment selection; rather than results should only be used to "rank" system alternatives.

   2. The actual energy use of this building or project will be different from simulated results. Building systems and other operating parameters used in the model approximate actual conditions, but differences in weather, operating parameters, occupancy level, future energy costs and changes that occur through the bidding and construction process will result in annual energy costs and use that will be different from what is predicted here. However, when a design strategy is selected relative to other alternatives, its energy (and dollar) conserving value can be expected to remain constant relative to the other alternatives, and the magnitude of the cost difference should be approximately as predicted. Any recent energy grant application has required that the electrical use cost be estimated even if not paid.

Thus, implementation of design strategies offers the opportunity for energy savings, but the realization of those savings is the responsibility of the owner/operator of the building, not A&J Associates. Savings are not guaranteed.

3. Equipment and repair costs for future years depend on factors beyond accurate repair predictions. The future costs are only predicted consistently between options in accordance with publicly accepted Life Cycle Cost Analysis tracking specified by ASHRAE.

4. **Currently the City of Muscatine does not pay for electrical power since the City of Muscatine is the electrical utility provider. The comparative analysis evaluates energy costs with no charge for electricity and with a "representative" charge for electricity to reflect the reduced use of electricity by an option. This comparison method does factor electricity costs into the life cycle cost analysis as required by the State of Iowa.**

K. The estimated energy use changes from existing to new are based on a cursory review of the existing systems. A&J did not perform onsite test or monitor years of operation so we had to rely on what we were told about the current system performance. Because of this cursory investigation changes in the sizes of equipment actually during the detailed design of any new system required (an increase or decrease) may occur depending on the results of more detailed analysis. Detailed design decisions may increase or decrease the actual construction cost over the projected construction cost of an option.

L. The Muscatine Art Center and Museum Building HVAC systems are estimated to be past the useful life or just temporary and the zone temperature and humidity control provided from these units is unacceptable. The Energy Conservation code was considerably different when the existing systems were installed compared to today's Energy Conservation code. Most significant changes have come in energy use and mandatory ventilation requirements. These areas have been re-evaluated to reduce the amount of energy used by building mechanical systems. Consequently, the existing HVAC systems do not meet present day energy conservation requirements.

M. The above code uncertainties do not apply to the recently installed hot water heating system in the Museum. The hot water heating system meets the current codes.

N. Current and modern control systems provide much more control than the system currently installed. It is now possible to achieve closer environmental control by using less energy through more sophisticated control systems. The better control system will provide the daily, weekly and monthly humidity level records required for the Art Center to document the Museum exhibit quality control.

O. The potential geothermal well site has not yet been determined suitable for drilling. Exploratory soil borings and conductivity tests should be completed to determine the viability of the geothermal options, 1B and 2B.

P. We recommend the variable refrigerant flow (VRF) system option with the geothermal loop heat exchanger (if that is viable) Option 1B or 1BB, be provided for the following reasons:

1. Provides better zone temperature control than the other three options.
2. Provides better humidity control than the other options.
3. Projected to have less annual maintenance cost and energy costs.
4. The recommended VRF system coupled with the geothermal loop field heat exchanger is very similar to the system recently installed in the County Courthouse.
5. Use of the geothermal loop option will depend on the outcome of the soil borings and soil conductivity tests.
6. Option 1BB is recommended if the stringent humidity control can be limited to the storage areas of the Art Center.
7. Option 1B or 1BB is aesthetically satisfactory when considering the Museum portion of the facility for inclusion on the National Register.

Q. The Art Center Museum does not qualify for historic preservation tax credits that have been distributed by the State of Iowa. Doug Steinmetz, historic preservation architect, stated that the Art Center portion of the building is not historically relevant. However, the Museum or Musser House is historically relevant and may be eligible to be listed on the National Register if the upgrades or additions to the both the Art Center and the Musser House follow the historic preservation requirements. No tax credit savings has been applied to reduce the first cost of any upgrades since the buildings are <u>not</u> yet eligible.

Summary 1A
(Electrical Data Not Included)

	Net Occupiable Project Area (Sq. Ft.)	Median Construction Cost (1)	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
Option 1A ***	5,950	$ 1,333,481	NA	1,438	$1,107	$0.19	$2,878.00	$0.48	$3,985	88.09	442.12
Option 1AA ***	5,950	$ 1,118,021	NA	1,438	$1,107	$0.19	$2,878.00	$0.48	$3,985	73.85	370.69
Option 1B ***	5,950	$ 1,518,456	NA	80	$62	$0.01	$2,878.00	$0.48	$2,940	93.83	373.84
Option 1BB ***	5,950	$ 1,323,996	NA	80	$62	$0.01	$2,878.00	$0.48	$2,940	81.81	325.97
Option 2A ***	5,950	$ 1,330,408	NA	1,274	$981	$0.16	$2,878.00	$0.48	$3,859	87.16	423.38
Option 2B ***	5,950	$ 1,494,733	NA	637	$490	$0.08	$2,878.00	$0.48	$3,368	94.87	411.45

Total Utility Load

Electrical Load (kWh)	NA	***
Gas Load (therm)	5,355	
Total Utility Cost Existing	$ 4,123.35	→12 month bill period***

Estimated Yearly Maintenance Cost Existing	$15,000
Total Estimated Yearly Operating Cost	$19,123

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. See summary 1B for estimated electrical Cost/kWh used to compare the differences in electrical usage for options 1A/B & 2A/B.

****Options 1A/1AA/1B/1BB & 2A/B may not provide significant energy use savings over the existing energy use, because of the addition of the air conditioning system capacity for the ventilation air.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

Summary 1B
(Estimated Electrical Cost Included)

	Net Occupiable Project Area (Sq. Ft.)	Median Construction Cost (1)	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Electrical & Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
Option 1A ***	5,950	$ 1,333,481	52,585	1,438	$4,105	$0.69	$2,878.00	$0.48	$6,983	62.96	147.24
Option 1AA ***	5,950	$ 1,118,021	52,585	1,438	$4,105	$0.69	$2,878.00	$0.48	$6,983	52.79	123.45
Option 1B ***	5,950	$ 1,518,456	43,170	80	$2,522	$0.42	$2,878.00	$0.48	$5,400	66.71	142.73
Option 1BB ***	5,950	$ 1,323,996	43,170	80	$2,522	$0.42	$2,878.00	$0.48	$5,400	58.17	124.45
Option 2A ***	5,950	$ 1,330,408	57,178	1,274	$4,240	$0.71	$2,878.00	$0.48	$7,118	63.22	149.13
Option 2B ***	5,950	$ 1,494,733	46,903	637	$3,164	$0.53	$2,878.00	$0.48	$6,042	67.58	149.51

Total Utility Load

Electrical Load (kWh)	158,560	***
Gas Load (therm)	5,355	
Total Utility Cost Existing	$ 13,161.27	→12 month bill period***

Estimated Yearly Maintenance Cost Existing	$15,000
Total Estimated Yearly Operating Cost	$28,161

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. Cost/kWh provided is estimated from previous projects located in Muscatine and will be used to compare the differences in electrical usage for options 1A/B & 2A/B.

****Options 1A/1AA/1B/1BB & 2A/B may not provide significant energy use savings over the existing energy use, because of the addition of the air conditioning system capacity for the ventilation air.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

Summary - 1.5 x Utilities 1A
(Electrical Data Not Included)

	Net Occupiable Project Area (Sq. Ft.)	Median Construction Cost (1)	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
Option 1A ***	5,950	$ 1,333,481	NA	1,438	$1,661	$0.28	$2,878.00	$0.48	$4,539	80.11	294.75
Option 1AA ***	5,950	$ 1,118,021	NA	1,438	$1,661	$0.28	$2,878.00	$0.48	$4,539	67.16	247.12
Option 1B ***	5,950	$ 1,518,456	NA	80	$92	$0.02	$2,878.00	$0.48	$2,970	83.36	249.23
Option 1BB ***	5,950	$ 1,323,996	NA	80	$92	$0.02	$2,878.00	$0.48	$2,970	72.69	217.31
Option 2A ***	5,950	$ 1,330,408	NA	1,274	$1,471	$0.25	$2,878.00	$0.48	$4,349	79.02	282.25
Option 2B ***	5,950	$ 1,494,733	NA	637	$736	$0.12	$2,878.00	$0.48	$3,614	85.07	274.30

Total Utility Load

Electrical Load (kWh)	NA	***
Gas Load (therm)	5,355	
Total Utility Cost Existing	$ 6,185.03	→12 month bill period***

Estimated Yearly Maintenance Cost Existing	$15,000
Total Estimated Yearly Operating Cost	$21,185.03

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. Cost/kWh is not included in the total estimated yearly operating cost calculated on this sheet.

****Options 1A/1AA/1B/1BB & 2A/B may not provide significant energy use savings over the existing energy use, because of the addition of the air conditioning system capacity for the ventilation air.**

This summary table evaluates the scenario where utility costs may increase by a factor of 50%.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

	Net Occupiable Project Area (Sq. Ft.)	Median Construction Cost (1)	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Electrical & Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
Option 1A ***	5,950	$ 1,333,481	52,585	1,438	$6,157	$1.03	$2,878.00	$0.48	$9,035	51.87	98.16
Option 1AA ***	5,950	$ 1,118,021	52,585	1,438	$6,157	$1.03	$2,878.00	$0.48	$9,035	43.49	82.30
Option 1B ***	5,950	$ 1,518,456	43,170	80	$3,783	$0.64	$2,878.00	$0.48	$6,661	54.08	95.15
Option 1BB ***	5,950	$ 1,323,996	43,170	80	$3,783	$0.64	$2,878.00	$0.48	$6,661	47.15	82.97
Option 2A ***	5,950	$ 1,330,408	57,178	1,274	$6,360	$1.07	$2,878.00	$0.48	$9,238	52.17	99.42
Option 2B ***	5,950	$ 1,494,733	46,903	637	$4,746	$0.80	$2,878.00	$0.48	$7,624	55.12	99.68

Total Utility Load
Electrical Load (kWh) 158,560 ***
Gas Load (therm) 5,355
Total Utility Cost Existing $ 19,741.91 →12 month bill period***

Estimated Yearly Maintenance Cost Existing $15,000
Total Estimated Yearly Operating Cost $34,741.91

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. Cost/kWh provided is estimated from previous projects located in Muscatine and will be used to compare the differences in electrical usage for options 1A/B & 2A/B.

****Options 1A/1AA/1B/1BB & 2A/B may not provide significant energy use savings over the existing energy use, because of the addition of the air conditioning system capacity for the ventilation air.

This summary table evaluates the scenario where utility costs may increase by a factor of 50%.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

Life Cycle Cost Analysis 1A
(Electrical Data Not Included)

	Project Area (Sq. Ft.)	Median Construction Cost (1)	LCCA Gas Energy Use Cost	LCCA Maintenance Cost	LCCA Replacement Cost	Less Remaining Value	LCCA TOTAL COST
Option 1A	5,950	$ 1,333,481	$19,207	$69,072	$175,125	-$42,963	$1,553,922
Option 1AA	5,950	$ 1,118,021	$19,207	$69,072	$175,125	-$42,963	$1,338,462
Option 1B	5,950	$ 1,518,456	$1,069	$69,072	$191,225	-$52,284	$1,727,538
Option 1BB	5,950	$ 1,323,996	$1,069	$69,072	$191,225	-$52,284	$1,533,078
Option 2A	5,950	$ 1,330,408	$17,016	$69,072	$189,725	-$47,503	$1,558,718
Option 2B	5,950	$ 1,494,733	$8,508	$69,072	$197,725	-$62,637	$1,707,401

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

Assumptions:
- 25 year Life Cycle Cost time period
- Life Cycle Costs are not based on the assumption that utility costs will soon increase by 50%.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

	Project Area (Sq. Ft.)	Median Construction Cost (1)	LCCA Energy Use Cost	LCCA Maintenance Cost	LCCA Replacement Cost	Less Remaining Value	LCCA TOTAL COST
Option 1A	5,950	$ 1,333,481	$65,895	$69,072	$184,875	-$43,256	$1,610,067
Option 1AA	5,950	$ 1,118,021	$65,895	$69,072	$184,875	-$43,256	$1,394,607
Option 1B	5,950	$ 1,518,456	$39,398	$69,072	$191,225	-$52,284	$1,765,867
Option 1BB	5,950	$ 1,323,996	$39,398	$69,072	$191,225	-$52,284	$1,571,407
Option 2A	5,950	$ 1,330,408	$67,783	$69,072	$199,475	-$47,795	$1,618,943
Option 2B	5,950	$ 1,494,733	$50,152	$69,072	$197,725	-$55,342	$1,756,340

Option 1A
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1AA
Variable refrigerant flow, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 1B
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat.

Option 1BB
Variable refrigerant flow connected geothermal loop field, energy recovery units, humidifiers & dehumidifiers, and reuse existing perimeter hot water heat. Reduced Humidity control option.

Option 2A
Cooling tower, water to air heat pumps, energy recovery units, new return duct, humidifiers & dehumidifiers, reuse existing hot water heating equipment.

Option 2B
Geothermal Loop Field, water-to-water heat pumps, circulating pumps, humidifiers & dehumidifiers, water to air heat pumps, energy recovery units, new return duct, reuse existing hot water heating equipment.

Assumptions:
- 25 year Life Cycle Cost time period
- Life Cycle Costs are not based on the assumption that utility costs will soon increase by 50%.

1. Construction Cost used in the table is the "Median" opinion of the costs, not the high or low of the range.

APPENDIX

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	VRF sensible cooling load (btuh)	VRF total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	VRF sensible heating load (btuh)	VRF total heating load (btu/month)	Boiler heating load (btuh)	Boiler total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	327	21227	254718	408525	32682002	22696	907833
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	303	19096	229153	378486	30278914	21027	841081
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	256	14913	178953	319502	25560122	17750	710003
april	83.3	23.5	50.4	44.5	33	136679	139	0	1673	1857	148555	0	0	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	140653	4114	0	49363	54779	4382359	0	0	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	143965	7425	3373	129566	98882	7910530	0	0	0	0	0	0	0	0
july	97	55	75.9	68.5	92	145568	9029	6432	185534	120236	9618907	0	0	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	144871	8332	1626	119488	110952	8876135	0	0	0	0	0	0	0	0
september	89.5	37	64	54.7	46	141420	4881	0	58567	64993	5199409	0	0	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	137899	1360	0	16315	18105	1448407	0	0	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	248	14216	170587	309671	24773657	17204	688157
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	304	19174	230063	379579	30366299	21088	843508
													see note 6					see note 6	

	cooling		heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	VRF operating cost (month)	gas heating operating cost (month)	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	252	4	116	188	60307	4,824,566	20,349	1627920	12826	1026088
february	0	0	233	4	108	174	60307	4,824,566	20,349	1627920	12826	1026088
march	0	0	197	3	91	147	60307	4,824,566	20,349	1627920	12826	1026088
april	0	1	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
may	1	16	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
june	2	28	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
july	3	34	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
august	2	32	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
september	1	19	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
october	0	5	0	0	0	0	60307	4,824,566	20,349	1627920	12826	1026088
november	0	0	191	3	88	142	60307	4,824,566	20,349	1627920	12826	1026088
december	0	0	234	4	108	175	60307	4,824,566	20,349	1627920	12826	1026088
	$9	$134	$1,107	$18	$512	$826		$966.90		$326.25		$205.64
			see note 6					see note 4		see note 5		

Net Occuplable Building Area:	5,950	sq. ft.	
estimated project cost:	$ 1,333,481		
electrical cost per kWh:	$ 0.05700	City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.	
estimated yearly maintenance cost:	$ 2,878		
estimated yearly HVAC electrical load (kWh):	**52,585**		
estimated yearly HVAC electrical utility cost:	**$1,498.57**		
estimated yearly gas cost:	**$1,106.96**	1438 therm	$0.77/ therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$966.90**		
estimated yearly plug load cost:	**$326.25**		
estimated yearly service hot water cost:	**$205.64**		
	$4,104.33		
estimated yearly utility cost per sq. foot:	**$0.69**		

Notes:

1. Costs above assume variable refrigerant flow to be used in the entire Art Center and Museum. VRF, ERV Units, Humidifiers, Dehumidifiers Supply and Return Duct and Reuse Hot Water Heat Supply Equipment.
2. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
3. Ventilation air and return air quantities were assumed for this study based on minimum ventilation rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
4. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
5. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
6. Gas fired heating required only for supplemental heat at extreme low outside air temperatures estimated to occur two weeks or 40 Hours of the year.

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	VRF sensible cooling load (btuh)	VRF total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	VRF sensible heating load (btuh)	VRF total heating load (btu/month)	Boiler heating load (btuh)	Boiler total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	327	21227	254718	408525	32682002	22696	907833
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	303	19096	229153	378486	30278914	21027	841081
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	256	14913	178953	319502	25560122	17750	710003
april	83.3	23.5	50.4	44.5	33	136679	139	0	1673	1857	148555	0	0	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	140653	4114	0	49363	54779	4382359	0	0	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	143965	7425	3373	129566	98882	7910530	0	0	0	0	0	0	0	0
july	97	55	75.9	68.5	92	145568	9029	6432	185534	120236	9618907	0	0	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	144871	8332	1626	119488	110952	8876135	0	0	0	0	0	0	0	0
september	89.5	37	64	54.7	46	141420	4881	0	58557	64993	5199409	0	0	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	137899	1360	0	16315	18105	1448407	0	0	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	248	14216	170587	309671	24773657	17204	688157
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	304	19174	230083	379579	30366299	21088	843508
													see note 6					see note 6	

	cooling		heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	VRF operating cost (month)	gas heating operating cost (month)	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	252	4	116	188	60307	4,824,565	20,349	1627920	12826	1026088
february	0	0	233	4	108	174	60307	4,824,568	20,349	1627920	12826	1026088
march	0	0	197	3	91	147	60307	4,824,565	20,349	1627920	12826	1026088
april	0	1	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
may	1	16	0	0	0	0	60307	4,824,565	20,349	1627920	12826	1026088
june	2	28	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
july	3	34	0	0	0	0	60307	4,824,565	20,349	1627920	12826	1026088
august	2	32	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
september	1	19	0	0	0	0	60307	4,824,565	20,349	1627920	12826	1026088
october	0	5	0	0	0	0	60307	4,824,565	20,349	1627920	12826	1026088
november	0	0	191	3	88	142	60307	4,824,568	20,349	1627920	12826	1026088
december	0	0	234	4	108	175	60307	4,824,565	20,349	1627920	12826	1026088
	$9	$134	$1,107	$18	$512	$826		$966.90		$326.25		$205.64
			see note 6					see note 4		see note 5		

Net Occupiable Building Area:	5,950	sq. ft.	
estimated project cost:	$ 1,118,021		
electrical cost per kWh:	$ 0.05700	City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.	
estimated yearly maintenance cost:	$ 2,878		
estimated yearly HVAC electrical load (kWh):	**52,585**		
estimated yearly HVAC electrical utility cost:	**$1,498.57**		
estimated yearly gas cost:	**$1,106.96**	1438 therm	$0.77/ therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$966.90**		
estimated yearly plug load cost:	**$326.25**		
estimated yearly service hot water cost:	**$205.64**		
	$4,104.33		
estimated yearly utility cost per sq. foot:	**$0.69**		

Notes:

1. Costs above assume variable refrigerant flow to be used in the entire Art Center and Museum. VRF, ERV Units, Humidifiers, Dehumidifiers Supply and Return Duct and Reuse Hot Water Heat Supply Equipment.
2. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
3. Ventilation air and return air quantities were assumed for this study based on minimum ventilation rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
4. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
5. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
6. Gas fired heating required only for supplemental heat at extreme low outside air temperatures estimated to occur two weeks or 40 Hours of the year.

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	VRF sensible cooling load (btuh)	VRF total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	VRF sensible heating load (btuh)	VRF total heating load (btu/month)	Boiler heating load (btuh)	Boiler total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	18	21227	254718	408525	16341001	22696	907833
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	17	19096	229153	378486	15139457	21027	841081
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	14	14913	178953	319502	12780061	17750	710003
april	83.3	23.5	50.4	44.5	33	136679	139	0	1673	1857	74277	0	0	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	140653	4114	0	49363	54779	2191180	0	0	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	143965	7425	3373	129586	98882	3955265	0	0	0	0	0	0	0	0
july	97	55	75.9	68.5	92	145568	9029	6432	185534	120236	4809454	0	0	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	144871	8332	1626	119488	110952	4438067	0	0	0	0	0	0	0	0
september	89.5	37	64	54.7	46	141420	4881	0	58567	64993	2599705	0	0	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	137899	1360	0	16315	18105	724203	0	0	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	14	14216	170587	309671	12386828	17204	688157
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	17	19174	230083	379579	15183149	21088	843508
											30 min./hr see note 6		see note 7				30 min./hr see note 6	see note 7	

	cooling			heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	gas heating operating cost (month)	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	0	14	4	58	91	60307	4,824,568	20,349	1627920	12826	1026088
february	0	0	0	13	4	54	85	60307	4,824,568	20,349	1627920	12826	1026088
march	0	0	0	11	3	46	71	60307	4,824,568	20,349	1627920	12826	1026088
april	0	0	1	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
may	1	8	25	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
june	2	14	44	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
july	3	17	54	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
august	2	16	50	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
september	1	9	29	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
october	0	3	8	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
november	0	0	0	11	3	44	69	60307	4,824,568	20,349	1627920	12826	1026088
december	0	0	0	13	4	54	85	60307	4,824,568	20,349	1627920	12826	1026088
	$9	$67	$210	$61 see note 7	$18	$256	$402		$966.90 see note 4		$326.25 see note 5		$205.64

Net Occupiable Building Area:	5,950	sq. ft.	
estimated project cost:	$ 1,518,456		
electrical cost per kWh:	$ 0.05700	City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.	
estimated yearly maintenance cost:	$ 2,878		
estimated yearly HVAC electrical load (kWh):	**43,170**		
estimated yearly HVAC electrical utility cost:	**$961.88**		
estimated yearly gas cost:	**$61.45**	80 therm	$0.77 / therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$966.90**		
estimated yearly plug load cost:	**$326.25**		
estimated yearly service hot water cost:	**$205.64**		
	$2,522.14		
estimated yearly utility cost per sq. foot:	**$0.42**		

Notes:

1. Costs above assume variable refrigerant flow to be used in the entire Art Center and Museum. Geothermal Loop Field (Heat Sink), VRF, ERV Unit, Humidifiers, Dehumidifiers Supply and Return Duct and Reuse Hot Water Heat Supply Equipment.
2. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
3. Ventilation air and return air quantities were assumed for this study based on minimum ventilation rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
4. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
5. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
6. The VRF cooling and heating system connected to geothermal loop field is assumed to run 30 minutes per hour which equals 12 hours per day.
7. Gas fired heating required only for supplemental heat at extreme low outside air temperatures estimated to occur two weeks or 5% (two weeks out of the year = 14 days/ 365 days = 0.04) of the year.

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	VRF sensible cooling load (btuh)	VRF total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	VRF sensible heating load (btuh)	VRF total heating load (btu/month)	Boiler heating load (btuh)	Boiler total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	18	21227	254718	408525	16341001	22696	907833
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	17	19096	229153	378486	15139457	21027	841081
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	14	14913	178953	319502	12780061	17750	710003
april	83.3	23.5	50.4	44.5	33	136679	139	0	1673	1857	74277	0	0	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	140653	4114	0	49363	54779	2191180	0	0	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	143965	7425	3373	129566	98882	3955265	0	0	0	0	0	0	0	0
july	97	55	75.9	68.5	92	145568	9029	6432	185534	120236	4809454	0	0	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	144871	8332	1626	119488	110952	4438067	0	0	0	0	0	0	0	0
september	89.5	37	64	54.7	46	141420	4881	0	58567	64993	2599705	0	0	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	137899	1360	0	16315	18105	724203	0	0	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	14	14216	170587	309671	12386828	17204	688157
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	17	19174	230083	379579	15183149	21088	843508
											30 min./hr see note 6		see note 7				30 min./hr see note 6	see note 7	

	cooling			heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	gas heating operating cost (month)	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	bulding lighting load peak (btu/h)	building total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	0	14	4	58	91	60307	4,824,568	20,349	1627920	12826	1026086
february	0	0	0	13	4	54	85	60307	4,824,568	20,349	1627920	12826	1026068
march	0	0	0	11	3	46	71	60307	4,824,568	20,349	1627920	12826	1026088
april	0	0	1	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026068
may	1	8	25	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
june	2	14	44	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
july	3	17	54	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
august	2	16	50	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
september	1	9	29	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026068
october	0	3	8	0	0	0	0	60307	4,824,568	20,349	1627920	12826	1026088
november	0	0	0	11	3	44	69	60307	4,824,568	20,349	1627920	12826	1026068
december	0	0	0	13	4	54	85	60307	4,824,568	20,349	1627920	12826	1026086
	$9	$67	$210	$61 see note 7	$18	$256	$402		$966.90 see note 4		$326.25 see note 5		$205.64

Net Occupiable Building Area:	5,950	sq. ft.	
estimated project cost:	$ 1,323,996		
electrical cost per kWh:	$ 0.05700	City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.	
estimated yearly maintenance cost:	$ 2,878		
estimated yearly HVAC electrical load (kWh):	**43,170**		
estimated yearly HVAC electrical utility cost:	**$961.88**		
estimated yearly gas cost:	**$61.45**	80 therm	$0.77 / therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$966.90**		
estimated yearly plug load cost:	**$326.25**		
estimated yearly service hot water cost:	**$205.64**		
	$2,522.14		
estimated yearly utility cost per sq. foot:	**$0.42**		

Notes:

1. Costs above assume variable refrigerant flow to be used in the entire Art Center and Museum, Geothermal Loop Field (Heat Sink), VRF, ERV Unit, Humidifiers, Dehumidifiers Supply and Return Duct and Reuse Hot Water Heat Supply Equipment.
2. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
3. Ventilation air and return air quantities were assumed for this study based on minimum ventilation rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
4. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
5. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
6. The VRF cooling and heating system connected to geothermal loop field is assumed to run 30 minutes per hour which equals 12 hours per day.
7. Gas fired heating required only for supplemental heat at extreme low outside air temperatures estimated to occur two weeks or 5% (two weeks out of the year = 14 days/ 365 days = 0.04) of the year.

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	Water/Air sensible cooling load (btuh)	Water/Air total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	Water/Air sensible heating load (btuh)	Water/Air total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	299	21227	305662	373261	29860848
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	272	19096	274984	339884	27190749
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	219	14913	214744	274346	21947647
april	83.3	23.5	50.4	44.5	33	217335	139	0	2008	82840.7258	6627258	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	221309	4114	0	59236	145102.5611	11608205	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	224621	7425	3373	155503	196987.4239	15758994	0	0	0	0	0	0
july	97	55	75.9	68.5	92	226224	9029	6432	222641	222110.6206	17768850	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	225527	8332	1626	143385	211187.4916	16894999	0	0	0	0	0	0
september	89.5	37	64	54.7	46	222076	4881	0	70280	157118.003	12569440	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	218555	1360	0	19578	101956.2016	8156496	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	211	14216	204704	263422	21073797
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	273	19174	276100	341098	27287844

	cooling				heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	hplp operating cost (month)	Water/Air Heat Pump operating cost (month)	Cooling Tower operating cost (month)	hplp operating cost (month)	boiler operating cost (month)	ventilation unit fans operating cost (month)	Water/Air Heat Pump operating cost (month)	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	0	0	50	230	5	75	60307	4,824,568	20,349	1,627,920.00	12826	1026088
february	0	0	0	0	46	209	5	69	60307	4,824,568	20,349	1,627,920.00	12826	1026088
march	0	0	0	0	37	169	4	55	60307	4,824,568	20,349	1,627,920.00	12826	1026088
april	0	22	28	73	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
may	1	39	48	74	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
june	3	53	66	75	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
july	4	60	74	76	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
august	2	57	71	75	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
september	1	42	53	74	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
october	0	27	34	73	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
november	0	0	0	0	35	162	3	53	60307	4,824,568	20,349	1,627,920.00	12826	1026088
december	0	0	0	0	46	210	5	69	60307	4,824,568	20,349	1,627,920.00	12826	1026088
	$11	$300	$373	$520	$214	$981	$21	$321 see note 7		$966.90		$326.25		$205.64

Net Occupiable Building Area:	5,950	sq. ft.	
estimated project cost:	$ 1,330,408		
electrical cost per kWh:	$ 0.05700	City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.	
estimated yearly maintenance cost:	$ 2,878		
estimated yearly HVAC electrical load (kWh):	**57,178**		
estimated yearly HVAC electrical utility cost:	**$1,760.38**		
estimated yearly gas cost:	**$980.68**	1274 therm	$0.77/ therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$966.90**		
estimated yearly plug load cost:	**$326.25**		
estimated yearly service hot water cost:	**$205.64**		
	$4,239.85		
estimated yearly utility cost per sq. foot:	**$0.71**		

Notes:

1. Cooling Tower, or Evaporation Cooler, Water to Air Heat Pumps, Energy Recovery Units, Existing Heating Hot Water Boilers, Supplemental Electric Perimeter Heat, up to 44 zones.
2. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
3. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
4. The conversion of btu/month to kW-hr cost is calculated by multiplying the btu/month value by 0.000293 (standard multiplier for converting btu to to kW-hr) and finally multiplying by the cost per kW-hr ($0.057).
5. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
6. Ventilation air and return air quantities were assumed for this study based on exhaust rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
7. Heat provided by new water to air heat pumps.

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	Water/Air sensible cooling load (btuh)	Water/Air total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	Water/Air sensible heating load (btuh)	Water/Air total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	64064	149	21227	305662	373261	22395636
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	62146	136	19096	274984	339884	20393062
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	58381	110	14913	214744	274346	16460736
april	83.3	23.5	50.4	44.5	33	217335	139	0	2008	82840.7258	3313629	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	221309	4114	0	59236	145102.5611	5804102	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	224621	7425	3373	155503	196987.4239	7879497	0	0	0	0	0	0
july	97	55	75.9	68.5	92	226224	9029	6432	222641	222110.6206	8884425	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	225527	8332	1626	143385	211187.4916	8447500	0	0	0	0	0	0
september	89.5	37	64	54.7	46	222076	4881	0	70280	157118.003	6284720	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	218555	1360	0	19578	101956.2016	4078248	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	57754	105	14216	204704	263422	15805348
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	62216	136	19174	276100	341098	20465883
											30 min./hr see note 6						30 min./hr see note 6

	cooling				heating					heat rejection to space					
month	ventilation unit fans operating cost (month)	hplp operating cost (month)	Water/Air Heat Pump operating cost (month)	Water/Water HP operating cost (month)	hplp operating cost (month)	boiler operating cost (month)	ventilation unit fans operating cost (month)	Water/Air Heat Pump operating cost (month)	Water/Water HP operating cost (month)	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	0	0	38	115	5	75	69	60307	4,824,568	20,349	1,627,920.00	12826	1026088
february	0	0	0	0	34	105	5	69	63	60307	4,824,568	20,349	1,627,920.00	12826	1026088
march	0	0	0	0	28	84	4	55	51	60307	4,824,568	20,349	1,627,920.00	12826	1026088
april	0	11	28	10	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
may	1	19	48	18	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
june	3	26	66	24	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
july	4	30	74	27	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
august	2	28	71	26	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
september	1	21	53	19	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
october	0	14	34	13	0	0	0	0	0	60307	4,824,568	20,349	1,627,920.00	12826	1026088
november	0	0	0	0	27	81	3	53	49	60307	4,824,568	20,349	1,627,920.00	12826	1026088
december	0	0	0	0	34	105	5	69	63	60307	4,824,568	20,349	1,627,920.00	12826	1026088
	$11	$150	$373	$138	$160	$490	$21	$321	$294 see note 8		$966.90		$326.25		$205.64

Net Occupiable Building Area: 5,950 sq. ft.

estimated project cost: $ 1,494,733

electrical cost per kWh: $ 0.05700 City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.

estimated yearly maintenance cost: $ 2,878

estimated yearly HVAC electrical load (kWh): 46,903

estimated yearly HVAC electrical utility cost: $1,174.67
estimated yearly gas cost: $490.34 637 therm $0.77 / therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost: $966.90
estimated yearly plug load cost: $326.25
estimated yearly service hot water cost: $205.64
$3,163.81

estimated yearly utility cost per sq. foot: $0.53

Notes:

1. Geothermal Loop Field (Heat Sink), Water-to-Water Heat Pumps, Terminal Chilled/Hot Water Units, Water to Air Heat Pumps, Energy Recovery Units, Existing Heating Hot Water Boilers, Supplemental Electric Perimeter Heat, up to 44 zones.
2. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
3. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy inparted to inside the building.
4. The conversion of btu/month to kW-hr cost is calculated by multiplying the btu/month value by 0.000293 (standard multiplier for converting btu to to kW-hr) and finally multiplying by the cost per kW-hr ($0.057).
5. Hours of operation assumed @ 20 hours/week, 4 weeks/month equaling 80 hours/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the Art Center & Museum Building.
6. The water/water heat pump & water/air heat pump connected to geothermal are assumed to run 30 muniters per hour which equals 12 hours per day.
7. Ventilation air and return air quantities were assumed for this study based on exhaust rates from IMC 2012.
   Ventilation air Ratio = 0.06
   Return air Ratio = 1.00-0.06 (ventilation air ratio) = 0.94
8. Heat provided by new water to water heat pumps.

Option 1A: Variable Refrigerant Flow (VRF), Reuse existing Hot Water Boilers and Pumps

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
-INSTALL-				
Variable Refrigerant Flow (Lossnay, Refrigerant Piping, Controls, Test & Training Included)	30	TON	$6,500.00	$195,000.00
VRF Installation Cost	1	LUMP	$90,000.00	$90,000.00
Energy Recovery Unit (2000 CFM Outside Air)	2	EACH	$13,500.00	$27,000.00
Humidifier	6	EACH	$1,000.00	$6,000.00
Central Dehumidifier (Located in parallel w/ ERV)	2	EACH	$11,000.00	$22,000.00
Point-of-Use Dehumidifier (3 for each building)	6	EACH	$6,500.00	$39,000.00
Miscellaneous Piping (Condensate Drain & domestic for humidifier)	1800	L.F.	$40.00	$72,000.00
Piping Insulation	1800	L.F.	$20.00	$36,000.00
New Ventilation Ductwork	7000	LBS.	$22.00	$154,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$12.00	$84,000.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC Controls - Extra outside of VRF	1	LUMP	$60,000.00	$60,000.00
Test and Balance - Equipment	1	LUMP	$10,000.00	$10,000.00
-DEMO-				
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$897,186.50

ELECTRICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$8,800	$8,800
			TOTAL	$55,300

	Mechanical and Electrical Total Cost	$952,486.50
	Labor Adjustment for Remodel of Office (40%)*	$380,994.60
	TOTAL	$1,333,481.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

Option 1AA: Variable Refrigerant Flow (VRF), Reuse existing Hot Water Boilers and Pumps; Reduced Humidity Control to one room.

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
-INSTALL-				
Variable Refrigerant Flow (Lossnay, Refrigerant Piping, Controls, Test & Training Included)	30	TON	$6,500.00	$195,000.00
VRF Installation Cost	1	LUMP	$90,000.00	$90,000.00
Energy Recovery Unit (2000 CFM Outside Air)	2	EACH	$13,500.00	$27,000.00
Humidifier	1	EACH	$1,000.00	$1,000.00
Central Dehumidifier (Located in parallel w/ ERV)	2	EACH	$11,000.00	$22,000.00
Point-of-Use Dehumidifier (in special area with stored works)	1	EACH	$6,500.00	$6,500.00
Miscellaneous Piping (Condensate Drain & domestic for humidifier)	360	L.F.	$40.00	$14,400.00
Piping Insulation	360	L.F.	$20.00	$7,200.00
New Ventilation Ductwork	7000	LBS.	$22.00	$154,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$12.00	$84,000.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC Controls - Extra outside of VRF	1	LUMP	$30,000.00	$30,000.00
Test and Balance - Equipment	1	LUMP	$10,000.00	$10,000.00
-DEMO-				
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$743,286.50

ELECTRICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$8,800	$8,800
			TOTAL	$55,300

Mechanical and Electrical Total Cost	$798,586.50
Labor Adjustment for Remodel of Office (40%)*	$319,434.60
TOTAL	$1,118,021.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

Option 1B: Variable Refrigerant Flow Connected to Geothermal Loop Field, Reuse existing Hot Water Boilers & Pumps

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	QUANTITY	UNITS	COST PER	COSTS
-INSTALL-				
Soil Conductivity Test, results tell if Geo Field is feasible	1	EACH	$8,000.00	$8,000.00
Geothermal Loop Field	30	TON	$2,600.00	$78,000.00
Geothermal Loop Vault for Piping	1	EACH	$16,000.00	$16,000.00
Geothermal Loop Circulating Pumps, 2 H.P.	2	EACH	$3,175.00	$6,350.00
Geothermal Loop Circ. Pump VFDs, 2 H.P.	2	EACH	$2,200.00	$4,400.00
Hydraulic Separator	1	EACH	$9,500.00	$9,500.00
Variable Refrigerant Flow (Lossnay, Refrigerant Piping, Controls, Test & Training Included)	30	TON	$6,000.00	$180,000.00
VRF Installation Cost	1	LUMP	$90,000.00	$90,000.00
Energy Recovery Unit	2	EACH	$13,500.00	$27,000.00
Humidifier	6	EACH	$1,000.00	$6,000.00
Central Dehumidifier	2	EACH	$11,000.00	$22,000.00
Point-of-Use Dehumidifier (3 in each building)	6	EACH	$6,500.00	$39,000.00
HPLP Piping	1	LUMP	$15,000.00	$15,000.00
HPLP Piping Insulation	1500	L.F.	$5.25	$7,875.00
Miscellaneous Piping (Condensate Drain & domestic piping for humidifier)	1800	L.F.	$40.00	$72,000.00
Piping Insulation	1800	L.F.	$20.00	$36,000.00
New Ventilation Ductwork	7000	LBS.	$22.00	$154,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$12.00	$84,000.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC Controls - Extra outside of VRF	1	LUMP	$55,000.00	$55,000.00
Test and Balance - Equipment	1	LUMP	$15,000.00	$15,000.00
-DEMO-				$0.00
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$1,027,311.50

ELECTRICAL				
ITEM	QUANTITY	UNITS	COST PER	COSTS
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$10,800	$10,800
			TOTAL	$57,300

Mechanical and Electrical Total Cost	$1,084,611.50
Labor Adjustment for Remodel of Office (40%)*	$433,844.60
TOTAL	$1,518,456.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

Option 1BB: Variable Refrigerant Flow Connected to Geothermal Loop Field, Reuse existing Hot Water Boilers & Pumps
Reduced Humidity Control to one room

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	QUANTITY	UNITS	COST PER	COSTS
-INSTALL-				
Soil Conductivity Test, results tell if Geo Field is feasible	1	EACH	$8,000.00	$8,000.00
Geothermal Loop Field	30	TON	$2,600.00	$78,000.00
Geothermal Loop Vault for Piping	1	EACH	$16,000.00	$16,000.00
Geothermal Loop Circulating Pumps, 2 H.P.	2	EACH	$3,175.00	$6,350.00
Geothermal Loop Circ. Pump VFDs, 2 H.P.	2	EACH	$2,200.00	$4,400.00
Hydraulic Separator	1	EACH	$9,500.00	$9,500.00
Variable Refrigerant Flow (Lossnay, Refrigerant Piping, Controls, Test & Training Included)	30	TON	$6,000.00	$180,000.00
VRF Installation Cost	1	LUMP	$90,000.00	$90,000.00
Energy Recovery Unit	2	EACH	$13,500.00	$27,000.00
Humidifier	1	EACH	$1,000.00	$1,000.00
Central Dehumidifier	2	EACH	$11,000.00	$22,000.00
Point-of-Use Dehumidifier (in special area with stored works)	1	EACH	$6,500.00	$6,500.00
HPLP Piping	1	LUMP	$15,000.00	$15,000.00
HPLP Piping Insulation	1500	L.F.	$5.25	$7,875.00
Miscellaneous Piping (Condensate Drain & domestic piping for humidifier)	360	L.F.	$40.00	$14,400.00
Piping Insulation	360	L.F.	$20.00	$7,200.00
New Ventilation Ductwork	7000	LBS.	$22.00	$154,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$12.00	$84,000.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC Controls - Extra outside of VRF	1	LUMP	$40,000.00	$40,000.00
Test and Balance - Equipment	1	LUMP	$15,000.00	$15,000.00
-DEMO-				$0.00
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$888,411.50

ELECTRICAL				
ITEM	QUANTITY	UNITS	COST PER	COSTS
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$10,800	$10,800
			TOTAL	$57,300

Mechanical and Electrical Total Cost	$945,711.50
Labor Adjustment for Remodel of Office (40%)*	$378,284.60
TOTAL	$1,323,996.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

Option 2A: New Water-to-Air Heat Pumps, Cooling Tower, Reuse Existing Boilers and Hot Water Pumps

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
-INSTALL-				
Loop Circulating Pumps (225 GPM 5 H.P.)	2	EACH	$4,125.00	$8,250.00
VFD for Loop Pumps (5 H.P.)	2	EACH	$3,700.00	$7,400.00
Booster Circulating Pumps for Heat Pumps (1/8 H.P.)	6	EACH	$1,200.00	$7,200.00
Grade Mounted Cooling Tower (30 Tons)	1	EACH	$40,000.00	$40,000.00
Heat Exchanger (Shell-Type, Liquid-to-Liquid 75 GPM)	1	EACH	$12,000.00	$12,000.00
Dirt/Air Separators	2	EACH	$2,450.00	$4,900.00
Water to Air Heat Pumps	10	EACH	$10,000.00	$100,000.00
Supply & Return Duct for Water to Air Heat Pumps	1	LUMP	$40,000.00	$40,000.00
Multizone control system for heat pump	6	EACH	$5,000.00	$30,000.00
Water to Water Heat Exchanger	1	EACH	$12,000.00	$12,000.00
Humidifier	6	EACH	$1,000.00	$6,000.00
Slipstream Dehumidifier for ventilation air	2	EACH	$11,000.00	$22,000.00
Point-of-Use Dehumidifier	6	EACH	$6,500.00	$39,000.00
New Filtration	6	EACH	$455.00	$2,730.00
Energy Recovery Ventilator/DOAS	2	EACH	$13,500.00	$27,000.00
New Ventilation Ductwork	7000	LBS.	$22.00	$154,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$12.00	$84,000.00
HPLP Piping	1	LUMP	$35,000.00	$35,000.00
HPLP Insulation	2500	L.F.	$5.25	$13,125.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC/Demand Control Ventilation	1	LUMP	$115,000.00	$115,000.00
Test and Balance - Equipment	1	LUMP	$20,000.00	$20,000.00
Crane Time	1	LUMP	$5,000.00	$5,000.00
-DEMO-				$0.00
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$886,791.50

ELECTRICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$17,000	$17,000
			TOTAL	$ 63,500

Mechanical and Electrical Total Cost		$950,292
Labor Adjustment for Remodel (40%)*		$380,116.60
	TOTAL	$1,330,408.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

Option 2B: Geothermal Loop Field, New Water-to-Water Heat Pumps, Heating/Cooling Units, Reuse existing Boilers

Building Area (ft^2)	7,000
Net occupiable Building Area (ft^2)	5,950
Total Cooling Load (tons)	29.75
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
-INSTALL-				
Soil Conductivity Test, results tell if Geo Field is feasible	1	EACH	$8,000.00	$8,000.00
Geothermal Loop Field	30	TON	$2,600.00	$78,000.00
Geothermal Vault for Piping Header	1	EACH	$16,000.00	$16,000.00
Loop Circulating Pumps (105 GPM 2 H.P.)	2	EACH	$3,175.00	$6,350.00
VFD for Loop Pumps (2 H.P.)	2	EACH	$2,200.00	$4,400.00
Hydraulic Separator	1	EACH	$9,500.00	$9,500.00
Dirt/Air Separators	2	EACH	$2,450.00	$4,900.00
Fan Coil Unit (20 1 ton unit, 5 2 ton unit)	1	LUMP	$31,750.00	$31,750.00
Water to Water Heat Pumps (10 ton)	3	EACH	$18,000.00	$54,000.00
Circulating Pumps (Load Side of Heat Pumps)	2	EACH	$3,175.00	$6,350.00
VFD for Loop Pumps (2 H.P.)	2	EACH	$2,200.00	$4,400.00
Humidifier	2	EACH	$1,000.00	$2,000.00
Central Humidifier	2	EACH	$11,000.00	$22,000.00
Slipstream Dehumidifier for ventilation air	2	EACH	$1,375.00	$2,750.00
Point-of-Use Dehumidifier (3 in each building)	6	EACH	$6,500.00	$39,000.00
New Filtration	6	EACH	$455.00	$2,730.00
Energy Recovery Ventilator/DOAS	2	EACH	$13,500.00	$27,000.00
New Ventilation Ductwork	7000	LBS.	$11.00	$77,000.00
New Ventilation Ductwork Insulation	7000	S.F.	$3.20	$22,400.00
HPLP Piping	1	LUMP	$25,000.00	$25,000.00
HPLP Insulation	1500	L.F.	$5.25	$7,875.00
Miscellaneous Piping (Condensate and domestic piping for humidifier)	1800	L.F.	$20.00	$36,000.00
Piping Insulation	1800	L.F.	$10.00	$18,000.00
Chilled Water Piping	1	LUMP	$107,887.50	$107,887.50
Chilled Water Piping Insulation	1	LUMP	$17,400.00	$17,400.00
Heating Hot Water Piping	1	LUMP	$107,887.50	$107,887.50
Heating Hot Water Piping Insulation	1	LUMP	$17,400.00	$17,400.00
Water Heater (40 gallon, Electric)	3	EACH	$1,875.00	$5,625.00
Fire Protection System	1	LUMP	$60,000.00	$60,000.00
-SPECIAL DESIGN CRITERIA-				
Special Exhibit Shielding	1	LUMP	$15,000.00	$15,000.00
-TEMPORARY UNIT-				
Temporary HVAC Unit	1	LUMP	$8,000.00	$8,000.00
DDC/Demand Control Ventilation	1	LUMP	$115,000.00	$115,000.00
Test and Balance - Equipment	1	LUMP	$30,000.00	$30,000.00
-DEMO-				
AHU-1, 2 & 3	3	EACH	$770.00	$2,310.00
Condensing Unit/Fluid Cooler for AHU-1, 2 & 3	1	EACH	$3,075.00	$3,075.00
Furnaces serving Art Center (front of building)	3	EACH	$740.00	$2,220.00
Condensing Units for Art Center Furnaces	3	EACH	$980.00	$2,940.00
Rooftop Unit serving Linkage between Art Center & Museum	1	EACH	$875.00	$875.00
Humidifiers	6	EACH	$116.00	$696.00
Water Heater (40 gallon)	3	EACH	$112.00	$336.00
Window Air Conditioner	1	EACH	$34.50	$34.50
Diffusers	50	EACH	$21.50	$1,075.00
			TOTAL	$1,003,168.50

ELECTRICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Demolition: Disconnect existing HVAC equipment, disconnect and remove switches, motor starters, raceways, and wiring.	20	EACH	$150	$3,000
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$19,500	$19,500
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Back-feed exisitng electrical service	1	LUMP	$1,200	$1,200
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeders to HVAC equipment, connections to HVAC equipment, disconnect switches at HVAC equipment	1	LUMP	$18,000	$18,000
			TOTAL	$ 64,500

Mechanical and Electrical Total Cost	$1,067,667
Labor Adjustment for Remodel (40%)*	$427,066.60
TOTAL	$1,494,733.10

SEPARATE DISCIPLINE

-WINDOW REPLACEMENT-				
Efficient Windows for Gallery & Carriage House	1	LUMP	$219,050.00	$219,050.00

*The 40% labor adjustment is included to convey the difficulty of working in the Art Museum/Musser House, while maintaining historical relevance of the building and allowing the building to stay operational during construction. To implement an upgraded HVAC system in the building will most certainly uncover unforseen issues, the 40% labor adjustment is an attempt to include costs for unforseen issues.

City of Muscatine Art Center and Museum Energy HVAC Study - System Options
#201310.00

Option 1A Summary	
Mechanical & Electrical Total Cost Estimate	$1,333,481.00
Mechanical & Electrical Total Cost Estimate - 30% (1)	$933,436.70
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,733,525.30

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Option 1AA Summary	
Mechanical & Electrical Total Cost Estimate	$1,118,021.00
Mechanical & Electrical Total Cost Estimate - 30% (1)	$782,614.70
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,453,427.30

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Option 1B Summary	
Mechanical & Electrical Total Cost Estimate	$1,518,456.10
Mechanical & Electrical Total Cost Estimate - 30% (1)	$1,062,919.27
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,973,992.93

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Option 1BB Summary	
Mechanical & Electrical Total Cost Estimate	$1,323,996.10
Mechanical & Electrical Total Cost Estimate - 30% (1)	$926,797.27
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,721,194.93

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Option 2A Summary	
Mechanical & Electrical Total Cost Estimate	$1,330,408.10
Mechanical & Electrical Total Cost Estimate - 30% (1)	$931,285.67
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,729,530.53

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Option 2B Summary	
Mechanical & Electrical Total Cost Estimate	$1,494,733.10
Mechanical & Electrical Total Cost Estimate - 30% (1)	$1,046,313.17
Mechanical & Electrical Total Cost Estimate + 30% (2)	$1,943,153.03

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

Window Replacement Summary	
Window Replacement Total Cost (3)	$219,050.00
Window Total Cost Estimate - 30% (1)	$153,335.00
Window Total Cost Estimate + 30% (2)	$284,765.00

1. Using the total cost estimate minus (-) 30% allows a low-end range final cost, which could come up from unforeseen changes to design (less demolition, reuse equipment, easier way to accomplish a goal).

2. Using the total cost estimate plus (+) 30% allows a high-end range final cost, which could come up from unforeseen changes to design (more demolition, inflation, difficult working conditions).

3. Total cost for window replacement is based on $65 per square foot of building face.

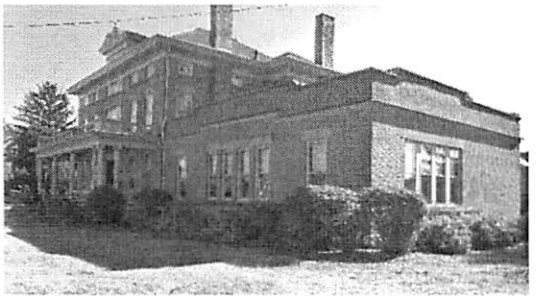
EXECUTIVE SUMMARY

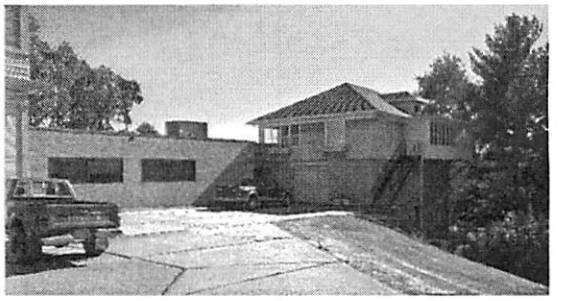
This section of the report focuses on the implications of energy conservation measures which are architectural in nature as well as their potential impact on the historic character of the buildings that comprise the art center complex. While the Muscatine Art Center is not currently listed on the National Register of Historic Places (NRHP) nor has it recently been determined by the State Historic Preservation Office (SHPO) as eligible for listing on the (NRHP) it appears, in my opinion, to hold potential for such listing. This potential should be further investigated by the City in consultation with the State Historic Preservation Office. NRHP eligibility or listing could benefit current and future rehabilitation projects completed on historic resources at this site.

Based on the observed sound and stable condition of materials in the historic portions of the facility no recommendations for architectural energy conservation measures are made at this time. It is important to note that work anywhere on the site or on building additions that are not deemed to be historic may adversely impact the historic elements at this site. Therefore, it is recommended that all work conform to the Secretary of the Interior's Standards for Rehabilitation as a means of protecting the historic qualities the site holds. In reality this approach should have little impact on the types of work or detailing of work implemented on the contemporary additions.

Summary Conclusions

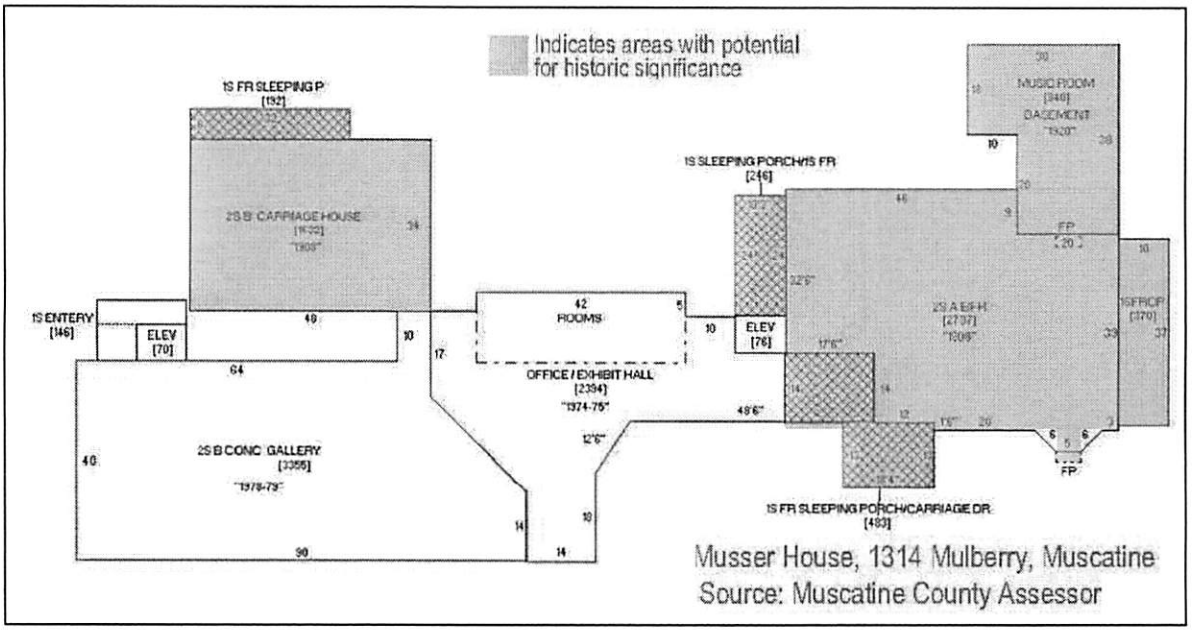
- Pursue a determination of eligibility for listing the site on the National Register of Historic Places.
- To preserve eligibility of the site for listing on the National Register of Historic Places and any benefits that may be derived from that listing, all work should conform to the Secretary of the Interior's Standards for Rehabilitation regardless of the era of original building construction.
- Retain and maintain windows in the historic buildings.
- Replace deteriorated and underperforming windows in the newer additions.
- When evaluating options consider not only life cycle and operational costs/savings but also to what extent the treatment impacts existing historic fabric and overall historic integrity and character.





NATIONAL REGISTER ELIGIBILITY CONSIDERATION

Existing construction is characterized by two distinct eras. The original Musser House and its detached Carriage House date to ca 1908 while the Art Gallery, Offices and Exhibit Hall are mid to late 1970 construction. The original house and carriage house are believed to be potentially NRHP eligible and should be further evaluated by a qualified architectural historian. Listing on the NRHP brings opportunities for financial assistance and recognition in the community as an important link to the development of Muscatine. The following diagram delineates construction associated with these two distinct eras.



To assist building owners with efforts to secure a determination of eligibility for listing property on the NRHP the state offers a grant program which I recommend the city of Muscatine pursue. The grant is called a Technical Advisory Network (TAN) grant. The application process involves only a phone call to the grant's administrator (contact information provided below) to provide her a brief description of the project's goal. The goal in this instance is to be provided with necessary assistance to gather and provide sufficient documentation to SHPO staff so they may make a determination of NRHP eligibility for the site.

TAN grant application contact information:

Vander Molen, Kristen [DCA]
State Historical Society of Iowa
Grants Manager

(515) 281-4228 Work
Kristen.VanderMolen@iowa.gov

600 East Locust
Des Moines, IA 50319-0290

Once an initial determination of eligibility is provided by SHPO you can decide if the next step of actually having the building NRHP listed is desirable. Some grants require only a determination of eligibility, additional grants may be available to properties that are actually listed. There are also grants available to help with costs of preparing National Register Nominations.

POTENTIAL ENERGY CONSERVATION MEASURES – ARCHITECTURAL IN NATURE

Possible energy conservation measures (ECM) that are architectural in nature and which may be accomplished without adverse impact on fabric that helps define the character of the historic buildings and setting are virtually nonexistent in the older areas of construction (ca 1908). Work on the building envelope of the newer buildings (ca 1970) will not adversely impact the historic structure if completed in accordance with the Secretary of the Interior's Standards. Even so the only suggestion made for the newer building areas is to consider upgrading the windows.

WINDOWS AND INTERIOR FINISHES – CIRCA 1908 CONSTRUCTION AREAS

Windows are critical architectural elements that define historic character making retention the preferred treatment. Based on a sampling of existing windows the primary sash, frames and trim as well as storm windows were observed to be in very good condition, appropriately treated to minimize air infiltration, well maintained and secure. Because of this the windows do not meet the minimum requirements allowing for replacement under the guidelines of the Secretary of the Interior's Rehabilitation Standards. Therefore, the recommendation is made to continue to maintain the historic windows and storm windows. Historic windows that are properly maintained and in good working order have been found to be as efficient as many modern replacement windows which due largely to inferior workmanship and materials may not out last a well maintained historic window unit. When repairs are necessary to the historic sash they should be completed in conformance with recommendations of National Park Service Technical Preservation Service's Preservation Brief 9 *The Repair of Historic Wooden Windows*. This document is available at http://www.nps.gov/tps/how-to-preserve/briefs/9-wooden-windows.htm.

Replacement of the current windows will adversely impact historic character and is likely to make the building ineligible for the NRHP. Similarly the interior finishes are intact and well maintained so there is no advantage to considering ECMs since such improvements will disrupt or alter those finishes and thus jeopardize NRHP eligibility. In conclusion, the report recommends that no changes be made to architectural features of the historic building areas as do so will adversely impact intact and sound historic fabric and the building's potential eligibility for listing on the NRHP.

WINDOWS AND INTERIOR FINISHES – CIRCA 1970 CONSTRUCTION AREAS

Several windows at the newer additions were found to be in disrepair and replacement is suggested as a way to correct the deficiencies and to upgrade the window systems to contemporary levels of energy efficiency. This includes both better framing systems and better performing glass. For estimating purposes such systems can run in the $60-65/sf range for installed systems.

Alterations to improve thermal performance of exterior walls or roofs were not included in the scope of this study. It is unlikely that any such alteration would adversely impact the potential eligibility of the older construction particularly if not visible from the exterior.

REHABILITATION STANDARDS AND PROJECT IMPLEMENTATION

Work completed on properties listed on the National Register of Historic Places must conform to the guidelines of the Secretary of the Interior's Standards for Rehabilitation (Standards) to maintain eligibility for that listing and the associated benefits of such listing including eligibility for grants and financial assistance not available to buildings not listed or determined eligible for listing.

The Standards (Attachment 1) provide guidance for rehabilitation treatments which retain and protect historic materials (fabric) thus protecting the character of the resource so its historic significance is not

diminished. The National Park Service (NPS) publishes a series of useful Preservation Briefs (Attachment 2) which provide detailed discussions of appropriate treatments for historic buildings and materials including specific discussion on the subject of windows. Each of these documents is used as a basis for suggested remedial work proposed in this study.

STATE TAX CREDIT REHABILITATION INCENTIVE PROGRAM

Buildings determined eligible for listing on the National Register of Historic Places and those that are listed are eligible to participate in this program. However, ownership structure also plays a significant role in eligibility for this program and other available grant dollars making exploration of that element a critical piece of any initial planning. For example, Iowa has a preservation tax credit incentive program (*The State Historic Preservation and Cultural & Entertainment District Tax Credit Program*) which although not directly available to a government agency is available to and currently utilized by non-profit groups charged with "management" of historic property owned by a government agency. This has been accomplished through a structuring agreement establishing the non-profit as an authorized agent for the government agency. Through this partnership the incentive program helps participants recover rehabilitation costs of historic properties by providing a fully refundable tax credit equal to 25% of qualified rehabilitation costs incurred on a project. Such a procedure requires professional legal and tax guidance beyond the scope of this report and the expertise of the report's authors.

For more information on the state tax credit programs see:

> http://www.iowahistory.org/historic-preservation/index.html under the "Tax Incentives for Rehabilitation" link or contact Elizabeth (Beth) Foster Hill, Tax Incentive Programs Manager/National Register Coordinator, at (515) 281-4137 or Beth.Foster@iowa.gov.

The state also has other grant opportunities which may be utilized for planning or actual construction. For additional information on these grants contact:

> Kristen Vander Molen, Grants Manager
> Phone: (515) 281-4228
> E-mail: kristen.vandermolen@iowa.gov

The National Trust for Historic Preservation has several project planning grants that could be utilized to further develop the project.

> National Trust for Historic Preservation, Midwest Office
> Phone: (312) 939-5547
> http://www.preservationnation.org/resources/find-funding/deadlines-and-special-programs.html
> E-mail: grants@nthp.org

The Secretary of the Interior's Standards for Rehabilitation[1]

The Secretary of the Interior's Standards for Rehabilitation are ten basic principles created to help preserve the distinctive character of a historic building and its site, while allowing for reasonable change to meet new needs.

The Standards (**36 CFR Part 67**) apply to historic buildings of all periods, styles, types, materials, and sizes. They apply to both the exterior and the interior of historic buildings. The Standards also encompass related landscape features and the building's site and environment as well as attached, adjacent, or related new construction.

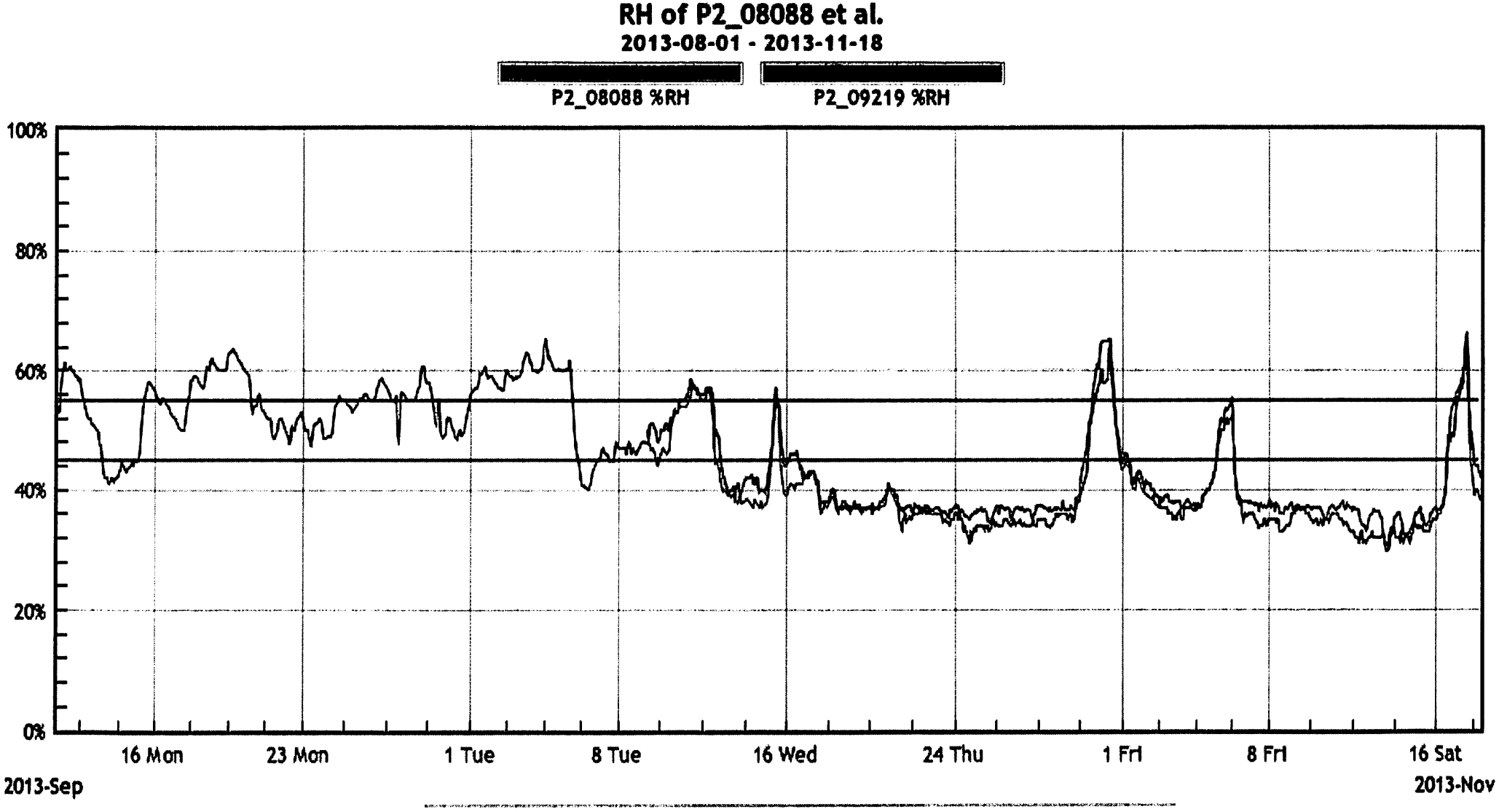
The Standards are applied to projects in a reasonable manner, taking into consideration economic and technical feasibility.

1. A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment.
2. The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of features and spaces that characterize a property shall be avoided.
3. Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or architectural elements from other buildings, shall not be undertaken.
4. Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.
5. Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a historic property shall be preserved.
6. Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.
7. Chemical or physical treatments, such as sandblasting, that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the gentlest means possible.
8. Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.
9. New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.
10. New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

National Park Service Preservation Briefs

Hard copies of the Preservation Briefs may be purchased from the Government Printing Office or viewed on line at http://www.nps.gov/histoy/hps/tps/briefs/presbhom.htm.

1. The Cleaning and Waterproof Coating of Masonry Buildings
2. Repointing Mortar Joints in Historic Brick Buildings
3. Conserving Energy in Historic Buildings
4. Roofing for Historic Buildings
5. Preservation of Historic Adobe Buildings
6. Dangers of Abrasive Cleaning to Historic Buildings
7. The Preservation of Historic Glazed Architectural Terra-Cotta
8. Aluminum and Vinyl Siding on Historic Woodwork
9. The Repair of Historic Wooden Windows
10. Exterior Paint Problems on Historic Woodwork
11. Rehabilitating Historic Storefronts
12. The Preservation of Historic Pigmented Structural Glass
13. The Repair and Thermal Upgrading of Historic Steel Windows
14. New Exterior Additions to Historic Buildings: Preservation Concerns
15. Preservation of Historic Concrete: Problems and General Approaches
16. The Use of Substitute Materials on Historic Building Exteriors
17. Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character
18. Rehabilitating Interiors in Historic Buildings: Identifying Character-Defining Elements
19. The Repair and Replacement of Historic Wooden Shingle Roofs
20. The Preservation of Historic Barns
21. Repairing Historic Flat Plaster – Walls and Ceilings
22. The Preservation and Repair of Historic Stucco
23. Preserving Historic Ornamental Plaster
24. Heating, Ventilating, & Cooling Historic Buildings: Problems & Recommended Approaches
25. The Preservation of Historic Signs
26. The Preservation and Repair of Historic Log Buildings
27. The Maintenance & Repair of Architectural Cast Iron
28. Painting Historic Interiors
29. The Repair, Replacement, and Maintenance of Historic Slate Roofs
30. The Preservation and Repair of Historic Clay Tile Roofs
31. Mothballing Historic Buildings
32. Making Historic Properties Accessible
33. The Preservation and Repair of Historic Stained and Leaded Glass
34. Applied Decoration for Historic Interiors: Preserving Composition Ornament
35. Understanding Old Buildings
36. Protecting Cultural Landscapes
37. Appropriate Methods for Reducing Lead-Paint Hazards in Historic Housing
38. Removing Graffiti from Historic Masonry
39. Holding the Line: Controlling Unwanted Moisture in Historic Buildings
40. Preserving Historic Ceramic Tile Floors
41. The Seismic Retrofit of Historic Buildings: Keeping Preservation in the Forefront
42. The Maintenance, Repair and Replacement of Historic Cast Stone
43. The Preparation and Use of Historic Structures Reports
44. The Use of Awnings on Historic Buildings: Repair, Replacement and New Design
45. Preserving Historic Wooden Porches
46. The Preservation and Reuse of Historic Gas Stations
47. Maintaining the Exterior of Small and Medium Size Historic Buildings



Joe Lomheim

To: Vic Amoroso
Subject: RE: Graph of RH of P2_08088 et al.--#201310.00

From: Hill, Randy [mailto:rhill@muscatineiowa.gov]
Sent: Tuesday, November 26, 2013 2:43 PM
To: Vic Amoroso
Subject: Fwd: Graph of RH of P2_08088 et al.--#201310.00

---------- Forwarded message ----------
From: **eClimatenotebook** <info@eclimatenotebook.com>
Date: Thu, Nov 21, 2013 at 10:53 AM
Subject: Graph of RH of P2_08088 et al.
To: rhill@muscatineiowa.gov

P2_08088

Min % RH: 29
Max % RH: 68
Mean % RH: 46
Median % RH: 44
Stdev % RH: 9

P2_08088

Min % RH: 29
Max % RH: 68
Mean % RH: 46
Median % RH: 44
Stdev % RH: 9

P2_09219

Min % RH: 30
Max % RH: 64
Mean % RH: 40
Median % RH: 37
Stdev % RH: 7

P2_09219

Min % RH: 30
Max % RH: 64
Mean % RH: 40
Median % RH: 37
Stdev % RH: 7

Joe Lomheim

To: Vic Amoroso
Subject: RE: Muscatine Art Center--#201310.00 Humidity Levels

From: Alexander, Melanie [mailto:malexander@muscatineiowa.gov]
Sent: Monday, December 02, 2013 3:23 PM
To: Vic Amoroso
Subject: Re: Muscatine Art Center--#201310.00 Humidity Levels

Just to clarify - on humidity +-5% is the requirement for many traveling exhibitions which are displayed in the Stanley Gallery. The general baseline is 50%. I think we could make some allowances for seasonal changes such as shifting to +-5% with a baseline of 45 in the winter and +-5 with a baseline of 55 in the summer. The trick will be to have better control so to limit rapid spikes. We may on occasion bring in traveling shows with more strict requirements which is why it would be nice to be able to control at +-2%, but that would not be a standard setting.

The two most important areas to address first are the Stanley Gallery and the 1908 house. The linkage does not house very many works of art. The carriage house is where collections are stored and, yes, it needs to be humidity and temperature controlled as well. However, this area may need to be addressed later as there are other problems with storing collections in the carriage house. Randy and I discussed very briefly that perhaps the plan for improved HVAC for the Art Center will need to be phased in over a period of years. If this is the case, the Stanley Gallery would be first on my list, followed by the 1908 house.

On Mon, Dec 2, 2013 at 11:14 AM, Vic Amoroso <vic@ajengineers.net> wrote:

Melanie;

Thanks for the information. We will incorporate the humidity reading information in our final revision of the study we are working on to finish.

Vic Amoroso, A&J Associates

365 Beaver Kreek Centre B

North Liberty IA 52317

vic@ajengineers.net

319-626-4719 voice

319-626-4941 fax

From: Alexander, Melanie [mailto:malexander@muscatineiowa.gov]
Sent: Monday, December 02, 2013 9:19 AM
To: Vic Amoroso
Subject: Re: Muscatine Art Center--#201310.00 Humidity Levels

Hi Vic,

Thanks for your email. I have three devices that are taking readings. One is located in the middle level of the Stanley Gallery, another in the Musser house on the second floor, and the third in the carriage house - just outside of the "inner vault". The Stanley Gallery is in red - I started with that location so it goes back a few more weeks than the others. I can only look at two readings at a time without paying for a subscription to the website.

I added the black bars for 45-55% just so I could get a glance at the number of days we fall out side of those ranges. Ideally, we should be at +-2. The rapid change is a serious problem. Stanley Gallery is where we house traveling shows which often have tight requirements. For example, I have been looking at an exhibition that has set +-5%. We will not be able to bring in that show - or many others - until the humidity level is under control.

If you are in Muscatine and want to take a look at the locations of the devices and the other functions of the website, just set up a time. I am in the office all week.

Thanks,

Melanie

On Wed, Nov 27, 2013 at 4:07 PM, Vic Amoroso <vic@ajengineers.net> wrote:

Melanie;

Good afternoon. I have attached the relative humidity reading graph that Randy Hill emailed me. I have a few questions for you. The answers will help us finish the current revision we are making to the HVAC Upgrade study for Art Center Museum.

1. Are the two readings taken at two different spots in the building?

2. Where are the humidity sensors located in the buildings?

3. Do you have any other readings in the buildings?

4. There are two horizontal black lines on the graph. I read 45% to 55% for the space bounded by the horizontal black lines. Am I reading the graph correctly?

5. Is the 45% to 55% range the humidity level control you want in the Art Center? In the Museum? In the Carriage House?

6. Do you need to have the humidity levels remain within this band in all spaces or a select few?

7. Are you concerned about the rapidity of change from low to high humidity? For instance I notice a change 35 % to 70% in two days.

Melanie, please call me if you have questions or comments about my list of questions.

Thanks, have a Happy Thanksgiving.

Vic Amoroso, A&J Associates

365 Beaver Kreek Centre B

North Liberty IA 52317

vic@ajengineers.net

319-626-4719 voice

319-626-4941 fax

City of Muscatine
City Administration Building
Muscatine, IA

Energy Conservation Study
A&J #201309.00

RECOMMENDATIONS

- The variable refrigerant flow (VRF) system without geothermal loop field (Option 1) is recommended for implementation at the City Administration Building.
- Geothermal loop field determined not feasible based on ground conditions discovered under the parking lot adjacent to the City Administration Building. The most significant concern is the underground storm sewer located under the parking lot.
- **VRF heat pump** system supplemental heat is provided by the recently upgraded hot water heating system.
- Window, vestibule and awning replacement for improved energy conservation and historic preservation.
- Perform envelope upgrades prior to HVAC upgrades to increase building efficiency.

DISCUSSION

- City Administration Building **is** eligible for Historic Preservation tax credits.
- **Projects** can be **phased** over a period of time or completed under **separate contracts**. Recommended upgrades do not need to be completed simultaneously to be effective. For example, the Administration Building window replacement and HVAC upgrades could be done as separate projects at separate times.
- **Upgraded HVAC** system will utilize and **connect** with existing/recently installed heating hot water **boiler system**.

- Outside weather conditions will limit when the windows can be replaced and vestibules can be installed.
- The inside VRF system can be installed any time during the year and while the facility is occupied.

COST PROJECTIONS

Architectural/Envelope Upgrades:

• All Upgrades	$ 529,000.00
• All Upgrades Less Tax Credit	$ 396,750.00

Option 1 HVAC Upgrades:

• High Cost of Range	$ 641,985.50
• Median Cost of Range	$ 513,588.40
• Low Cost of Range	$ 385,191.30

Combined HVAC and Architectural/Envelope Upgrades:

• High Cost of Range	$ 1,038,735.50
• Median Cost of Range	$ 910,338.40
• Low Cost of Range	$ 781,941.30

*Combined cost includes Rehabilitation Tax Credit.

Energy Conservation Study
City Administration Building
Muscatine, Iowa

A&J #201309.00
November 12, 2013
Revision #1

A&J Associates

I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Licensed Professional Engineer under the laws of the State of Iowa.

Printed or typed name
Victor Amoroso Jr.
Discipline - Mechanical Engineer
Reg. No. 10536 IA

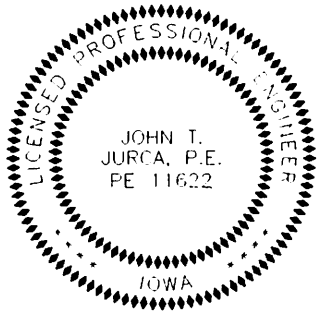
Victor Amoroso Jr.
Signature

My license renewal date is December 31, 2013.

Pages or sheets covered by this seal:
Entire Study

Date issued: _____

I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Licensed Professional Engineer under the laws of the State of Iowa.



Printed or typed name
John Jurca
Discipline - Electrical Engineer
Reg. No. 11622 IA

John T. Jurca
Signature

My license renewal date is December 31, 2014.

Pages or sheets covered by this seal:
Electrical Portions

Date issued: _____

STUDY

I. OBJECTIVES

A. Review existing heating, ventilation and air conditioning (HVAC) systems to determine what system modifications and upgrades would enhance system efficiencies and reliability of operation.

B. Evaluate different options using an American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Modified BIN Analysis and Life Cycle Cost Analysis techniques.

C. Currently, the Muscatine City Hall or Administration Building does not have permanent air conditioning that provides adequate cooling and de-humidification during the spring, summer and fall cooling seasons.

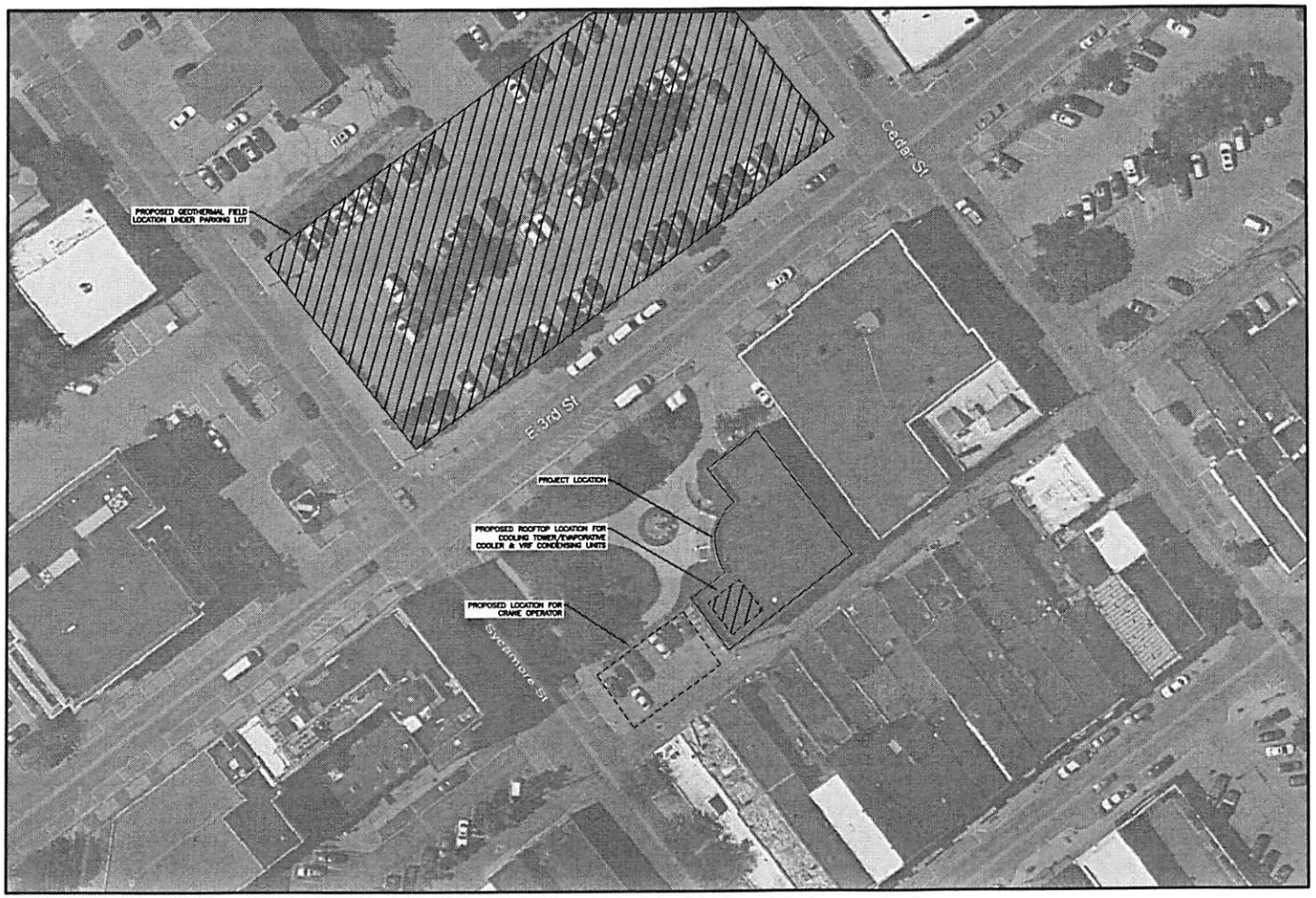
D. The Muscatine City Hall is located in the Mississippi River Valley in southeast Iowa. During the cooling season the normal high relative humidity levels in the locale cause uncomfortable conditions for the building occupants and have potential for moisture damage to the building.

E. The purposes of this study are the following:
   1. Evaluate the feasibility of adding geothermal heat pump system capability to the City Hall or adding a cooling/heating enhancement to the recently installed hot water heating system.
   2. If the addition of geothermal is possible provide a concept opinion of estimated costs for implementing the conversion of the existing HVAC systems to a geothermal heat pump system.
   3. Because of the current natural gas costs and future expectation of higher costs the City of Muscatine desires to switch to a non-gas based heating system as much as possible. Also the City of Muscatine benefits very positively, because the City is the utility supplying electricity.

F. Provide descriptions of alternative HVAC concepts.

G. Review HVAC options such as evaporative cooler assisted heat pumps and an air cooled variable refrigerant flow system.

H. Review building envelope replacement or upgrades.
   1. Primary focus is the exploration of the window rehabilitation or replacement to repair leaking and failing window and to return the historic character to the building façade.
   2. Secondary focus is the exploration of the window rehabilitation to enhance energy conservation.



A & J ASSOCIATES P.C.
mechanical & electrical engineers

365 beaver kreek centre suite b
north liberty, ia 52317
ajpceengineers.net (email)
319-626-4719 (voice) / 319-626-4941 (fax)

DESIGNED BY	ITEM	DATE	PROJECT TITLE	PROJECT NO.	DRAWING TITLE	DRAWING NO.
C. FINN	AERIAL VIEW		CITY OF MUSCATINE CITY HALL HVAC STUDY MUSCATINE, IA	A&J 20130900 PROJECT NO. OWNER	AERIAL VIEW	
CHECKED BY V. AMOROSO						

3. A third objective includes the energy improvement of the entry ways to the building, and the potential of adding historically relevant window awnings to provide shading for the windows.

II. EXISTING CONDITIONS

A. The City Administration Building is located at Third Street and Sycamore Street in Muscatine, Iowa.

B. Currently, there is no permanently fixed cooling capacity provided in City Hall. Temporary window air conditioners are added during the worst periods of the summer cooling season in some offices to provide "spot" cooling.

C. Ventilation is provided by opening windows in the individual rooms or spaces.

D. A new high efficient gas fired boiler and variable speed pumping hot water heating system was installed during the summer of 2012. The system used the existing cast iron radiators and fin tubes for heating and the existing steam and condensate piping for hot water distribution. The project was a steam heat to water heat conversion.

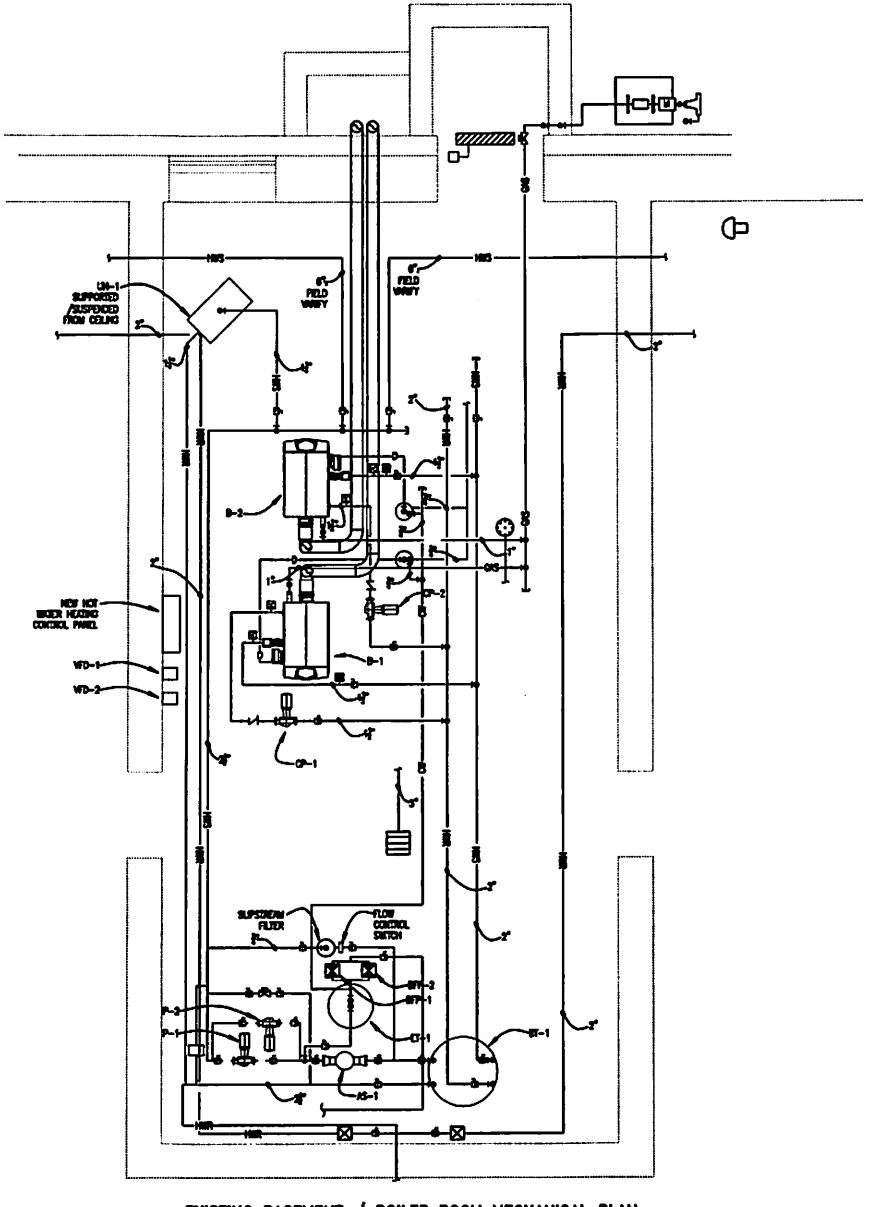
E. City Hall is supplied heating from a mechanical room located in the lower level. Refer to the attached drawings for the specific location. The boiler and pumps are located in this room.

F. Lighting and Lighting Control:
   1. No lighting change out or lighting control upgrades were evaluated in this study.

G. Domestic water heating:
   1. No changes to the domestic water heating components were evaluated in this study.

H. The building occupancy is the normal 8:00 a.m. to 5:00 p.m. five days per week for business or office use. Refer to the Appendix to the study for projected hours of use for the office occupancy.

I. Historic perspective is as follows:
   1. The three story Classical Revival building was built in 1914-1915.
   2. The structure is steel and brick with an exterior cladding of limestone.
   3. The original "historical" windows were one over one light double hung sashes, all of the historic double hung windows were replaced with combination double hung steel windows circa 1970.
   4. The existing windows are <u>not</u> energy efficient per current standards and do <u>not</u> meet historic preservation standards.
   5. These are several instances of interior condensation damage caused at the failing windows.
   6. The building is listed on the National Register of Historic Places.



EXISTING BASEMENT / BOILER ROOM MECHANICAL PLAN

SCALE: NO SCALE

III. CODES, STANDARDS, GOOD PRACTICES

A. The following partial listing of codes applies currently to the building HVAC and plumbing systems, with exceptions or exemptions specified for "historic" building.
   1. International Energy Conservation Code, 2012. (IECC)
   2. International Mechanical Code, 2012. (IMC)
   3. Uniform Plumbing Code, 2012. (State of Iowa Code) (UPC)
   4. American Society of Heating, Refrigeration and Air Conditioning Engineers, Standards. (ASHRAE)
      a. ASHRAE standard 90.1-2012, Energy Standard for Buildings Except Low Rise Residential Buildings.
   5. National Fire Protection Association, Standards. (NFPA)
   6. International Fire Code, 2012. (IFC)
   7. National Electric Code, 2012 (NEC)
   8. NFPA 90A – Standard for Installation of Air Conditioning and Ventilation Systems.
   9. Sheet Metal and Air Conditioning Contractors National Association, Standards. (SMACNA)
   10. Iowa State Fire Marshal's Rules and Regulations (Smoke and Fire Detection)
   11. USEPA Prohibitions on Certain Refrigerants.
   12. International Ground Source Heat Pump Association. (IGSHPA)
   13. International Building Code, 2012 (IBC)
   14. United States Secretary of Interior's Standards for Rehabilitation.
   15. National Park Service Preservation Briefs.
   16. State of Iowa Historic Preservation and Cultural & Entertainment District Tax Credit Program.

B. Following are items that appear to be out of the prescribed limits of the applicable codes listed above.
   1. Minimum ventilation is not provided to the different areas of City Hall throughout the year. Minimum ventilation is required per IMC 2012. Providing minimum ventilation may increase utility bills because of the required energy transfer to heat and cool the ventilation air.
   2. The hot water heating system installed in 2012 does meet the Energy Code requirement.

C. Following are items that do not appear to follow what we consider good engineering practice.
   1. There are insufficient HVAC control zones to provide overall satisfactory building temperature and humidity control. Only individual radiator control valves provide heating control currently, and these were part of the heating system upgrade.
   2. No constant de-humidification is provided in the building to provide low cooling load moisture removal in off peak cooling periods. This results in "higher" than recommended relative humidity in the space during high humidity periods.
   3. Window air conditioning units do <u>not</u> remove high humidity adequately through the entire cooling season.

IV. BUILDING ENVELOPE UPGRADE OPTIONS

A. Refer to the "full" study prepared by historic preservation architect Douglas Steinmetz, AIA in the Appendix to this study.

B. Envelope Upgrade Changes

1. Replace existing windows with historically relevant windows.
   a. Glass for windows must meet historic rehabilitation criteria before it meets energy conservation criteria.
   b. With the exception of required exit windows (if any), new replacement windows will not be operable.
   c. Replacement or repair of some interior good trim will be required to facilitate the replacement windows.
   d. Because of the special requirements for the windows, the windows may be made outside of Muscatine County and perhaps the State of Iowa.
   e. Replacement sash and panning system with brick molding included. The window replacement system considered would be a metal clad wood replacement sash (*similar to Pella's Architect's Series*), or an all-aluminum system (*similar to EFCO's Replica Series*). Both systems are detailed to appear similar to the historic double hung windows.

C. Additional Energy Conservation and Historic Rehabilitation Measures
1. Provide window awnings where historic documentation shows they once existed.
2. Replacement of primary entry doors including transom to improve energy conservation and appearance.
3. Provide air lock vestibules at three entries where none now exist.

D. Refer to cost estimates, life cycle cost projections and projected energy savings of the different envelope upgrade options.

V. HVAC SYSTEM OPTIONS

A. Iowa Department of Natural Resources (IADNR) "Life Cycle Cost Analysis Guidelines" 2008 requires evaluation of HVAC system options against "baseline" HVAC system per IECC (Energy Code) specifications.

B. A new HVAC system should meet the following criteria.
1. Individual room or zone temperature control.
2. Both heating and cooling capability at all times (important for humidity control).
3. Controlled outside air for ventilation to aid in humidity control.
4. Be energy efficient.
5. System installation should not require significant changes to the building's "historic" character.

6. New system should incorporate the recently installed hot water heating system as an integral part of the heating system.

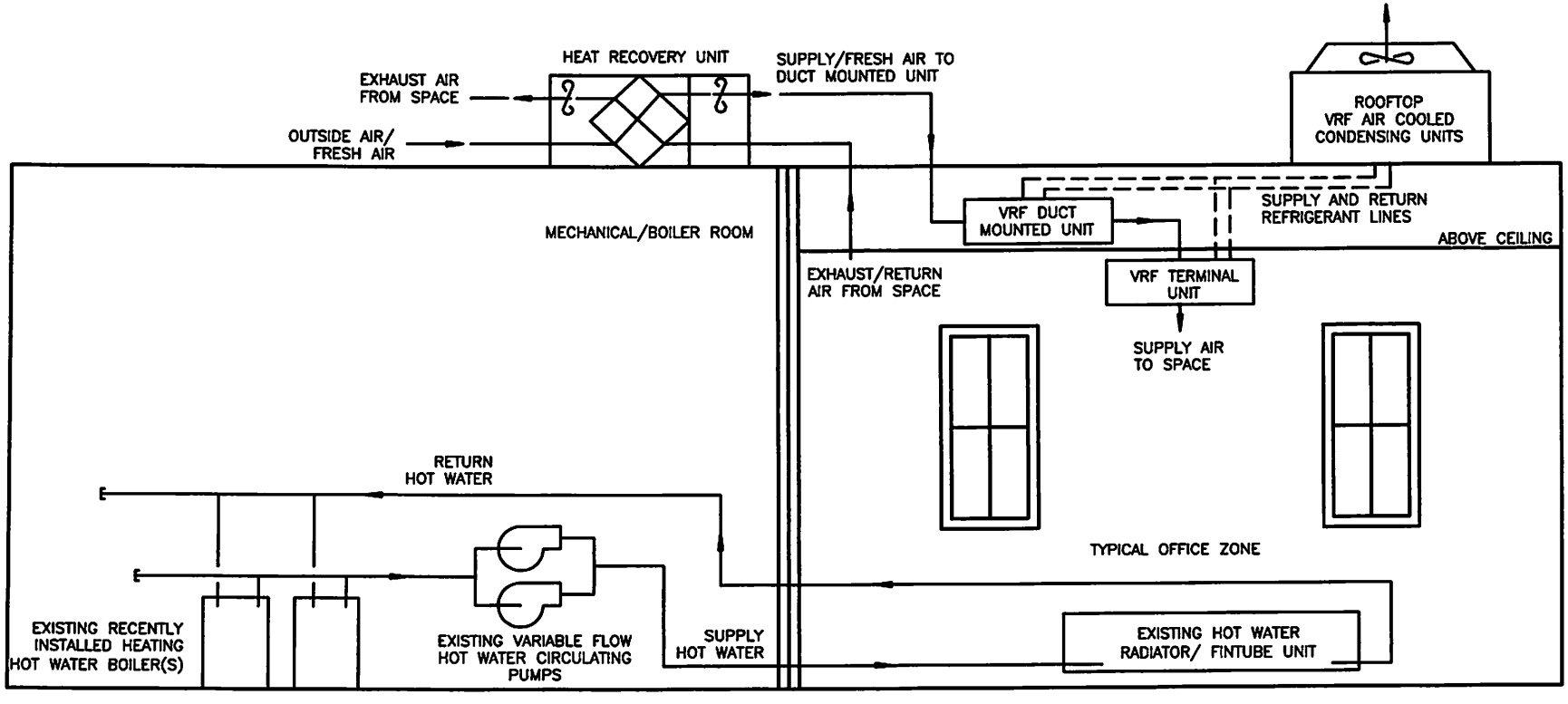
C. Other concepts considered but not evaluated further include because they did not meet all criteria specified above in letter B.
   1. Two pipe hot/chilled fan coil system.
   2. Four pipe hot chilled fan coil system.
   3. Four pipe radiant panel cooling and heating system.
   4. Small air handling units dispersed throughout the facilities.
   5. The geothermal loop field proved to be unacceptable because of "poor" soil conditions and the existing underground obstructions. Underground obstructions were discovered when the boring contractor investigated the potential geothermal loop field sites.

D. The City Hall is a four story building including a partially finished Basement Level and three floors; Lower Level, First Floor and Second Floor.

E. A&J estimates that approximately 30 tons of cooling capacity will be required to handle both the individual room cooling requirements and the outside ventilation requirements for the facility.

F. The existing facility does not currently have permanent central system air conditioning so the existing electrical system is not sized to allow just plugging in a new air conditioning system to replace the old. Significant additions or upgrades will be required for the electrical system to handle a new air conditioning system.

G. Following is the specific description of options considered in the evaluation.
   1. Option 1A – Variable Refrigerant Flow System *Without* Geothermal Loop System. Refer to the explanation contained herein for proposing systems without a geothermal loop heat exchanger.
      a. The Mitsubishi Electric VRF system was used as the study basis because in our experience this two pipe VRF system has the lowest first cost. Also the Muscatine County Court House has the Mitsubishi VRF System already installed. This is very close to the City Hall so the City staff can go on a site tour in Muscatine. (City Staff has already visited the Courthouse and observed that system operating)
      b. Three of the Mitsubishi Outdoor R2-Series 10 ton rooftop heat exchangers for heat rejection or heat sink for the variable refrigerant flow system.
      c. Heating and cooling shall be provided by refrigerant piping distributing two phase gas/liquid to terminal units.
      d. Low ambient temperature backup heating shall be provided by two existing half capacity high efficiency gas fired boilers and hot water terminal heating units (radiators) already operational. These terminal heating units provide backup heat at outside air temperatures below the temperature where the air cooled VRF



OPTION 1 HEATING, COOLING & VENTILATION AIR:

- VARIABLE REFRIGERANT FLOW WITHOUT GEOTHERMAL LOOP FIELD, ENERGY RECOVERY UNIT, HUMIDIFIERS AND USE OF THE EXISTING PERIMETER HOT WATER HEAT.

system becomes less efficient. The low ambient temperature "efficiency limit" for the air cooled Mitsubishi VRF system is approximately 20°F.

e. The existing hot water heating system will also provide heating below that limit where the VRF loses the capacity to draw heat from the "cold" outside air. The backup hot water heating boilers and pumps are located in the basement. Hot water heating terminal units are the existing cast iron radiators and some copper fin tubes.
f. An energy recovery and makeup air unit will provide conditioned makeup air to the offices and council chambers for ventilation during occupied periods of the building.
g. Provide digital control system to interface with the VRF HVAC controls and the existing hot water heating system.
h. Provide new ductwork to supply ventilation air only, and exhaust restrooms in the building.
i. Individual VRF units located in each zone will circulate cooling or heating air within each zone and will provide individual zone control currently missing in the cooling season.
j. Individual terminal units will be encased with furniture or case work to match the City Hall finish.

2. Option 1B – Identical in scope to Option 1A:
   a. Includes potential 25% rehabilitation tax credit.
3. Option 2A – Water to Air Heat Pumps with Heating Boilers and Rooftop Evaporative Cooler or a Cooling Tower and Heat Exchanger:
   a. Tie into existing closed circuit hot water heating boilers to heat the closed loop supplying the new heat pumps during the winter months. Rely on the heat pumps to provide heating throughout the winter months to the individual rooms.
   b. Provide a new rooftop evaporative cooler or cooling tower and heat exchanger to provide the heat sink for the heat pump loop for heat rejection.
   c. Provide glycol water mixture at evaporative cooler or cooling tower to provide spring and fall freeze protection while the heat rejection devices are operating.
   d. Energy recovery and makeup air unit shall provide conditioned makeup air to the office areas and council chambers for ventilation as needed.
   e. The existing hot water heating system will provide heating to the distributed heat pumps with the boilers and pumps via a heat exchanger connected to the heat pump loop. Some of the radiators will be demolished and removed to allow for installation of heat pumps while most of the radiators will remain for backup heat throughout the heating season.
   f. The terminal heat pumps will be encased with case work to match the City Hall finish.
   g. Option 2A is a closed loop water source heat pump system similar in concept to the Community Services Building HVAC owned by Muscatine County. An onsite tour for City Staff could be arranged to see this system type. Refer to the attached schematic of the water source heat pump system.
4. Option 2B – Identical in scope to Option 2A:
   a. Includes potential 25% rehabilitation tax credit.

5. Geothermal Loop Options: Geothermal loop heat exchanger operation were researched but not used for the following reasons.
   a. A&J evaluated the geothermal loop option with the intent to combine the geothermal loop heat exchanger with either the variable refrigerant flow (VRF) option or the water source heat pump option (options 1 and 2 above).
   b. A-One Geothermal of Earlham, Iowa attempted to perform conductivity tests for the proposed geothermal loop field located beneath the parking lot across Third Street. A-One was not able to drill because of the underground storm sewer under the parking lot. A-One Geothermal installed the geothermal heat exchanger used at the City Police and Fire Station.
   c. A&J decided to not evaluate the geothermal option further because we cannot confidently assign expected costs to account for the unknown debris, extra well casings and other unknowns associated with construction around the old underground storm sewer. We do not feel the geothermal loop field option is viable because of the unknown costs, and the lack of readily accessible loop field real estate.

VI. ELECTRICAL UPGRADES

A. The existing electrical service to the City Hall Building is 120/240 Volts, Single Phase with the service disconnect installed in the Boiler Room in the Basement. The existing service lacks space capacity to power any HVAC system upgrades.

B. Options #1 or #2 will require approximately 30 tons of cooling capacity. The estimated electrical load for the HVAC equipment proposed by either option will be +/- 50KVA.

C. Install a new 400 amp, 208 volt, 3 phase electrical service into the Lower Level Boiler Room. The new electrical service will terminate in a new Main Distribution Panel. The main distribution panel will contain circuit breakers to power the proposed new HVAC equipment and to "back-feed" the existing electrical service. Disconnect and remove the existing electrical service.

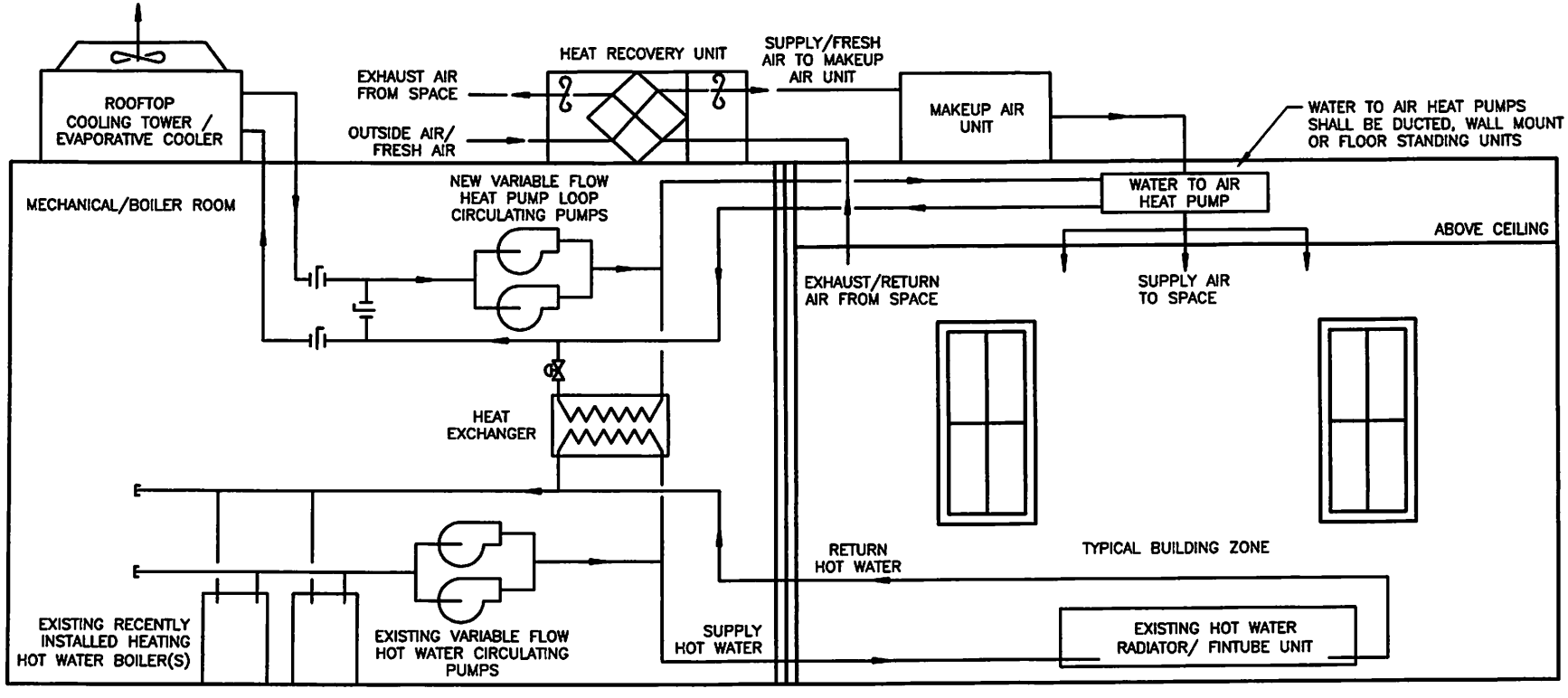
D. Install new feeders to power proposed roof mounted equipment.

E. Install new feeders to power proposed variable refrigerant flow system components (Option #1) or heat pumps (Option #2). Main runs of new circuits would be routed in surface mounted conduits/raceways horizontally along corridor ceilings and individual circuits to heat pumps/condensate pumps would be run in surface mounted conduits/raceways horizontally along ceilings into individual rooms

F. Refer to attached electrical plan which schematically shows the concepts described.

VII. LIGHTING AND LIGHTING CONTROL UPGRADE OPTIONS

A. No lighting upgrades were considered for this study.



OPTION 2 HEATING, COOLING & VENTILATION AIR:

- COOLING TOWER AND HEAT EXCHANGER, WATER TO AIR PUMPS, ENERGY RECOVERY UNITS, NEW SUPPLY AND RETURN DUCT, DEMOLITION OF EXISTING PERIMETER HOT WATER HEATING AND REUSE OF EXISTING HOT WATER HEATING BOILERS, PUMPS AND CONTROLS.

VIII. DOMESTIC WATER HEATING UPGRADE

A. No domestic water heating upgrades were considered for the study.

IX. RECOMMENDATIONS

A. Recommendations are based on the modified BIN analysis and the Life Cycle Cost Analysis of the upgrades. The 25 year gage is one used by the USDOE and the Iowa Office of Economic Development to rate "straight" energy conservation projects. Refer to attached Life Cycle Cost Analysis spreadsheets.

B. Option 1 upgrades the HVAC system to variable refrigerant flow system without geothermal loop field including new centralized ventilation air capability. Option 1 will require supplemental hot water heat at extreme low ambient temperatures. The existing and recently installed hot water heating upgrade will be used with the new Option 1 HVAC system to the fullest extent of the options considered. Structural reinforcing of the existing roof will be required.

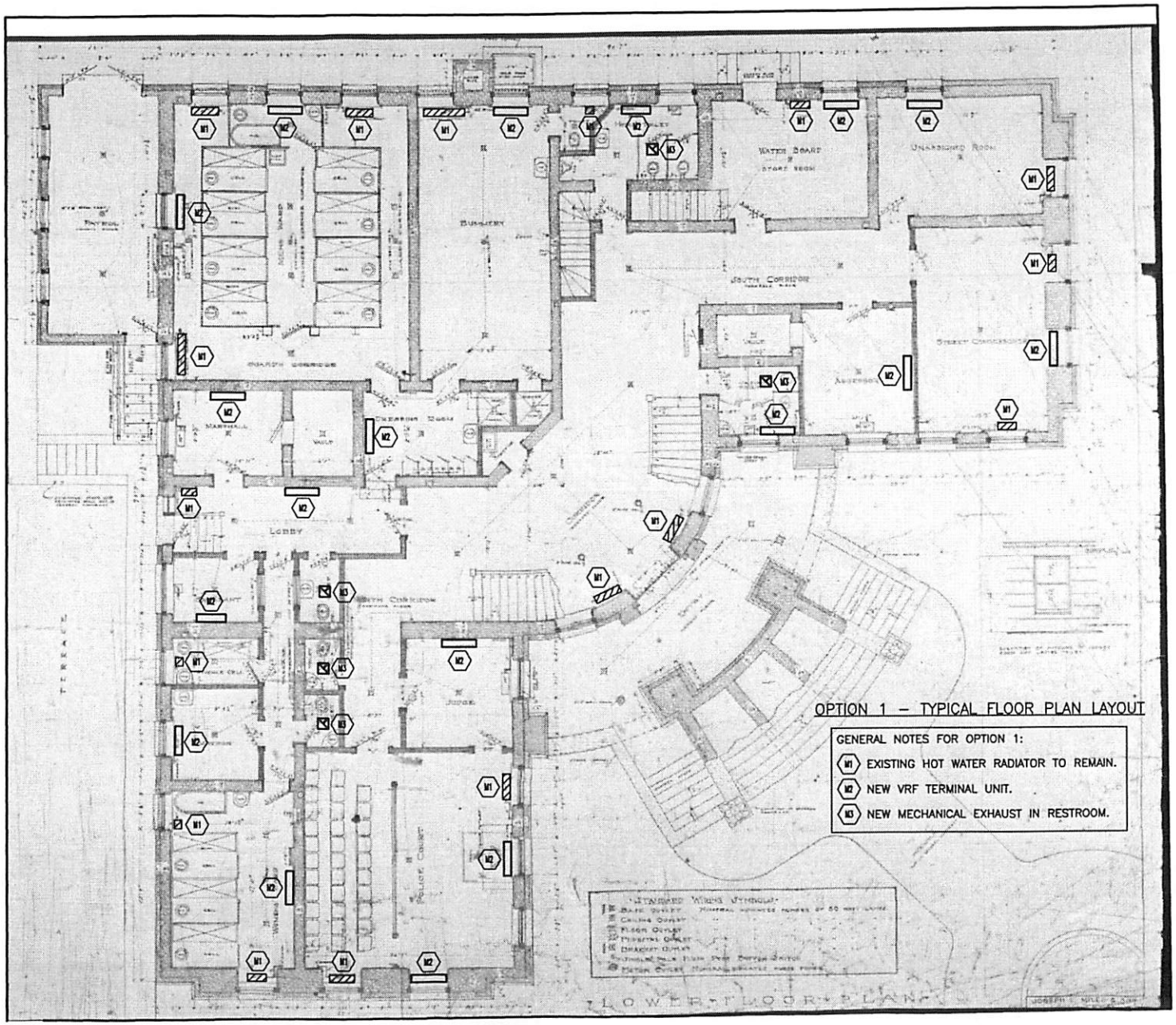
C. Option 2 upgrades the HVAC system with a rooftop evaporative cooler or cooling tower and heat exchanger, central ventilation air conditioning units and individual water to air heat pumps. Option 2 also includes the demolition and removal of the existing hot water heating piping and cast iron radiators but uses the existing boilers and circulating pumps for heating. Structural reinforcing of the existing roof will be required.

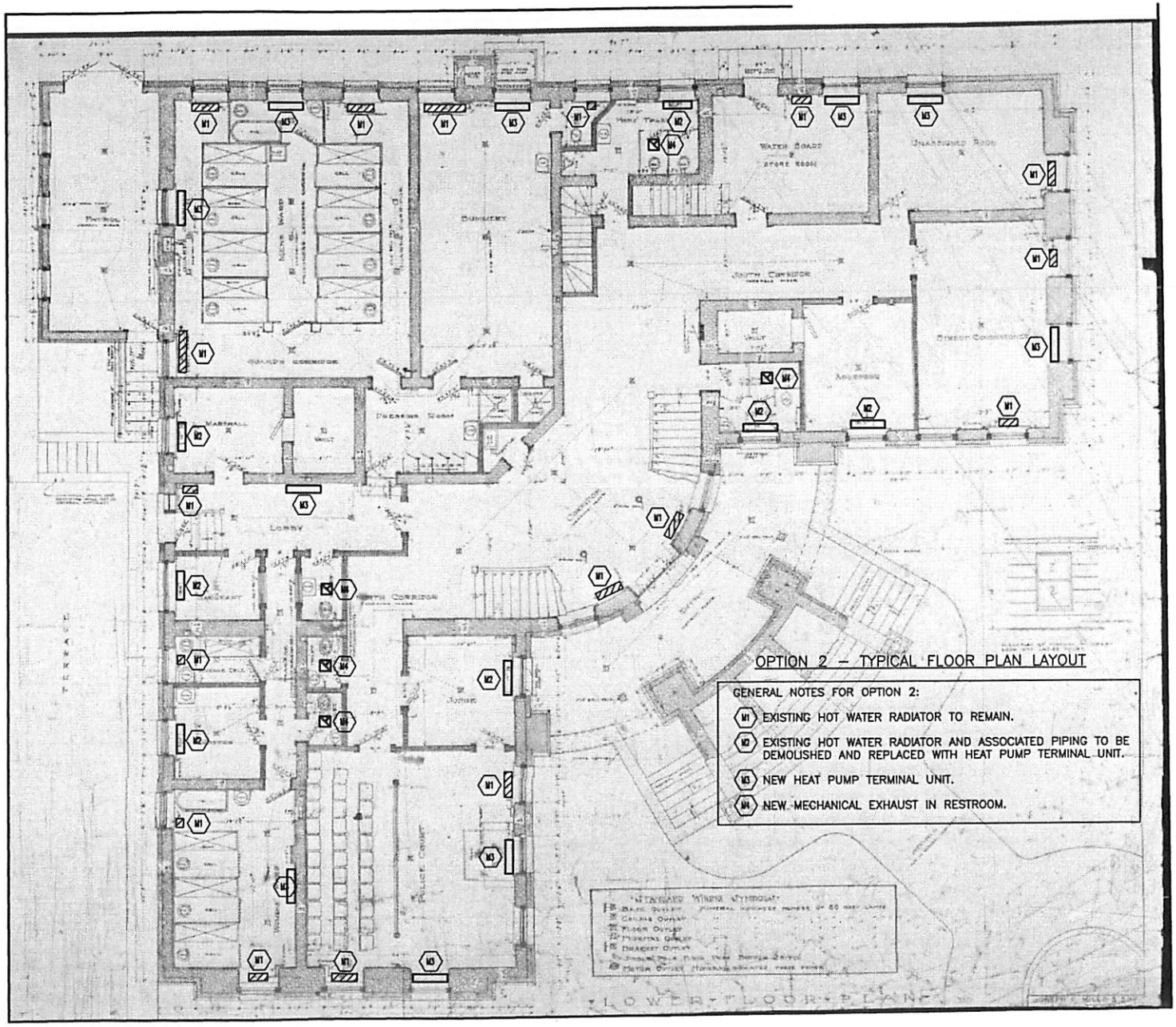
D. HVAC Option 1 or 2 can be phased to be completed in stages to allow the continued occupancy and use of the City Administration Building.

E. The attached Life Cycle Cost Analysis and BIN evaluations indicate which operation is preferable from cost outlay standpoints only, from life cycle costs which include initial cost, potential rehabilitation tax credits and energy savings payback.

F. The attached estimated costs of Options are based on concepts only and A&J's experience with basic construction cost parameters. Refer to the Appendix for detailed concept cost estimates.

G. Subject to the following qualifications, the modified Life Cycle Cost Analysis and ASHRAE BIN analysis offers predictions of energy savings with estimations as good as any other means available for projecting energy use and future costs for the systems or project that have not been built.
   1. The energy savings results compare relative differences in net energy use for design alternatives. The results are not appropriate for system design and/or equipment selection; rather than results can be used to "rank" system alternatives.
   2. The actual energy use of this building or project will be different from simulated results. Building systems and other operating parameters used in the model approximate actual conditions, but differences in weather, operating parameters,


OPTION 1 – TYPICAL FLOOR PLAN LAYOUT
GENERAL NOTES FOR OPTION 1:
M1 EXISTING HOT WATER RADIATOR TO REMAIN.
M2 NEW VRF TERMINAL UNIT.
M3 NEW MECHANICAL EXHAUST IN RESTROOM.
STANDARD WIRING SYMBOLS
LOWER FLOOR PLAN


OPTION 2 – TYPICAL FLOOR PLAN LAYOUT
GENERAL NOTES FOR OPTION 2:
M1 EXISTING HOT WATER RADIATOR TO REMAIN.
M2 EXISTING HOT WATER RADIATOR AND ASSOCIATED PIPING TO BE DEMOLISHED AND REPLACED WITH HEAT PUMP TERMINAL UNIT.
M3 NEW HEAT PUMP TERMINAL UNIT.
M4 NEW MECHANICAL EXHAUST IN RESTROOM.
LOWER FLOOR PLAN

NOTE: Girders are to carry Uniform Load of 30,000 Lbs each
GIRDER DESIGNS ARE TO BE CAREFULLY CHECKED AND GIRDERS CONSTRUCTED TO SAFELY CARRY ABOVE LOAD

THREE QUARTER INCH SCALE DETAIL OF PLATE GIRDERS

PROPOSED ROOFTOP LOCATION FOR COOLING TOWER/EVAPORATIVE COOLER & VRF CONDENSING UNITS

STRUCTURAL ANALYSIS OF ROOFTOP SUPPORTS SHALL BE PERFORMED IN DESIGN PHASE

DETAIL OF "H" COLUMN

SECTION

TAKEN THRU CENTER OF SOUTH WING FACING ALLEY

Scale ¼in. 1ft.

JOSEPH L. MILLS & SON
ARCHITECTS
DETROIT MICHIGAN

JOB NO. 418
DATE DEC 30 1918
SCALE AS INDICATED
DRAWN BY WHW

SHEET NO. 3

City of Muscatine City Hall HVAC Study
#201309.00

Summary
(Electrical Data Not Included)

Energy Use and Maintenance Cost Payback Analysis

	Net Occupiable Project Area (Sq. Ft.)	Construction Cost	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
HVAC Option 1A ***	15,590	$ 513,588	NA	173	$194	$0.01	$7,054.00	$0.45	$7,248	27.89	49.06
HVAC Option 1B***	15,590	$ 385,191	NA	173	$194	$0.01	$7,054.00	$0.45	$7,248	20.92	36.80
HVAC Option 2A ***	15,590	$ 891,554	NA	4,869	$5,453	$0.35	$11,681.00	$0.75	$17,134	104.56	171.19
HVAC Option 2B***	15,590	$ 668,666	NA	4,869	$5,453	$0.35	$11,681.00	$0.75	$17,134	78.42	128.39

Total Utility Load

Electrical Load (kWh)	NA	***
Gas Load (therm)	9,519	
Total Utility Cost Existing	$ 10,661.28	→12 month bill period***
Estimated Yearly Maintenance Cost Existing	$15,000	
Total Estimated Yearly Operating Cost	$25,661	

HVAC Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

HVAC Option 1B
Same as option 1A less potential rehabilitation tax credit included in construction cost.

HVAC Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps and controls.

HVAC Option 2B
Same as option 2A less potential rehabilitation tax credit included in construction cost.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. See summary 1B for estimated electrical Cost/kWh used to compare the differences in electrical usage for options 1 & 2.

****Options 1 & 2 may not provide significant energy use savings because of the addition of the air conditioning system and capacity for ventilation air that is now non-existant.

General Note:
Payback periods do not reflect typical HVAC system upgrade outcomes due to there being no air conditioning or ventilation equipment installed in the present system. Energy use will probably increase due to providing the Energy Code required ventilation.

City of Muscatine City Hall HVAC Study
#201309.00

Summary
(Estimated Electrical Cost Included)

Energy Use and Maintenance Cost Payback Analysis

	Net Occupiable Project Area (Sq. Ft.)	Construction Cost	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Electrical & Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
HVAC Option 1A ***	15,590	$ 513,588	164,966	173	$9,597	$0.62	$7,054.00	$0.45	$16,651	28.46	50.84
HVAC Option 1B***	15,590	$ 385,191	164,966	173	$9,597	$0.62	$7,054.00	$0.45	$16,651	21.34	38.13
HVAC Option 2A ***	15,590	$ 891,554	214,170	4,869	$17,661	$1.13	$11,681.00	$0.75	$29,342	166.42	437.42
HVAC Option 2B***	15,590	$ 668,666	214,170	4,869	$17,661	$1.13	$11,681.00	$0.75	$29,342	124.82	328.06

Total Utility Load

Electrical Load (kWh)	158,560	
Gas Load (therm)	9,519	
Total Utility Cost Existing	$ 19,699.20	→12 month bill period***
Estimated Yearly Maintenance Cost Existing		$15,000
Total Estimated Yearly Operating Cost		$34,699

HVAC Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

HVAC Option 1B
Same as option 1A less potential rehabilitation tax credit included in the construction cost.

HVAC Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps and controls.

HVAC Option 2B
Same as option 2A less potential rehabilitation tax credit included in the construction cost.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. Cost/kWh provided is estimated from previous projects located in Muscatine and will be used to compare the differences in electrical usage for options 1 & 2 with electrical use assigned a typical cost basis.

****Options 1 & 2 may not provide significant energy use savings because of the addition of the air conditioning system and capacity for ventilation air that is now non-existant.

General Note:
Payback periods do not reflect typical HVAC system upgrade outcomes due to there being no air conditioning or ventilation equipment installed in the present system. Energy use will probably increase due to providing the Energy Code required ventilation.

City of Muscatine City Hall HVAC Study
#201309.00

Summary - 1.5x Utilities
(Electrical Data Not Included)

Energy Use and Maintenance Cost Payback Analysis

	Net Occupiable Project Area (Sq. Ft.)	Construction Cost	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
HVAC Option 1A ***	15,590	$ 513,588	NA	173	$194	$0.01	$7,054.00	$0.45	$7,248	21.63	32.51
HVAC Option 1B***	15,590	$ 385,191	NA	173	$194	$0.01	$7,054.00	$0.45	$7,248	16.22	24.38
HVAC Option 2A ***	15,590	$ 891,554	NA	4,869	$5,453	$0.35	$11,681.00	$0.75	$17,134	64.34	84.60
HVAC Option 2B***	15,590	$ 668,666	NA	4,869	$5,453	$0.35	$11,681.00	$0.75	$17,134	48.25	63.45

Total Utility Load

Electrical Load (kWh)	NA	***
Gas Load (therm)	9,519	
Total Utility Cost Existing	$ 15,991.92	→12 month bill period***

Estimated Yearly Maintenance Cost Existin $15,000
Total Estimated Yearly Operating Cost $30,992

HVAC Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

HVAC Option 1B
Same as option 1A less potential rehabilitation tax credit included in the construction cost.

HVAC Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps and controls.

HVAC Option 2B
Same as option 2A less potential rehabilitation tax credit included in the construction cost.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. See summary 1B for estimated electrical Cost/kWh used to compare the differences in electrical usage for options 1 & 2.

****Options 1 & 2 may not provide significant energy use savings because of the addition of the air conditioning system and capacity for ventilation air that is now non-existant.

General Note:
Payback periods do not reflect typical HVAC system upgrade outcomes due to there being no air conditioning or ventilation equipment installed in the present system. Energy use will probably increase due to providing the Energy Code required ventilation.

City of Muscatine City Hall HVAC Study
#201309.00

Summary - 1.5x Utilities
(Estimated Electrical Cost Included)

Energy Use and Maintenance Cost Payback Analysis

	Net Occupiable Project Area (Sq. Ft.)	Construction Cost	Estimated Yearly Electrical Load (kWh)	Estimated Yearly Natural Gas Load (therm)	Estimated Yearly Utility Cost (Electrical & Natural Gas)	Estimated Utility Cost per. Sq. Ft.	Estimated Yearly Maintenance Cost	Estimated Maintenance Cost per Sq. Ft.	Total Estimated Yearly Utility and Maintenance Cost	Estimated Pay Back on Energy and Maintenance Cost **combined*** (years)	Estimated Pay Back based on **Utility Costs**** (years)
HVAC Option 1A ***	15,590	$ 513,588	164,966	173	$9,597	$0.62	$7,054.00	$0.45	$16,651	18.41	25.74
HVAC Option 1B***	15,590	$ 385,191	164,966	173	$9,597	$0.62	$7,054.00	$0.45	$16,651	13.81	19.31
HVAC Option 2A ***	15,590	$ 891,554	214,170	4,869	$17,661	$1.13	$11,681.00	$0.75	$29,342	58.63	75.00
HVAC Option 2B***	15,590	$ 668,666	214,170	4,869	$17,661	$1.13	$11,681.00	$0.75	$29,342	43.97	56.25

Total Utility Load

Electrical Load (kWh)	158,560	
Gas Load (therm)	9,519	
Total Utility Cost Existing	$ 29,548.80	→12 month bill period***

Estimated Yearly Maintenance Cost Existin $15,000
Total Estimated Yearly Operating Cost $44,549

HVAC Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

HVAC Option 1B
Same as option 1A less potential 25% rehabilitation tax credit included in construction cost.

HVAC Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps and controls.

HVAC Option 2B
Same as option 2A less potential 25% rehabilitation tax credit included in construction cost.

*Estimated pay back on maintenance and energy cost combined is the payback of construction costs between the existing maintenance & utility costs and the option's maintenance & utility costs.

**Estimated pay back on utility costs is the payback of construction cost between the existing utility costs and the option's utility cost.

***City of Muscatine does not pay for electrical service. Cost/kWh provided is estimated from previous projects located in Muscatine and will be used to compare the differences in electrical usage for options 1 & 2 with electrical use assigned a typical cost basis.

****Options 1 & 2 may not provide significant energy use savings because of the addition of the air conditioning system and capacity for ventilation air that is now non-existant.

General Note:
Payback periods do not reflect typical HVAC system upgrade outcomes due to there being no air conditioning or ventilation equipment installed in the present system. Energy use will probably increase due to providing the Energy Code required ventilation.

City of Muscatine Administration Building Architectural Upgrades Payback:

	Project Area (Sq. Ft.)	Upgrade Cost ($)	Estimated Yearly Utility Savings from Block Load with **NO upgrades** (kWhr)	Estimated Yearly Utility Savings from Block Load with **NO upgrades** (therm)	Estimated Yearly Utility Savings ($)	Estimated Payback from Implementing Upgrades; Utility Savings (years)
Arch Option 1	15,590	$330,000.00	--	1927	$2,158.24	152.90
Arch Option 2	15,590	$199,000.00	--	2628	$2,943.36	67.61
Arch Option 3A	15,590	$396,750.00	--	4752	$5,322.24	74.55
Arch Option 3B	15,590	$529,000.00	--	4752	$5,322.24	99.39

Arch Option 1
Replacement System (Aluminum Clad Wood)

Arch Option 2
Main Enrty Door, Awnings and Vestibules A, B & C

Arch Option 3A
All Upgrades Implemented Less Potential Rehabilitation Tax Credit

Arch Option 3B
All Upgrades Implemented

1. Refer to report sections describing the architectural changes

2. The Estimated Yearly Utility Savings from the Architectural Upgrades are significant compared to the existing utility bills; however, the savings do not include the energy use from a new mechanical/electrical system.

3. City of Muscatine does not pay for electrical service. See summary 1B for estimated electrical Cost/kWh used to compare the differences in electrical usage for options 1 & 2.

DISCLAIMER: The savings estimated for a specific architectural alternate may **not** result in the predicted savings if all upgrades are incorporated. This is true because all energy conservation upgrades contribute to the overall bulding operation. Individual option cost and savings projection should be used only for comparison "relative" value between options, not to project actual cost savings.

City of Muscatine Administration Building Architectural Upgrades Payback:

	Project Area (Sq. Ft.)	Upgrade Cost ($)	Estimated Yearly Utility Savings from Block Load with **NO upgrades** (kWhr)	Estimated Yearly Utility Savings from Block Load with **NO upgrades** (therm)	Estimated Yearly Utility Savings ($)	Estimated Payback from Implementing Upgrades; Utility Savings (years)
Arch Option 1	15,590	$330,000.00	152,278	1927	$11,294.92	29.22
Arch Option 2	15,590	$199,000.00	207,971	2628	$15,421.62	12.90
Arch Option 3A	15,590	$396,750.00	297,462	4752	$23,169.96	17.12
Arch Option 3B	15,590	$529,000.00	297,462	4752	$23,169.96	22.83

Arch Option 1
Replacement System (Aluminum Clad Wood)

Arch Option 2
Main Enrty Door, Awnings and Vestibules A, B & C

Arch Option 3A
All Upgrades Implemented Less Potential Rehabilitation Tax Credit

Arch Option 3B
All Upgrades Implemented

1. Refer to report sections describing the architectural changes

2. The Estimated Yearly Utility Savings from the Architectural Upgrades are significant compared to the existing utility bills; however, the savings do not include the energy use from a new mechanical/electrical system.

3. City of Muscatine does not pay for electrical service. Cost/kWh provided is estimated from previous projects located in Muscatine and will be used to compare the differences in electrical usage for archictural options 1, 2 & 3 with electrical use assigned a typical cost basis.

DISCLAIMER: The savings estimated for a specific architectural alternate may **not** result in the predicted savings if all upgrades are incorporated. This is true because all energy conservation upgrades contribute to the overall bulding operation. Individual option cost and savings projection should be used only for comparison "relative" value between options, not to project actual cost savings.

City of Muscatine City Hall HVAC Study
#201309.00

Life Cycle Cost Analysis
(Electrical Data Not Included)

Energy Use and Maintenance Cost Analysis

	Project Area (Sq. Ft.)	Construction Cost	LCCA Gas Energy Use Cost	LCCA Maintenance Cost	LCCA Replacement Cost	LCCA TOTAL COST
Option 1A	15,590	$ 513,588	$3,683	$169,296	$210,000	$896,567
Option 1B	15,590	$ 385,191	$3,683	$169,296	$210,000	$768,170
Option 2A	15,590	$ 891,554	$95,190	$280,344	$86,500	$1,353,588
Option 2B	15,590	$ 668,666	$95,190	$280,344	$86,500	$1,130,700

Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

Option 1B
Same as option 1A less potential 25% rehabilitation tax credit.

Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps, and conrtrols.

Option 2B
Same as option 2A less potential 25% rehabilitation tax credit.

Assumptions:
- 25 year Life Cycle Cost time period
- Life Cycle Costs are not based on the assumption that utility costs will soon increase by 50%.

City of Muscatine City Hall HVAC Study
#201309.00

Life Cycle Cost Analysis
(Estimated Electrical Cost Included)

Energy Use and Maintenance Cost Analysis

	Project Area (Sq. Ft.)	Construction Cost	LCCA Energy Use Cost	LCCA Maintenance Cost	LCCA Replacement Cost	LCCA TOTAL COST
Option 1A	15,590	$ 513,588	$152,002	$169,296	$210,000	$1,044,886
Option 1B	15,590	$ 385,191	$152,002	$169,296	$210,000	$916,489
Option 2A	15,590	$ 891,554	$287,747	$280,344	$86,500	$1,546,145
Option 2B	15,590	$ 891,554	$287,747	$280,344	$86,500	$1,546,145

Option 1A
Variable refrigerant flow without geothermal loop field, energy recovery units, humidifiers and use of the existing perimeter hot water heat and recently installed boilers.

Option 1B
Same as option 1A less potential 25% rehabilitation tax credit.

Option 2A
Cooling tower and heat exchanger, water to air heat pumps, energy recovery units, new supply & return duct, demolition of existing perimeter hot water heating and reuse of existing hot water heating boilers, pumps, and conrtrols.

Option 2B
Same as option 2A less potential 25% rehabilitation tax credit.

Assumptions:
- 25 year Life Cycle Cost time period
- Life Cycle Costs are not based on the assumption that utility costs will soon increase by 50%.

occupancy level, future energy costs and changes that occur through the bidding and construction process will result in initial construction costs and annual energy costs and use that will be different from what is predicted here. However, when a design strategy is selected relative to other alternatives, its energy (and dollar) conserving value can be expected to remain constant relative to the other alternatives, and the magnitude of the cost difference should be approximately as predicted. Thus, implementation of design strategies offers the opportunity for energy savings, but the realization of those savings is the responsibility of the owner/operator of the building, not A&J Associates. Initial construction costs and future savings are not guaranteed.

3. Equipment and repair costs for future years depend on factors beyond accurate predictions. The future costs are only predicted consistently between options in accordance with publicly accepted Life Cycle Cost Analysis tracking and modeling.
4. **Currently the City of Muscatine does not pay for electrical power since the City of Muscatine is the electrical utility provider. The comparative analysis evaluates energy costs with no charge for electricity and with a "representative" charge for electricity to reflect the reduced use of electricity by an option. This comparison method does factor electricity costs into the life cycle cost analysis as required by the State of Iowa.**

H. The Muscatine Administration Building/City Hall HVAC system is estimated to be just temporary. Also the zone control provided from these units is unacceptable. From the standpoint of temperature and humidity control the Energy Conservation code was considerably different when the existing system was installed compared to today's Energy Conservation Code. Most significant changes have come in energy use and mandatory ventilation requirements. These areas have been re-evaluated to reduce the amount of energy used from building mechanical systems. Consequently, the existing HVAC systems do not meet present day energy conservation requirements.

I. The specified system short falls and deficiencies do not apply to the recently installed hot water heating system which does meet current energy conservation codes and provide for individual zone heating control.

J. Current and modern control systems provide much more control than the system currently installed to control the radiators and fin tubes. It is currently possible to achieve closer environmental control by using less energy through more sophisticated control systems. The current head end heating system does have capability for more sophisticated controls.

K. The potential geothermal well site has been determined unsuitable for drilling based on significant unknowns and the underground storm sewer of the underground conditions at the parking lot across Third Street. A&J cannot assign an accurate cost to cover such unknowns in our option comparison studies and we think dealing with the old storm sewer is very risky. Consequently, A&J is going to recommend that the geothermal loop field heat pump option is not viable for any City Hall HVAC system upgrade.

City of Muscatine City Hall HVAC Study
#201309.00

Option # 1
Variable Refrigerant Flow, ERV Units, Humidifiers and Supplemental Heat
Modified BIN Analysis

Energy Use and Maintenance Cost Payback Analysis

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	VRF sensible cooling load (btuh)	VRF total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	VRF sensible heating load (btuh)	VRF total heating load (btu/month)	Boiler heating load (btuh)	Boiler total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	308298	20	74156	2447149	1047630	115239263	58202	21651013
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	301599	19	66713	2201541	970598	106765788	53922	20059027
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	288446	18	52099	1719256	819336	90126064	45519	16932945
april	83.3	23.5	50.4	44.5	33	350631	487	0	16076	4762	2657170	0	13	0	0	0	0	0	0
may	87.7	36.4	61.8	55.4	55	364515	14371	0	474247	140478	78386509	0	13	0	0	0	0	0	0
june	93.5	48	71.3	64.2	78	376085	25941	11785	1244965	253574	141494291	0	13	0	0	0	0	0	0
july	97	55	75.9	68.5	92	381687	31543	22471	1782479	308336	172051744	0	13	0	0	0	0	0	0
august	95.7	52	73.9	63.2	70	379251	29108	5679	1147953	284527	158765895	0	13	0	0	0	0	0	0
september	89.5	37	64	54.7	46	367194	17050	0	562666	166668	93000943	0	13	0	0	0	0	0	0
october	83.6	26.1	53.9	47	37	354893	4750	0	156743	46429	25907405	0	13	0	0	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	286254	18	49663	1638875	794126	87353827	44118	16411931
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	301843	19	66984	2210472	973399	107073914	54078	20116917
											45 min./hr see note 6		see note 7				30 min./hr	see note 7	

	cooling		heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	VRF operating cost (month)	gas heating operating cost (month)	ventilation unit fans operating cost (month)	VRF operating cost (month)	hplp operating cost	building lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	22	41	419	242	52695	11,592,900	27,880	6133600	6128	1348160
february	0	0	22	37	388	224	52695	11,592,900	27,880	6133600	6128	1348160
march	0	0	21	29	327	189	52695	11,592,900	27,880	6133600	6128	1348160
april	0	10	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
may	8	281	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
june	21	509	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
july	30	619	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
august	19	570	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
september	9	333	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
october	3	93	15	0	0	0	52695	11,592,900	27,880	6133600	6128	1348160
november	0	0	21	27	317	184	52695	11,592,900	27,880	6133600	6128	1348160
december	0	0	22	37	389	225	52695	11,592,900	27,880	6133600	6128	1348160
	$90	$2,414	$213 see note 7	$171	$1,841	$1,065 see note 7		$2,323.36 see note 5		$1,229.25 see note 5		$270.19 see note 5

Net Occupiable Building Area: 15,590 sq. ft.

estimated project cost: $ 513,588

electrical cost per kWh: $ 0.05700 City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.

estimated yearly maintenance cost: $ 7,054

estimated yearly electrical load (kWh): 164,966

estimated yearly electrical utility cost:	**$5,580.24**	See note 8
estimated yearly gas cost:	**$212.71**	173 therm $1.12 / therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost:	**$2,323.36**	
estimated yearly plug load cost:	**$1,229.25**	
estimated yearly service hot water cost:	**$270.19**	
	$9,615.75	

estimated yearly utility cost per sq. foot: $0.62

Notes:

1. Costs above assume variable refrigerant flow to be used in the entire City Hall Building. VRF, ERV Units, Humidifiers, Supply and Return Duct and Reuse Hot Water Heat Supply Equipment.
2. Hours of operation assumed @ 11 hours/day, 5 days/week, 4 weeks/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from the City Hall Building.
3. Ventilation air and return air quantities were assumed for this study based on minimum ventilation rates from IMC 2012.
   Ventilation air Ratio = 0.08
   Return air Ratio = 1.00-0.08 (ventilation air ratio) = 0.92
4. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
5. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy imparted to inside the building.
6. The VRF cooling and heating system is assumed to run 45 minutes per hour which equals 12 hours per day.
7. Gas fired heating required only for supplemental heat at extreme low outside air temperatures estimated to occur two weeks or 5% (two weeks out of the year = 14 days/ 365 days = 0.04) of the year.
8. The City of Muscatine does not pay for their electrical service. The yearly electrical cost listed is based on the estimated annual electrical load for option 1 and the estimated electrical cost per kWh. This BIN analysis includes a projected electrical retail cost to comply with the State of Iowa Energy Grant analysis requirements.

Option # 2
Existing Heating Hot Water Boilers, Cooling Tower, Water to Air Heat Pumps, ERV Units,
Modified BIN Analysis

month	mean of extreme highs db (°f)	mean of extreme lows db (°f)	mean highs db (°f)	mean highs wb (°f)	humidity ratio grain water / lb dry air	building sensible cooling load (btuh)	ventilation ahu sensible cooling load (btuh)	ventilation ahu latent cooling load (btuh)	ventilation ahu total cooling load (btu/month)	Water/Air sensible cooling load (btuh)	Water/Air total cooling load (btu/month)	building sensible heating load (btuh)	gas fired heating (therm)	ventilation ahu heating load (btuh)	ventilation ahu total heating load (btu/month)	Water/Air sensible heating load (btuh)	Water/Air total heating load (btu/month)
january	51.2	-11.6	20.2	20.8	15	0	0	0	0	0	0	308298	1205	74156	2936578	1083458	119160376
february	56.8	-5.2	25.7	25.2	19	0	0	0	0	0	0	301599	1111	66713	2641849	997867	109765403
march	72.9	7.2	36.5	34.1	25.0	0	0	0	0	0	0	288446	926	52099	2063107	829798	91277821
april	83.3	23.5	50.4	44.5	33	431206	487	0	19291	86177.29768	9479503	0	13	0	0	0	0
may	87.7	36.4	61.8	55.4	55	445090	14371	0	569096	245842.7816	27042706	0	13	0	0	0	0
june	93.5	48	71.3	64.2	78	456660	25941	11785	1493958	378897.3515	41678709	0	13	0	0	0	0
july	97	55	75.9	68.5	92	462262	31543	22471	2138975	443323.7748	48765815	0	13	0	0	0	0
august	95.7	52	73.9	63.2	70	459826	29108	5679	1377543	415312.2864	45684352	0	13	0	0	0	0
september	89.5	37	64	54.7	46	447769	17050	0	675199	276655.4188	30432096	0	13	0	0	0	0
october	83.6	26.1	53.9	47	37	435468	4750	0	188091	135197.4024	14871714	0	13	0	0	0	0
november	68.3	11	38.3	34.3	23	0	0	0	0	0	0	286254	895	49663	1966650	801787	88196557
december	56.9	-4.4	25.5	23.8	17.0	0	0	0	0	0	0	301843	1115	66984	2652566	1000980	110107766

30 min./hr
see note 6

	cooling				heating				heat rejection to space					
month	ventilation unit fans operating cost (month)	hplp operating cost (month)	Water/Air Heat Pump operating cost (month)	Cooling Tower operating cost (month)	hplp operating cost (month)	boiler operating cost (month)	ventilation unit fans operating cost (month)	Water/Air Heat Pump operating cost (month)	bulding lighting load peak (btu/h)	buildling total lighting load (btu/month)	building plug load (btuh)	building total plug load (btu/month)	building service hot water load (btuh)	building total service hot water load (btu/month)
january	0	0	0	0	205	1350	49	601	52695	11,592,900	27,880	6,133,600.00	6128	1352887
february	0	0	0	0	189	1244	44	553	52695	11,592,900	27,880	6,133,600.00	6128	1352887
march	0	0	0	0	157	1037	34	460	52695	11,592,900	27,880	6,133,600.00	6128	1352887
april	0	32	79	396	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
may	10	93	226	409	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
june	25	145	348	420	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
july	36	171	407	425	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
august	23	158	382	423	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
september	11	104	254	412	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
october	3	51	124	400	0	15	0	0	52695	11,592,900	27,880	6,133,600.00	6128	1352887
november	0	0	0	0	151	1003	33	444	52695	11,592,900	27,880	6,133,600.00	6128	1352887
december	0	0	0	0	189	1248	44	555	52695	11,592,900	27,880	6,133,600.00	6128	1352887
	$108	$753	$1,821	$2,884	$891	$5,989	$205	$2,613 see not 8		$2,323.36		$1,229.25		$271.13

Net Occupiable Building Area: 15,590 sq. ft.

estimated project cost: $ 891,554

electrical cost per kWh: $ 0.05700 City of Muscatine does not pay for their electrical service, the value listed is estimated from past projects located in Muscatine and will be used to represent the differences in the electrical usage for the two options being considered.

estimated yearly maintenance cost: $ 11,680

estimated yearly electrical load (kWh): 214,170

estimated yearly electrical utility cost: $8,383.96 See note 8
estimated yearly gas cost: $5,988.71 4869 therm $1.12 / therm estimated from Alliant Energy bill provided to A&J Associates
estimated yearly light load cost: $2,323.36
estimated yearly plug load cost: $1,229.25
estimated yearly service hot water cost: $271.13
$18,196.41

estimated yearly utility cost per sq. foot: $1.17

Notes:

1. Existing Heating Hot Water Boilers, Cooling Tower, or Evaporation Cooler, Water to Air Heat Pumps, Energy Recovery Units, Supplemental Electric Perimeter Heat, up to 44 zones.
2. Lighting load calculated using ASHRAE Standard 90.1 - 2012 Building Performance Rating Method found in Appendix, and using Light load of 1.00 W/sq. ft.
3. Heat rejection to space represents equipment heat rejection to spaces from internal cooling requirement. HVAC equipment load is the fan and pump energy imparted to inside the building.
4. The conversion of btu/month to kW-hr cost is calculated by multiplying the btu/month value by 0.000293 (standard multiplier for converting btu to to kW-hr) and finally multiplying by the cost per kW-hr ($0.057).
5. Hours of operation assumed @ 11 hours/day, 5 days/week, 4 weeks/month for all months. Per ASHRAE Standard 90.1 Office Occupancy and information from Administration Building.
6. The water to air heat pumps are assumed to run 30 munites per hour which equals 12 hours per day.
7. Ventilation air and return air quantities were assumed for this study based on exhaust rates from IMC 2012.
   Ventilation air Ratio = 0.08
   Return air Ratio = 1.00-0.08 (ventilation air ratio) = 0.92
8. The City of Muscatine does not pay for their electrical service. The yearly electrical cost listed is based on the estimated annual electrical load for option 1 and the estimated electrical cost per kWh. This BIN analysis includes a projected electrical retail cost to comply with the State of Iowa Energy Grant analysis requirements.

L. **We recommend the variable refrigerant flow (VRF) HVAC system option be provided for the following reasons:**
   1. **Provide better zone control than the other option considered.**
   2. **Provide better high humidity control than the other option considered.**
   3. **Reduced annual maintenance cost and energy costs.**
   4. **The VRF system option utilizes the existing hot water radiator heating system to the greatest extent. Consequently, the historic character of the building is maintained more so than with the heat pump option.**
   5. **The VRF system is very similar to the system recently installed in the County Courthouse. Consequently a comparative evaluation is relatively easy.**

M. **We recommend the following envelope upgrade options in descending order of preference to satisfy first the façade repair and second to conserve energy:**
   1. **The window replacement will restore the historic appearance of City Hall and significantly improve the energy conservation of the building.**
   2. **Restoration of the historic window awnings.**
   3. **Replacement of primary entry door.**
   4. **Provide air lock vestibules at three entry points where none exist now.**
   5. **The window replacement project can be reasonably completed in two phases if the funding dictates this strategy.**

N. The Administration Building/City Hall appears to qualify for historic preservation tax credits that have been distributed by the State of Iowa. Tax credits up to 25 percent of the construction and design expenditures may be available to offset the costs of available expenditures. However, the historic preservation tax credits can only be achieved through a "process". A&J recommends that the City of Muscatine consult with a historic preservation specialist (architect) who is well versed in the application and tax credit documentation process. HVAC options and envelope upgrade options would have to adhere to the preservation requirements to ensure the tax credit eligibility was maintained. Refer to Appendix section covering the different envelope upgrades for a more detailed discussion of the tax credit potential. The cost analyses of the different options consider the overall savings of the 25 per cent tax credit potential.

APPENDIX

Window and Vestibule Upgrades for the City of Muscatine Administration Building

Architectural Upgrades								
ITEM	QUANTITY	UNITS	COST PER	COSTS	Payback of Option Using Break Down Cost Savings (years)	ITEM	Combined Cost ($)	Payback of Combined Option from Cost Savings (years)
Replacement System (Aluminum Clad Wood)	1	LUMP	$330,000.00	$330,000.00	29.22	All Upgrades Implemented	$529,000.00	22.83
Main Entry, Awnings Door and Vestibules A, B & C	1	LUMP	$199,000.00	$199,000.00	12.90	All Upgrades Implemented Less Potential Rehabilitation Tax Credit	$396,750.00	17.12

Block Load without Window or Insulation Upgrades:

			Utility Bill		
cooling load (tons) without upgrade	46		$19,700.00		
heating load (MBH) without upgrade	553				

Energy Savings and Energy Cost Savings with Replacement Windows:

	ton/MBH	btuh	btuh x hours of cooling/heating season		convert to kWhr x $0.06
cooling load (tons) with upgrade	35.1				
difference (tons)	10.9	130800	327000000		$9,136.68
heating load (MBH) with upgrade	421		therm	kWhr	
difference (MBH)	132	132000	192720000	192720000	therm x $1.12
total utility cost savings ($)	$11,295.14		1927		$2,158.46

Energy Savings and Energy Cost Savings with Vestibules A, B & C

	ton/MBH	btuh	btuh x hours of cooling/heating season		convert to kWhr x $0.06
cooling load (tons) with upgrade	31.1				
difference (tons)	14.9	178800	447000000		$12,478.28
heating load (MBH) with upgrade	373		therm	kWhr	
difference (MBH)	180	180000	262800000	262800000	therm x $1.12
total utility cost savings ($)	$15,421.64		2628		$2,943.36

Energy Savings and Energy Cost Savings with Replacement Windows and Vestibules A, B & C :

	ton/MBH	btuh	btuh x hours of cooling/heating season		convert to kWhr x $0.06
cooling load (tons) with upgrade	28				
difference (tons)	18	216000	540000000		$17,847.74
heating load (MBH) with upgrade	814.1		therm	kWhr	
difference (MBH)	325.5	325500	475230000	475230000	therm x $1.12
total utility cost savings ($)	$23,170.32		4752		$5,322.58

NOTE: The "cost savings" were calculated by comparing the heating and cooling loads with upgrades implemented to heating and cooling loads with no upgrades. The cooling load difference was converted to kWhr and multiplied by $ per kWhr. The heating load was converted to therms and multiplied by $ per therm.

DISCLAIMER: The existing system has no outside air ventilation as it stands; therefore, adding in code minimum required ventilation air to the system may negate any energy savings "potential" from an upgrade. Also, the savings estimated for a specific architectural alternate may not result in the predicted savings if all upgrades are incorporated. This is true because all energy conservation upgrades contribute to the overall buiding operation. Individual option cost and savings projection should be used only for comparison "relative" value between options, not to project actual cost savings.

EXECUTIVE SUMMARY

The architectural portion of the study considers replacement of the primary window system at all openings and suggests additional building envelop alterations to improve energy conservation. The additional items include upgrading entry doors for energy conservation and visual enhancement and providing awnings (especially at locations where they historically) to shade windows.

City Hall, located at 215 Sycamore Street, is listed on the National Register of Historic Places as a contributing building in Muscatine's *Downtown Commercial Historic District,* a distinction that brings prestige to the community. Listing on the National Register not only brings recognition to a community as thoughtful stewards of an important historical resource it also opens doors to forms of financial assistance unavailable to non-listed buildings. In recognition of the City's desire to maintain the building's current listing on the National Register of Historic Places proposed Energy Conservation Measures are in conformance with current rehabilitation standards published by the Secretary of the Interior.

This study considers only replacement of the existing windows as requested. It does not consider repair of the existing aluminum sash and frames. Not only is the existing aluminum window system inappropriate by rehabilitation standards it is reported by staff to be difficult to operate, maintain and beyond reasonable repair. The operable sash also create an energy management situation that is nearly impossible to manage, having a noteworthy adverse impact on efficiency and operational costs for the facility.

The study also explores additional energy conservation measures related to architectural improvements such as providing awnings similar to those in historic photographs to reduce solar gain and improved entry door systems to better reflect historic doors and control energy losses at the building entrances. A separate engineering section of the report provides further analysis of the proposed alterations to assess their impact on energy conservation and overall life cycle costs of each treatment. Information in this section informs those analyses.

This study demonstrates that a range of options exist to address energy conservation goals and that such options can be sensitive to the building's historic features and character; one does not need to be ignored to exclusion of the other. However, compliance with the Standards is only one factor used in the complete assessment; initial cost, life-cycle cost, as well as impact on energy conservation must also be considered.

Summary Conclusions

- Work should conform to the Secretary of the Interior's Standards for Rehabilitation. Preferred replacement treatments match historic materials and details; under the rehabilitation standards that level of sensitivity is encouraged but considered optional in this instance where no historic windows exist. In this instance at this building, clad wood windows are acceptable in lieu of wooden systems[1]. All construction activity should avoid irreversibly damaging historic fabric and features that contribute to the building's historic character.
- When evaluating options consider not only life cycle and operational costs/savings but also to what extent the treatment impacts existing historic fabric or in the case of missing historic fabric how closely the treatment matches the documented historic features.

[1] Verified by conversation with SHPO staff.

- Consider implementing approaches that reverse previous treatments which have adversely impacted historic fabric and character rather than sustaining those treatments. Replacing inappropriate main entry doors is an example.

SCOPE OF STUDY

The primary focus of this section of the study is the exploration of window rehabilitation. However, additional architecturally-based energy conservation measures consistent with rehabilitation standards are also included. This section begins with a brief history of the building, general considerations for work on historic buildings and suggestions for additional information regarding potential funding strategies and sources before getting into specific discussion of proposed work which includes rehabilitation options, implementation and maintenance costs of various systems and a projected service life for each option explored.

MUSCATINE CITY HALL – BRIEF HISTORY

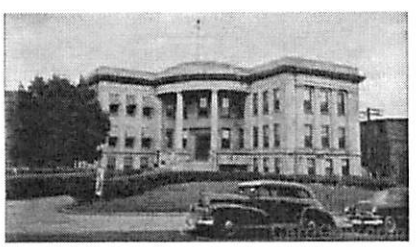
The building was listed in the National Register of Historic Places in 2006 as a contributing building in Muscatine's Downtown Commercial Historic District. The following text is excerpted from State Historical Society Site Inventory Form, Inventory No. 70-0193:

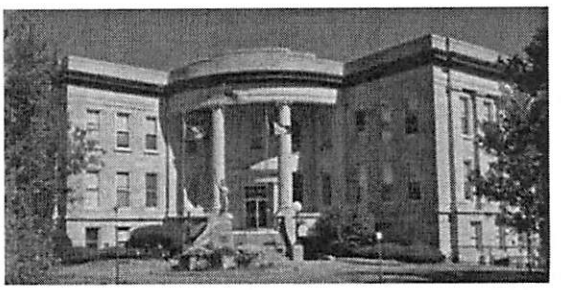
"This three-story, Classical Revival building is located at the corner of Sycamore and Third Streets, near the heart of the city's downtown business district and less than three blocks from the Mississippi River. The city hall was built in 1914-15, following two bond issue referendums. ... it appears the city hall vote was the first time women were able to cast ballots in a Muscatine election. The election(s) also marked the first use of an Iowa law allowing special charter cities the size of Muscatine to issue bonds to construct municipal buildings.

The Muscatine City Hall is a three-story public building with Classical Revival features. The structure is steel and brick with an exterior cladding of smooth Bedford limestone. Construction on the building was started in 1914 and completed in 1915. The structure incorporates two 90-foot long wings (east & west) to create a basic L-shaped footprint, with a curved, two-story, full-height portico set within the interior right angle formed by the two wings.

The building façade is dominated by the curved portico, which is accessed by a set of stone steps that flare out from the structure, going from about 15 feet wide at the top to nearly 20 feet at the bottom. The building's main entry is on the second story through the portico.

The dominant feature of each wing is the large number of windows found on each elevation. Copies of the original plans show the historic windows had one-over-one-light, double-hung sashes. The majority of the current windows have metal combination sashes. All of the historic double-hung, wood windows have been replaced with combination, double-hung, steel units."





In the 1970's a major window replacement project was undertaken resulting in substantial changes to the building's appearance (Attachments 6 & 7). Detail drawings of this replacement project are not available; however, all the then existing original sash were removed and replaced with aluminum frames and sash. The replacement windows completely fill the opening. Based on a sampling of rooms visited there does not appear to have been significant interior alterations made to accommodate the new windows. The metal sash/frames appear to have been butted up to the original trim detail on the interior. The current replacement window systems are not considered an acceptable substitute material under the Secretary of the Interior's guidelines for rehabilitation work. The replacement windows no longer function well, are drafty and in some locations are reported to leak.

It is recommended that the next generation of window renovation work correct these deficiencies by utilizing systems which improve energy conservation and enhance the historic character of the building by following guidance of the Secretary of the Interior's Standards for Rehabilitation.

REHABILITATION STANDARDS AND PROJECT IMPLEMENTATION

Work completed on buildings listed on the National Register of Historic Places must conform to the guidelines of the Secretary of the Interior's Standards for Rehabilitation (Standards) to maintain eligibility for that listing and the associated benefits of such listing including eligibility for grants and financial assistance not available to buildings not listed or determined eligible for listing.

The Standards (Attachment 1) provide guidance for rehabilitation treatments which retain and protect historic materials (fabric) thus protecting the character of the resource so its historic significance is not diminished. The National Park Service (NPS) publishes a series of useful Preservation Briefs (Attachment 2) which provide detailed discussions of appropriate treatments for historic buildings and materials including specific discussion on the subject of windows. The National Park Service also published a separate document focusing on replacement window approaches and requirements considered acceptable under the Standards (Attachment 3). Each of these documents is used as a basis for suggested remedial work proposed in this study.

Often people claiming extensive experience with the rehabilitation of historic buildings are not familiar with the Secretary of the Interior's Standards or do not adequately understand them. Extensive experience on "old" and even listed historic buildings does not necessarily equate to an understanding of appropriate treatments. When working on an historic building preference should be given to repairing deteriorated historic fabric over replacement whenever that is feasible. Workmen should be cautioned to protect significant historic features and held responsible to provide satisfactory repair if damage occurs.

STATE TAX CREDIT REHABILITATION INCENTIVE PROGRAM

Ownership structure also plays a significant role in available grant dollars making exploration of that element a critical piece of any initial planning. For example, Iowa has a preservation tax credit incentive program (*The State Historic Preservation and Cultural & Entertainment District Tax Credit Program*) which although not directly available to a government agency is available to and currently utilized by non-profit groups charged with "management" of historic property owned by a government agency. This has been accomplished through a structuring agreement establishing the non-profit as an authorized agent for the government agency. Through this partnership the incentive program helps participants recover rehabilitation costs of historic properties by providing a fully refundable tax credit equal to 25% of qualified

rehabilitation costs incurred on a project. Such a procedure requires professional legal and tax guidance beyond the scope of this report.

For more information on the state tax credit programs see:

http://www.iowahistory.org/historic-preservation/index.html under the "Tax Incentives for Rehabilitation" link or contact Elizabeth (Beth) Foster Hill, Tax Incentive Programs Manager/National Register Coordinator, at (515) 281-4137 or Beth.Foster@iowa.gov.

The state also has other grant opportunities which may be utilized for planning or actual construction. For additional information on these grants contact:

Kristen Vander Molen, Grants Manager
Phone: (515) 281-4228
E-mail: kristen.vandermolen@iowa.gov

The National Trust for Historic Preservation has several project planning grants that could be utilized to further develop the project.

National Trust for Historic Preservation, Midwest Office
Phone: (312) 939-5547
http://www.preservationnation.org/resources/find-funding/deadlines-and-special-programs.html
E-mail: grants@nthp.org

WINDOW REHABILITATION PROJECT

GENERAL

The window rehabilitation option considered in the study is thought to be acceptable under the Secretary of the Interior's Rehabilitation Standards (Standards). The selection of clad wood windows as the product was discussed with SHPO staff and deemed by them to meet the Standards. The following assumptions and architectural design parameters are used:

Assumptions made:

For Window Replacement:

- Costs for these systems are product intensive. Expenditures may go primarily to window manufacturer's located outside Muscatine County and depending on the system selected may go outside the state.
- Glass is selected to meet Rehabilitation Standards which may not be the highest performing glass available with respect to energy conservation.
- With the exception of required exit windows all sash will be non-operable. It is assumed there are no exit windows.
- Minimal replacement/repair of interior wood trim is required to facilitate window installation.

Replacement of Existing Doors

- The existing replacement door system would not be an acceptable treatment under the Standards if that work were proposed today as new work. The existing doors adversely impact historic character by imposing significant changes to the character of entry door openings, especially the main entrance. The mill finish of the doors and flat metal panning trim, deviations in sash and glass

configuration from historic configurations and existing door style selection are the primary reasons these units would be rejected.

- The Standards do allow for maintenance of noncompliant materials until that work becomes more extensive than the types of work normally associated with routine maintenance.

GUIDELINES FOR APPROPRIATE REPLACEMENT WINDOWS

No representative historic exterior windows survive on the building and so the guidance for this project is much less onerous than would be the case if historic sash remained. Guidance provided by the National Park Service for *Replacement Windows That Meet the Standards* (Attachment 3) is summarized as follows:

- Replacing existing incompatible, non-historic windows with similarly incompatible new windows does not meet the Standards
- Replacement windows need not precisely replicate the missing historic window
- The appearance, size and general type of replacement window must be consistent with the general characteristics of a historic window of the building type and construction era and be compatible with the historic appearance and character of the building
- Where possible the replacement should be based on physical or pictorial documentation
- Substitute materials may be permitted in lieu of matching historic materials.
- There may be additional flexibility with regard to the details of some windows on the north façade only, where openings are not highly visible

Glass characteristics are an important aspect in window replacement guidance offered in that attachment. Many of today's more advanced glass formulations and glass assemblies which may have improved thermal performance characteristics do not meet the basic test for compliance with the Standards which state (Attachment 5):

- Insulated glass is generally acceptable for new windows as long as it does not compromise other important aspects of the match.
- The clarity and reflectivity of standard clear window glass are significant characteristics of most windows. Because these characteristics are often diminished for old glass, new glass equivalent to the original should be the basis for evaluating the glazing proposed for new windows. Color should only be a noticeable characteristic of the new glass where it was historically, and any coating added must not perceptibly increase the reflectivity of the glass.

Following the guidance of the Secretary of the Interior's Standards (Standards) and the National Park Service guidance described above, window replacement options listed in the next subsection are considered acceptable.

WINDOW REPLACEMENT

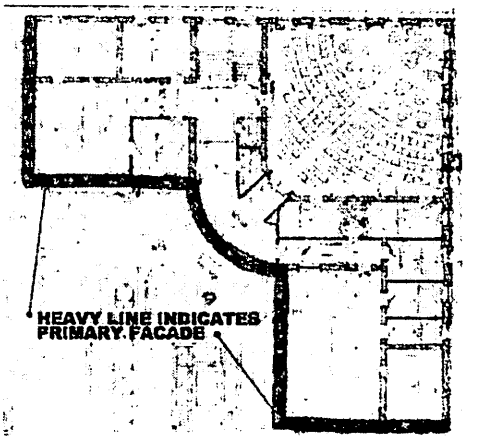
Replacement Sash and panning system with shaped metal brick mold including. Replacement systems considered is a metal clad wood replacement sash (similar to Pella's Architect's Series) or an all-aluminum system (similar to EFCO's Replica Series). Both systems are detailed to appear similar to historic double hung sash; however, most sashes will be inoperable.

ADDITIONAL ENERGY CONSERVATION MEASURES CONSIDERED

- Window awnings where historic documentation shows they once existed.
    - An alternate is considered to install awnings at additional openings.
- Replacement of primary entry door system including transom to improve energy conservation and appearance of primary public entry to coordinate with replacement windows.
- Air-lock vestibules at three entries where none now exist.

POTENTIAL PROJECT PHASING

The study also considers one potential phasing scenario with two distinct phases although additional phases could be developed if desirable. The proposed phases are:



PHASE I:

- Window replacement on the primary facades including south and west facing openings.
- Replacement of primary entry door system and transom on upper level entry as shown in Attachment 9.
- Air-lock vestibule at Parks and Rec entry west façade as shown in Attachment 9.

PHASE II

- Window replacement on the secondary facades including north and east facing openings.
- Air-lock vestibule at north entry as shown in Attachment 9.
- Air-lock entry at lower level entry below portico as shown in Attachment 9.
- Window awnings where historic documentation shows they once existed on second floor or at additional openings as shown on Attachment 4.

OPINIONS OF CONSTRUCTION COSTS

GENERAL

All dollar amounts are year 2013 values and have not been adjusted for projected (future) dollar values. Prevailing wage rates[2] have been used when calculating labor and material expenditures for the work described. The estimated prices are based on best judgments which can be made with available information. The full extent of work is in some areas obscured from view and can only be fully understood when actual construction starts and concealed conditions are exposed. Accordingly, the Consultant cannot warrant or represent that bids or negotiated prices will not vary from prices shown. Although a contingency amount cannot be included in your grant request, it is recommended that you carry funds totaling at least 10% of your anticipated project cost as reserve fund. These funds are intended to cover the cost of unforeseen work that may be discovered during the course of the project.

The assumption has been made that all work will be performed by a prime contractor[3] and not as separate contracts. The later approach is likely to increase project costs due in large part to increased administrative costs. Opinions of costs include the following markups:

General Project Requirements incl. Overhead and Profit..... 15%
Contingency 10%
Professional Fees 12%

[2] "Prevailing Wage Rates" are determined by the State Department of Labor and usually approximate local union rates.

[3] A "Prime Contractor" is one with a contract directly with the Owner; not a "subcontractor" who typically has a contract with the Prime Contractor.

REPLACEMENT WINDOW SYSTEM AND ADDITIONAL ENERGY CONSERVATION MEASURES COSTS

Replacement System (Aluminum Clad Wood)[4]	$330,000
and	
Awnings (six to twenty-four openings)	$17,000 - $60,000
Main Upper Entry Door and Transom	$38,000
Main Lower Entry (Vestibule A)[5]	$33,000
North Entry – off alley (Vestibule B)	$36,000
Parks and Rec Entry (Vestibule C)	$32,000
Total Project Cost	$486,000 to .$529,000
Potential Rehabilitation Tax Credit (25%)	($121,500 to..$132,250)
Project Cost including tax credit	**$364,500 to ..$396,750**

POTENTIAL PROJECT PHASING

The study also considers one possible phasing scenario with two distinct phases although additional phases could be developed if desirable. The proposed phases are:

PHASE I: ($260,000 less potential $65,000 State Rehabilitation Tax Credit or $195,000)

- Window replacement on the primary facades including south and west facing openings.
- Replacement of primary entry door system and transom on upper level entry as shown in Attachment 9.
- Air-lock vestibule at Parks and Rec entry west façade as shown in Attachment 9.

PHASE II ($262,000 less potential $65,500 State Rehabilitation Tax Credit assumes 5 year delay and 3%/yr inflation or $196,500 to $234,000 if additional awnings installed)

- Window replacement on the secondary facades including north and east facing openings.
- Air-lock vestibule at north entry as shown in Attachment 9.
- Air-lock entry at lower level entry below portico as shown in Attachment 9.
- Window awnings where historic documentation shows they once existed on second floor or at additional openings as shown on Attachment 4.
    - If additional eighteen awnings option is selected to provide twenty-four awnings in lieu of only six add $50,000 and increase potential State Rehabilitation Tax Credit an additional $12,500 for a total cost of $234,000)

ESTIMATED SYSTEM SERVICE LIFE

Based on historical evidence of existing wood windows still in operation after more than 150 years of service and the apparent durability of more contemporary materials, this study assumes that the service life of each new system is of equal duration. The actual service life of window systems is related to the maintenance received. Properly maintained windows will last for an indeterminate period of time.

[4] Based on pricing provided by Prairie Pella Inc. Attachment 8.

[5] Assumes frost footings are not necessary as slabs do not appear to interfere with operation of existing entry door at this location.

Each of the major systems has a level of required maintenance procedures and costs that differ from other systems; however, it cannot be simply stated that one system will outlast another. *For purposes of the Life Cycle Cost analysis a service life of 25 years is used.*

MAINTENANCE COSTS OF WINDOW SYSTEMS

Following are the maintenance procedures, assumed frequency and range of costs used in this study. The range of cost is shown to give an order of magnitude for each of the maintenance.

Washing: all glass surfaces 2 times/year. All glazing options considered result in the same number of glass surfaces (1 interior and 1 exterior). Fixed sash configuration requires use of lift equipment to reach exterior surfaces of many windows. **ALLOWANCE $7,000/YR.**

Painting: touch up of metal and prefinished component surfaces 1 time/10 years. Touch up for metal and prefinished systems is intended to repair scratches and other defects resulting from normal wear and tear. **ALLOWANCE $1,000/10YR.**

Broken Glass Replacement: assumed 0.25% of total glass area will require replacement of broken glass each year. **ALLOWANCE $400/YR.**

Insulating Glass Seal Failure: assumed 0.5% of total insulating glass area will require replacement of insulating glass because of failure of the vacuum seal at the perimeter of the glass panel. **ALLOWANCE $800/YR.**

Perimeter Sealant Failure: assumed restoring of perimeter sealant (sealant between window unit and adjacent construction) required 1 time/7 years. **ALLOWANCE $10,000/7YR.**

Contingency Repairs: Assumed a general allowance for unforeseen repairs and adjustments. **ALLOWANCE $400/YR.**

The Secretary of the Interior's Standards for Rehabilitation[1]

The Secretary of the Interior's Standards for Rehabilitation are ten basic principles created to help preserve the distinctive character of a historic building and its site, while allowing for reasonable change to meet new needs.

The Standards (**36 CFR Part 67**) apply to historic buildings of all periods, styles, types, materials, and sizes. They apply to both the exterior and the interior of historic buildings. The Standards also encompass related landscape features and the building's site and environment as well as attached, adjacent, or related new construction.

The Standards are applied to projects in a reasonable manner, taking into consideration economic and technical feasibility.

1. A property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment.
2. The historic character of a property shall be retained and preserved. The removal of historic materials or alteration of features and spaces that characterize a property shall be avoided.
3. Each property shall be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or architectural elements from other buildings, shall not be undertaken.
4. Most properties change over time; those changes that have acquired historic significance in their own right shall be retained and preserved.
5. Distinctive features, finishes, and construction techniques or examples of craftsmanship that characterize a historic property shall be preserved.
6. Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.
7. Chemical or physical treatments, such as sandblasting, that cause damage to historic materials shall not be used. The surface cleaning of structures, if appropriate, shall be undertaken using the gentlest means possible.
8. Significant archeological resources affected by a project shall be protected and preserved. If such resources must be disturbed, mitigation measures shall be undertaken.
9. New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.
10. New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

National Park Service Preservation Briefs

Hard copies of the Preservation Briefs may be purchased from the Government Printing Office or viewed on line at http://www.nps.gov/histoy/hps/tps/briefs/presbhom.htm.

1. The Cleaning and Waterproof Coating of Masonry Buildings
2. Repointing Mortar Joints in Historic Brick Buildings
3. Conserving Energy in Historic Buildings
4. Roofing for Historic Buildings
5. Preservation of Historic Adobe Buildings
6. Dangers of Abrasive Cleaning to Historic Buildings
7. The Preservation of Historic Glazed Architectural Terra-Cotta
8. Aluminum and Vinyl Siding on Historic Woodwork
9. The Repair of Historic Wooden Windows
10. Exterior Paint Problems on Historic Woodwork
11. Rehabilitating Historic Storefronts
12. The Preservation of Historic Pigmented Structural Glass
13. The Repair and Thermal Upgrading of Historic Steel Windows
14. New Exterior Additions to Historic Buildings: Preservation Concerns
15. Preservation of Historic Concrete: Problems and General Approaches
16. The Use of Substitute Materials on Historic Building Exteriors
17. Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character
18. Rehabilitating Interiors in Historic Buildings: Identifying Character-Defining Elements
19. The Repair and Replacement of Historic Wooden Shingle Roofs
20. The Preservation of Historic Barns
21. Repairing Historic Flat Plaster – Walls and Ceilings
22. The Preservation and Repair of Historic Stucco
23. Preserving Historic Ornamental Plaster
24. Heating, Ventilating, & Cooling Historic Buildings: Problems & Recommended Approaches
25. The Preservation of Historic Signs
26. The Preservation and Repair of Historic Log Buildings
27. The Maintenance & Repair of Architectural Cast Iron
28. Painting Historic Interiors
29. The Repair, Replacement, and Maintenance of Historic Slate Roofs
30. The Preservation and Repair of Historic Clay Tile Roofs
31. Mothballing Historic Buildings
32. Making Historic Properties Accessible
33. The Preservation and Repair of Historic Stained and Leaded Glass
34. Applied Decoration for Historic Interiors: Preserving Composition Ornament
35. Understanding Old Buildings
36. Protecting Cultural Landscapes
37. Appropriate Methods for Reducing Lead-Paint Hazards in Historic Housing
38. Removing Graffiti from Historic Masonry
39. Holding the Line: Controlling Unwanted Moisture in Historic Buildings
40. Preserving Historic Ceramic Tile Floors
41. The Seismic Retrofit of Historic Buildings: Keeping Preservation in the Forefront
42. The Maintenance, Repair and Replacement of Historic Cast Stone
43. The Preparation and Use of Historic Structures Reports
44. The Use of Awnings on Historic Buildings: Repair, Replacement and New Design
45. Preserving Historic Wooden Porches
46. The Preservation and Reuse of Historic Gas Stations
47. Maintaining the Exterior of Small and Medium Size Historic Buildings

Replacement Windows that Meet the Standards

The decision-making process for selecting replacement windows divides into two tracks depending on whether historic windows remain in place or no historic windows survive.

Replacement of Existing Historic Windows

When historic windows exist, they should be repaired when possible. When they are too deteriorated to repair, selection of the replacement windows must be guided by Standard 6. Design, visual qualities, and materials are specific criteria provided by the Standard that are pertinent to evaluating the match of a replacement window. Evaluating the adequacy of the match of the replacement window involves the consideration of multiple issues.

How accurate does the match need to be?

The more important a window is in defining the historic character of a building the more critical it is to have a close match for its replacement. Location is a key factor in two ways. It is usually a consideration in determining the relative importance of a building's various parts. For example, the street-facing facade is likely to be more important than an obscured rear elevation. The more important the elevation, feature or space of which the window is a part, the more important the window is likely to be, and thus, the more critical that its replacement be a very accurate match. Secondly, the location of the window can affect how much of the window's features and details are visible. This will affect the nature of an acceptable replacement. For example, windows at or near ground level present a different case from windows in the upper stories of a tall building.

Using the hierarchy of a building's features and taking into account the window's visibility, some general guidance can be drawn:

- Replacement windows on primary, street-facing or any highly visible elevations of buildings of three stories or less must match the historic windows in all their details and in material (wood for wood and metal for metal).

- Replacement windows on the primary, street-facing or any highly visible elevations that are part of the base of high-rise buildings must match the historic windows in all their details and in material (wood for wood and metal for metal). The base may vary in the number of stories, but is generally defined by massing or architectural detailing.

- Replacement windows on the primary, street-facing or highly visible elevations of tall buildings above a distinct base must match the historic windows in size, design and all details that can be perceived from ground level. Substitute materials can be considered to the extent that they do not compromise other important visual qualities.

Replacement windows on secondary elevations that have limited visibility must match the historic windows in size, configuration and general characteristics, though finer details may not need to be duplicated and substitute materials may be considered

- Replacement windows whose interior components are a significant part of the interior historic finishes must have interior profiles and finishes that are compatible with the surrounding historic materials. However, in most cases, the match of the exterior of a replacement window will take precedence over the interior appearance.

- Replacement windows in buildings or parts of buildings that do not fit into any of the above categories must generally match the historic windows in all their details and in material (wood for wood and metal for metal). Variations in the details and the use of substitute materials can be considered in individual cases where these differences result in only minimal change to the appearance of the window and in **no** change to the historic character of the overall building.

How well does the new window need to match the old?

The evaluation of the match of a replacement window depends primarily on its visual qualities. Dimensions, profiles, finish, and placement are all perceived in relative terms. For example, an eighth of an inch variation in the size of an element that measures a few inches across may be imperceptible, yet it could be more noticeable on the appearance of an element that is only half an inch in size. The depth of a muntin or the relative complexity of a brick mold profile are more often made visually apparent through the shadows they create. Thus, while comparable drawings are the typical basis for evaluating a replacement window, a three-dimensional sample or mock-up provides the most definitive test of an effective visual match.

The way a historic window operates is an important factor in its design and appearance. A replacement window, however, need not operate in the same manner as the historic window or need not operate at all as long as the change in operation does not change the form and appearance of the window to the point that it does not match the historic window or otherwise impair the appearance and character of the building.

Factors to consider in evaluating the match of a replacement window:

- **Window unit placement** in relation to the wall plane; the degree to which the window is recessed into the wall.

    - The location of the window affects the three-dimensional appearance of the wall.

- **Window frame size and shape**. For example, with a wood window, this would include the brick mold, blind stop, and sill.

    - The specific profile of the brick mold is usually less critical than its overall complexity and general shape, such as stepped or curved.

    - Typical sight lines reduce the importance of the size and profile of the sill on windows high above ground level, especially when the windows are deeply set in the wall.

    - Though a blind stop is a small element of the overall window assembly, it is a noticeable part of the frame profile and it is an important part of the transition between wall and glass.

- Steel windows that were installed as a building's walls were constructed have so little of their outer frame exposed that any replacement window will necessitate some addition to this dimension, but it must be minimal.

- **Glass size and divisions.**

  - Muntins reproduced as simulated divided lights – consisting of a three-dimensional exterior grid, between-the-glass spacers, and an interior grid – may provide an adequate match when the dimensions and profile of the exterior grid are equivalent to the historic muntin and the grid is permanently affixed tight to the glass.

- **Sash elements width and depth.** For example with a wood window, this would include the rails, stiles and muntins; with a steel window, this would include the operator frame and muntins.

  - The depth of the sash in a double-hung window, or its thickness, affects the depth of the offset at the meeting rail of a hung window. This depth is perceived through the shadow that it creates.

  - Because of its small size, even slight differences in the dimension of a muntin will have a noticeable effect on the overall character of a window. Shape, as well as depth, is important to the visual effect of a muntin.

  - The stiles of double-hung historic windows align vertically and are the same width at the upper and lower sashes. The use of single-hung windows as replacements may alter this relationship with varying effects on the appearance of a window. In particular, when the distinction between the frame and the sash is blurred, details such as lugs may be impossible to accurately reproduce.

  - Meeting rails of historic windows were sometimes too narrow to be structurally sound. Reproducing a structurally-inadequate condition is not required.

  - The operating sash of a steel window is usually wider than the overall muntin grid of the window. In addition, the frame of the operating sash often has slight projections or overlaps that vary from the profile of the surrounding muntins. The shadow lines the muntins create add another important layer to the three-dimensional appearance of the window.

- **Materials and finish.**

  - While it may be theoretically possible to match all the significant characteristics of a historic window in a substitute material, in actuality, finish, profiles, dimensions and details are all affected by a change in material.

  - In addition to the surface characteristics, vinyl-clad or enameled aluminum-clad windows may have joints in the cladding that can make them look very different from a painted wood window.

  - Secondary window elements that do not match the finish or color of the window can also diminish the match. Examples include white vinyl tracks on dark-painted wood windows or wide, black, glazing gaskets on white aluminum windows.

Glass characteristics.

- Insulated glass is generally acceptable for new windows as long as it does not compromise other important aspects of the match.

- The clarity and reflectivity of standard clear window glass are significant characteristics of most windows. Because these characteristics are often diminished for old glass, new glass equivalent to the original should be the basis for evaluating the glazing proposed for new windows. Color should only be a noticeable characteristic of the new glass where it was historically, and any coating added must not perceptibly increase the reflectivity of the glass.

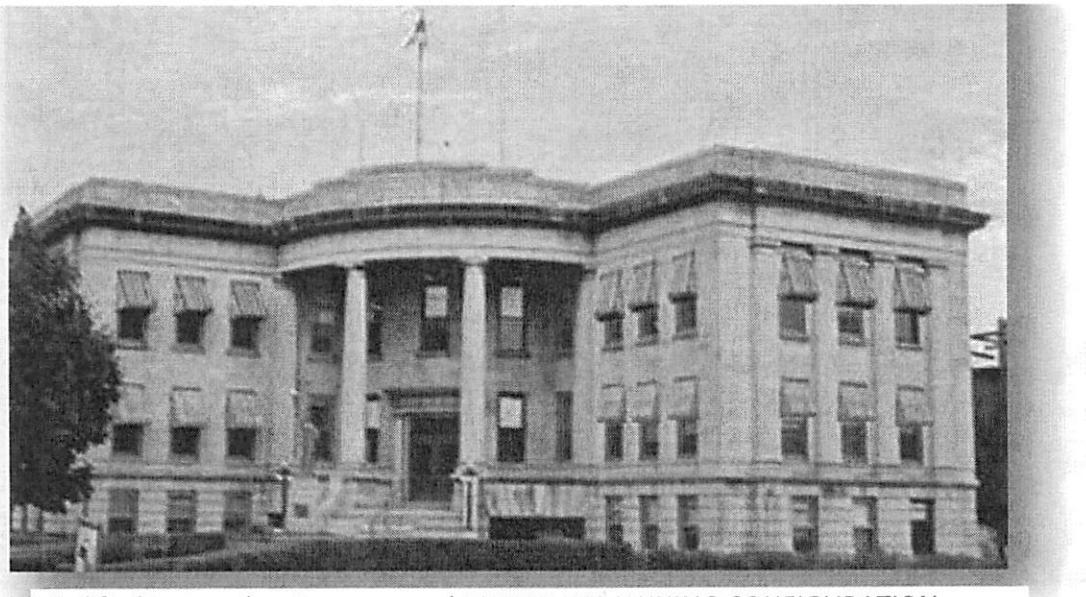
- Where the glazing is predominantly obscure glass, it may be replaced with clear glass, but some evidence of the historic glazing must be retained, either in parts of windows or in selected window units.

Replacement Windows Where No Historic Windows Remain

Replacement windows for missing or non-historic windows must be compatible with the historic appearance and character of the building. Although replacement windows may be based on physical or pictorial documentation, if available, recreation of the missing historic windows is not required to meet the Standards. Replacement of missing or non-historic windows must, however, always fill the original window openings and must be compatible with the overall historic character of the building. The general type of window – industrial steel, wood double-hung, etc. – that is appropriate can usually be determined from the proportions of the openings, and the period and historic function of the building. The appearance of the replacement windows must be consistent with the general characteristics of a historic window of the type and period, but need not replicate the missing historic window. In many cases, this may be accomplished using substitute materials. There may be some additional flexibility with regard to the details of windows on secondary elevations that are not highly visible, consistent with the approach outlined for replacing existing historic windows. Replacing existing incompatible, non-historic windows with similarly incompatible new windows does not meet the Standards.

December 2007

Postcard showing awnings on one wing of the building ca 1950. This documentation could be used to support installation of awnings on the same windows or an alternate proposal to include additional openings as shown below.



Modified image showing proposed ALTERNATE AWNING CONFIGURATION.

GLASS PERFORMANCE VALUES

Cardinal IG

Muscatine City Hall 2013

INSULATING GLASS PERFORMANCE COMPARISON

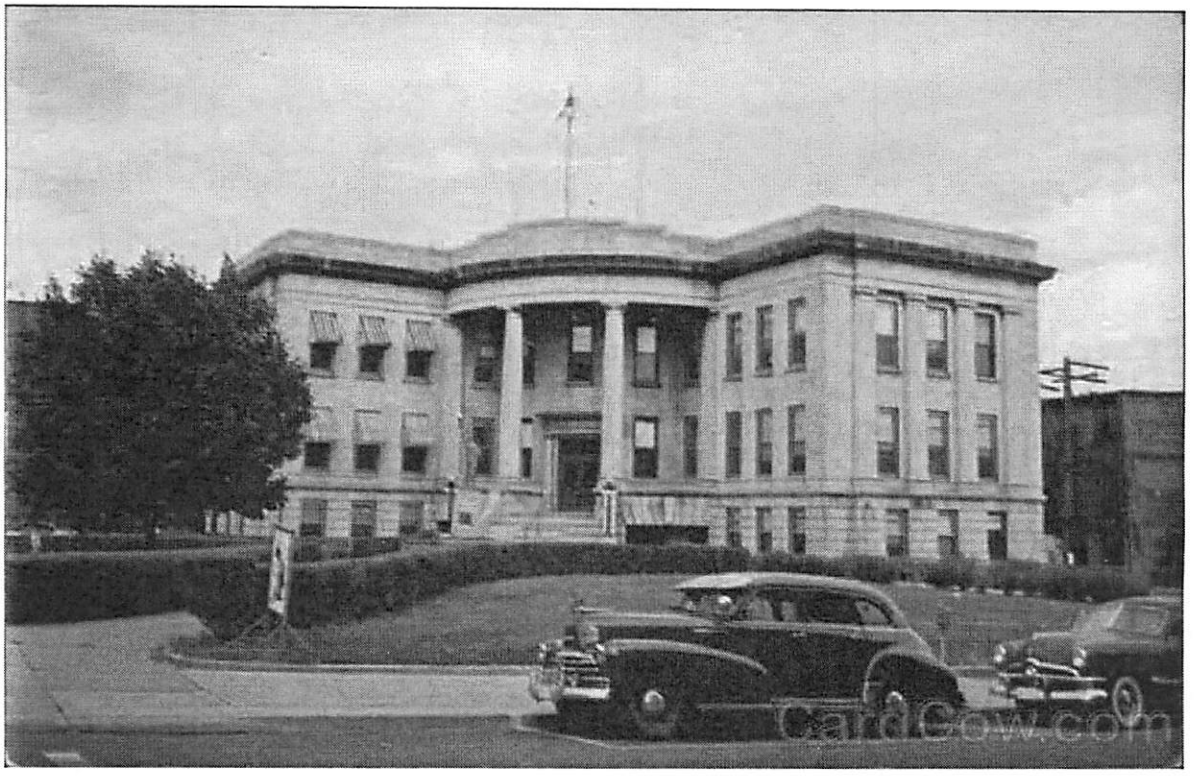
Product	Glass Thickness	Visible Light						Center of Glass Winter U-Value Btu/hr/ft²/°F		UV Trans	Krochman Damage (Fx)	ISO Fading Function
		Trans. %	Reflectance % Out	Reflectance % In	SHGC	SC	RHG	Air	Argon 90%	300-380 nm	300-600nm	300-700 nm
Two Pane LoE-180 #3	2.2/13.0/2.2C8	80	15	15	0.696	0.80	163	0.31	0.26	30	42	63
"	3.0/13.0/3.0C8	79	15	15	0.685	0.79	161	0.31	0.26	29	42	3
"	3.9/13.0/3.9C8	79	15	15	0.667	0.77	157	0.31	0.26	27	41	62
"	4.7/13.0/4.7C8	78	14	15	0.657	0.76	155	0.31	0.26	26	39	61
"	5.7/13.0/5.7C8	77	14	15	0.638	0.74	150	0.30	0.26	24	38	60

NOTES:

(1) Data was calculated using the Window 5.2 computer program.

(2) Comfort Indoor Glass Temperatures are for the center portion of the glass. Winter and Summer ASHRAE conditions used for calculations.

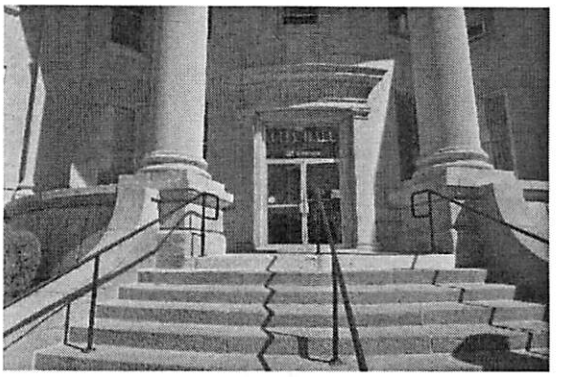
Attachment 5 (Page 1 of 1)



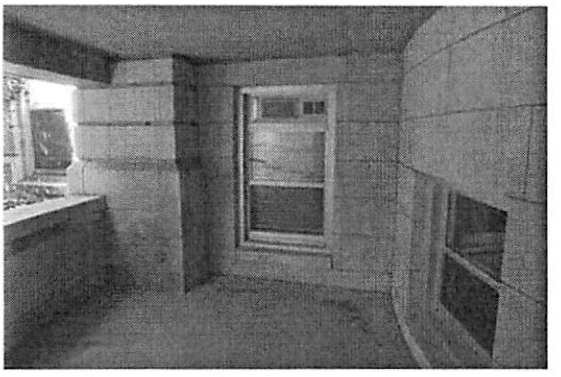
POST CARD CIRCA 1950.

SEPTEMBER 2013

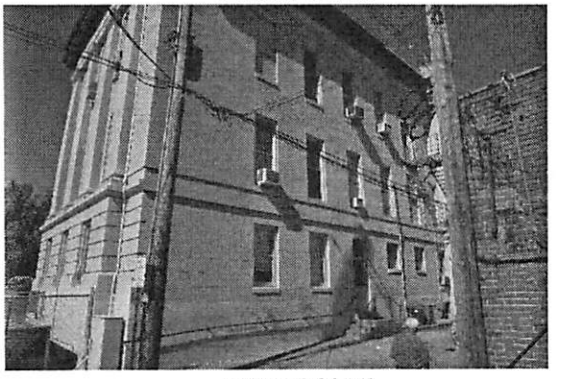
PRIMARY FACADE



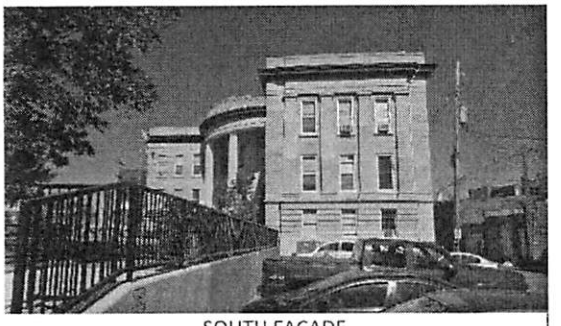
MAIN ENTRANCE



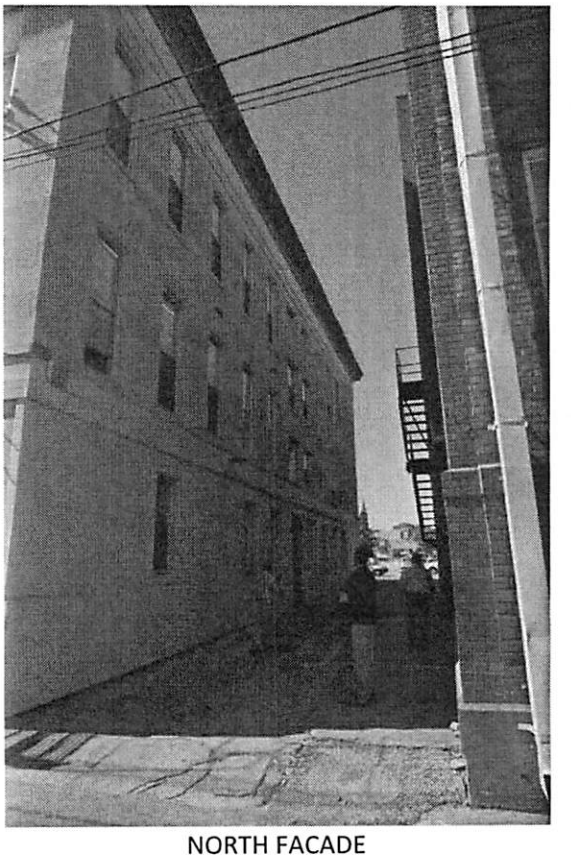
LOWER ENTRY



EAST FACADE



SOUTH FACADE



NORTH FACADE

Budgetary Proposal for

Pella Architect Series Windows

Muscatine City Hall

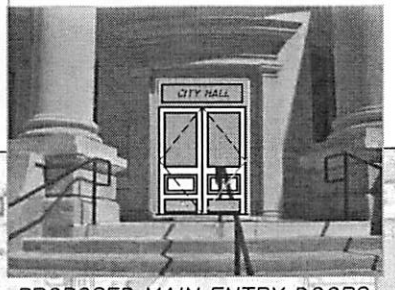
Scope of Proposal:	**We propose to provide Pella Architect Series windows for the Muscatine City Hall. The proposal was prepared from site visual inspection, rough field measurements and several existing building drawings. The budgetary proposal is limited to the quantities and specifications contained herein. Prairie Pella and Pella Corporation reserve the right to withdraw this proposal at any time without explanation.**
Products:	**Architect Series Double-Hungs, Monumental Hung and Awning Windows**
Frame:	**Select softwood, water-repellent, preservative-treated with EnduraGuard Triple protection in accordance with WDMA I.S.-4. EnduraGuard triple protection formula includes water repellency, three active fungicides and an insecticide applied to the frame. Interior surfaces are pine.**
Sash:	**Select softwood, water-repellent, preservative-treated with EnduraGuard Triple protection in accordance with WDMA I.S.-4. Interior surfaces are pine. Exterior surfaces are clad with aluminum, lap-joined and sealed. Corners are mortised and tenoned, glued and secured with metal fasteners.**
Exterior/Interor:	**Aluminum Clad exterior shall be finished with EnduraClad protective finish in a multi-step, baked –on finish. Color to be selected from Pella standard colors. Interior is stained and finished. Color to be selected from Pella standard colors.**
Glazing:	**Silicon-glazed dual seal insulated glass, Advanced LowE with argon.**
Hardware:	**Includes hardware. (No screens).**
Exterior Trim:	**Lineal aluminum frame expanders and aluminum brick mould profiles, Selected from Pella standard profiles, shall be finished with Enduraclad Protective finish in multi-step baked on finish. Color to be selected from Pella standard colors**
Shop Drawings:	**Installation shop drawings prepared by Pella Corp. Architectural Services**
Delivery:	**FOB Jobsite**

Excluded items:	**Installation Labor** **Jobsite storage and protection** **Miscellaneous wood locking and shims** **Flashing, sealants and insulation** **Backer rod** **Interior casings, trim and moldings** **Final cleaning and label removal** **Entry doors**
Quantity:	**99 window units**

Base cost[1]	**$127,500.00**
Add	**$1,450.00 for simulated (fixed) Double Hung and no screen.**
TOTAL	**$128,950.00 + any applicable tax**

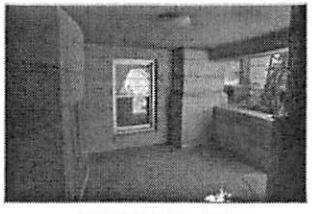
Submitted by:
Clay Hollmer
Prairie Pella Inc.
Senior Sales Representative
563 370-4333 cell
563 441-1756 office
chollmer@pellainc.com

[1] Modified to reflect additional cost to provide simulated divided light double hung units and credit for omitting screens from project since windows will not be operable.



PROPOSED MAIN ENTRY DOORS

PROPOSED DOOR AT PARKS AND REC



EXISTING AT VESTIBULE A

EXISTING AT VESTIBULE B

EXISTING AT VESTIBULE C

1 SK1 Lower Level Vestibules

SCALE: not to scale

N E S W

THIS DRAWING IS CONCEPTUAL ONLY. DO NOT USE FOR REGULATORY APPROVAL, BIDDING, PERMITTING OR CONSTRUCTION.

PROPOSED RENOVATIONS TO
Muscatine City Hall
215 Sycamore Street Muscatine, Iowa

Douglas J. Steinmetz AIA
4121 Timberview Drive NE Phone 319-294-4905
Cedar Rapids, IA 52411 Fax 319-892-0568
doug@djsaia.com

REVISIONS

SK1
DATE: OCT 2013
Lower Level Floor Plan
SHEET ___ OF ___

City of Muscatine City Hall HVAC Study
#201309.00
12-Nov-13

Option 1: Variable Refrigerant Flow Without Geothermal Loop Field

Building Area (ft^2)	17,160
Net occupiable Building Area (ft^2)	15,590
Total Cooling Load (tons)	30
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Variable Refrigerant Flow (Turn-key with Refrigerant Piping, Controls, Lossnay DOAS, Test & Training Included)	30	TON	$6,500.00	$195,000.00
Variable Refrigerant Flow 3 Ton CAC Unit	1	EACH	$15,000.00	$15,000.00
VRF Installation Cost	1	LUMP	$90,000.00	$90,000.00
Humidifier	3	EACH	$1,000.00	$3,000.00
Miscellaneous Piping (Condensate Drain)	900	L.F.	$20.00	$18,000.00
Piping Insulation	900	L.F.	$10.00	$9,000.00
New Ventilation Ductwork	2000	LBS.	$11.00	$22,000.00
New Ventilation Ductwork Insulation	1600	S.F.	$3.20	$5,120.00
Structural Reinforcement for Roof Mounted Equipment	1	LUMP	$25,000.00	$25,000.00
Roof Repair for Air Cooled Equipment Supports & Penetrations	1	LUMP	$5,000.00	$5,000.00
Crane Time	1	LUMP	$5,000.00	$5,000.00
DDC Controls - Extra outside of VRF	1	LUMP	$30,000.00	$30,000.00
Test and Balance - Equipment	1	LUMP	$10,000.00	$10,000.00
			SUB-TOTAL	$432,120.00
Labor Adjustment for Remodel of Office (7%)				$ 30,248.40
			TOTAL	$462,368.40

ELECTRICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
Demolition: Remove exisitng electrical service	1	LUMP	$2,500	$2,500
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$7,000	$7,000
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeder to roof-top hvac equipment	115	LF	$28	$3,220
GFI, Duplex on roof at HVAC equipment	1	LUMP	$700	$700
Back-feed exisitng service equipment from new MDP	1	LUMP	$1,750	$1,750
Electrical Connection for VRF terminal units	70	EACH	$95	$6,650
Electrical feeders to VRF terminal units	600	LF	$11	$6,600
			TOTAL	$51,220

Mechanical and Electrical Total Cost		$513,588.40
High/Low Range Totals	High (+25%)	$641,985.50
	Low (-25%)	$385,191.30

Note:
1. The plus or minus range represents what we might expect the cost variation between high and low might be.

Option 2: New heat pumps, cooling tower, reuse existing boilers and hot water pumps

Building Area (ft^2)	17,160
Net occupiable Building Area (ft^2)	15,590
Total Cooling Load (tons)	30
Total Heating Load (MBH)	427

MECHANICAL				
ITEM	**QUANTITY**	**UNITS**	**COST PER**	**COSTS**
-INSTALL-				
Heat Pump Loop Circulating Pumps (225 GPM 5 H.P.)	2	EACH	$4,125.00	$8,250.00
VFD for Heat Pump Loop Pumps (5 H.P.)	2	EACH	$3,700.00	$7,400.00
Heat Pump Loop Piping	1	LUMP	$200,000.00	$200,000.00
Heat Pump Loop Pining Insulation	1	LUMP	$50,000.00	$50,000.00
Booster Circulating Pumps for Heat Pumps (1/8 H.P.)	6	EACH	$1,200.00	$7,200.00
Roof Mounted Cooling Tower (30 Tons)	1	EACH	$40,000.00	$40,000.00
Structural Reinforcement for Roof Mounted Equipment	1	LUMP	$25,000.00	$25,000.00
Heat Exchanger (Shell-Type, Liquid-to-Liquid 75 GPM)	1	EACH	$12,000.00	$12,000.00
Dirt/Air Separators	2	EACH	$2,450.00	$4,900.00
Water to Air Heat Pumps	6	EACH	$10,000.00	$60,000.00
Miscellaneouse Piping (Condensate Drain)	900	L.F.	$20.00	$18,000.00
Supply & Return Duct for Water to Air Heat Pumps	1	LUMP	$40,000.00	$40,000.00
Multizone control system for heat pump	6	EACH	$5,000.00	$30,000.00
Water to Water Heat Exchanger	1	EACH	$12,000.00	$12,000.00
Humidifier	2	EACH	$1,000.00	$2,000.00
Slipstream Dehumidifier for ventilation air	2	EACH	$1,375.00	$2,750.00
New Filtration	6	EACH	$455.00	$2,730.00
Energy Recovery Ventilator/DOAS	1	EACH	$25,000.00	$25,000.00
3 Ton CAC Split System DX Unit	1	EACH	$21,500.00	$21,500.00
Crane Time	1	LUMP	$5,000.00	$5,000.00
DDC/Demand Control Ventilation	1	LUMP	$75,000.00	$75,000.00
Test and Balance - Equipment	1	LUMP	$20,000.00	$20,000.00
Remodel/Repair for Cooling Tower Relocation to Roof	1	LUMP	$5,500.00	$5,500.00
-DEMO-				
Piping - DEMO	1400	L.F.	$3.61	$5,054.00
Existing Radiators and Associated Piping - DEMO	1	LUMP	$10,000.00	$10,000.00
			SUB-TOTAL	$689,284.00
Labor Adjustment for Remodel (7%)				$48,249.88
			TOTAL	$737,533.88

ELECTRICAL				
ITEM	QUANTITY	UNITS	COST PER	COSTS
Demolition: Remove exisitng electrical service	1	LUMP	$2,500	$2,500
New electrical service: 120/208 volts, 3 phase, 400 amp & metering	1	LUMP	$7,000	$7,000
New Main Distribution Panel: 120/208 volts, 400 amp main circuit breaker	1	LUMP	$16,000	$16,000
Circuit breaker panelboard: 120/208 volts, 100 amp	1	LUMP	$6,800	$6,800
Feeder to roof-top hvac equipment	115	LF	$28	$3,220
GFI, Duplex on roof at HVAC equipment	1	LUMP	$700	$700
Back-feed exisitng service equipment from new MDP	1	LUMP	$1,750	$1,750
Electrical Connection for heat pump terminal units	70	EACH	$95	$6,650
Electrical feeders to heat pump terminal units	9800	LF	$11	$107,800
Electrical feeders and connections to new pumps in Boiler Room	2	EACH	$800	$1,600
			TOTAL	$ 154,020

Mechanical and Electrical Total Cost		$891,554
High/Low Range Totals	High (+25%)	$1,114,442.35
	Low (-25%)	$668,665.41

Note:

1. The plus or minus range represents what we might expect the cost variation between high and low might be.

City of Muscatine City Hall HVAC Study
#201309.00

Maintenance Cost (¢/sq. ft.)
C = 84.70 + 0.18n + h + c + d
where,
n = age in years
h = heating equipment
c = cooling equipment
d = distribution system

Building Area (ft^2) 17,160

OPTIONS	n	h	c	d	C (¢/ft^2)
1	0	-24.58	-11.97	-7.04	41.11
2	0	2.38	-11.97	-7.04	68.07

Total Maintenance
$7,054.48
$11,680.81

Option 1
For heating equipment, h,heat pump was chosen
For cooling equipment, c, heat pump
For distribution system, d, two-pipe fan coil was chosen

Option 2
For heating equipment, h, cast iron boiler was chosen
For cooling equipment, c, water source heat pump
For distribution system, d, two-pipe fan coil

City of Muscatine City Hall HVAC Study
#201309.00

Existing Energy Costs for Average Cost Per kWh and Therm 2012

usage (kWh)	Bill ($)	$/kWh		
10,160	--	--	feb	2012
11,680	--	--	mar	2012
9,840	--	--	apr	2012
14,160	--	--	may	2012
20,320	--	--	june	2012
21,440	--	--	july	2012
17,760	--	--	aug	2012
10,880	--	--	sept	2012
10,480	--	--	oct	2012
9,920	--	--	nov	2012
11,280	--	--	dec	2012
10,640	--	--	jan	2013
Average	$ -	$ -		

usage (therm)	Bill ($)	$/therm		
3,013	$ 2,259.30	0.75	feb	2012
2,237	$ 1,632.39	0.73	mar	2012
203	$ 160.39	0.79	apr	2012
91	$ 72.81	0.80	may	2012
10	$ 22.40	2.24	june	2012
-	$ -	0.00	july	2012
-	$ -	0.00	aug	2012
12	$ 29.97	2.50	sept	2012
42	$ 48.27	1.15	oct	2012
662	$ 453.39	0.68	nov	2012
1,161	$ 896.07	0.77	dec	2012
2,088	$ 1,566.93	0.75	jan	2013
	$ 7,141.92	$ 1.12		

Total $ 7,141.92
Usage
electricity 158,560 *
gas 9,519 therm

*The City of Muscatine does not currently pay for electricity. $/kWh rates used throughout this study have been estimated from past Muscatine projects.

SOURCE-JB-ID	VENDOR/CUSTOMER/EXPLANATION	REF/REC/CHK	INVOICE	P.O.	F	9	AMOUNT	DESCRIPTION	FIL
							ANNUAL AMENDED BUDGET / ENCUMBERED / ACT MTD POSTED AND IN PROCESS / ACT YTD POSTED AND IN PROCESS / REMAINING BALANCE / PCT		
1000	GENERAL FUND								
1151	BUILDINGS AND GROUNDS COMMUNICATIONS AND UTILITIES								
65310	GAS						26,000.00 / 0.00 / 1,293.38 / 24,548.98 / 1,451.02 / 94	---------	
V-081511-569	000147 ALLIANT ENERGY	110340	49300519585-01		N		577.18	JUL GAS-LIB	A
V-082311-696	000147 ALLIANT ENERGY	110585	49300559511-01		N		62.56	JULY GAS-ART	A
V-082311-696	000147 ALLIANT ENERGY	110585	49301674840-02		N		43.79	JULY GAS-PSB FIRE	A
V-082311-696	000147 ALLIANT ENERGY	110585	49301677420-01		N		20.32	JULY GAS-CITY HALL	A
V-090911-795	000147 ALLIANT ENERGY	110761	49300519585-01		N		379.47	AUG GAS-LIB	A
V-093011-981	000147 ALLIANT ENERGY	110971	49301674840-02		N		43.60	AUG GAS-PSB FIRE	A
V-093011-981	000147 ALLIANT ENERGY	110971	49301677420-01		N		20.98	AUG GAS-CITY HALL	A
V-102411-182	000147 ALLIANT ENERGY	111428	49300519585-01		N		494.29	SEP GAS-LIB	A
V-102411-182	000147 ALLIANT ENERGY	111428	49301674840-02		N		37.84	SEP GAS-PSB FIRE	A
V-102411-182	000147 ALLIANT ENERGY	111428	49301677420-01		N		77.54	SEP GAS-CITY HALL	A
V-103111-182	000147 ALLIANT ENERGY	111428	49301677810-02		N		24.12	SEP GAS-LOT 8 GARAGE	A
V-111011-244	000147 ALLIANT ENERGY	111641	49300519585-01		N		1,088.89	OCT GAS-LIB	A
V-112311-328	000147 ALLIANT ENERGY	111861	49301674840-02		N		41.95	OCT GAS-PSB FIRE	A
V-112311-328	000147 ALLIANT ENERGY	111861	49301677420-01		N		633.92	OCT GAS-CITY HALL	A
V-112311-328	000147 ALLIANT ENERGY	111861	49301677810-02		N		44.91	OCT GAS-LOT 8 GARAGE	A
V-121211-408	000147 ALLIANT ENERGY	112010	49300519585-01		N		1,254.92	NOV GAS-LIB	A
V-122911-518	000147 ALLIANT ENERGY	112193	49301674840-02		N		57.37	NOV GAS-PSB FIRE	A
V-122911-518	000147 ALLIANT ENERGY	112193	49301677420-01		N		2,061.65	NOV GAS-CITY HALL	A
V-122911-518	000147 ALLIANT ENERGY	112193	49301677810-02		N		107.60	NOV GAS-LOT 8 GARAGE	A
V-123011-518	000147 ALLIANT ENERGY	112193	49300559511-01		N		950.43	NOV GAS-ART CTR	A
V-013012-711	000147 ALLIANT ENERGY	112607	49300519585-01		N		1,231.43	DEC GAS-LIB	A
V-013012-711	000147 ALLIANT ENERGY	112607	49300559511-01		N		895.25	DEC GAS-ART	A
V-013012-711	000147 ALLIANT ENERGY	112607	49301674840-02		N		61.60	DEC GAS-PSB FIRE	A
V-013012-711	000147 ALLIANT ENERGY	112607	49301677420-01		N		1,512.55	DEC GAS-CITY HALL	A
V-013012-711	000147 ALLIANT ENERGY	112607	49301677810-02		N		109.89	DEC GAS-LOT 8 GARAGE	A
V-022312-878	000147 ALLIANT ENERGY	112995	49300519585-01		N		1,986.47	JAN GAS-LIB	A
V-022312-878	000147 ALLIANT ENERGY	112995	49301674840-02		N		36.94	JAN GAS-PSB FIRE	A
V-022312-878	000147 ALLIANT ENERGY	112995	49301677420-01		N		2,259.30	JAN GAS-CITY HALL	A
V-022312-878	000147 ALLIANT ENERGY	112995	49301677810-02		N		115.78	JAN GAS-LOT 8 GARAGE	A
V-022712-878	000147 ALLIANT ENERGY	112995	49300559511-01		N		799.34	JAN GAS-ART	A
V-030912-950	000147 ALLIANT ENERGY	113175	49300519585-01		N		565.38	FEB GAS-LIB	A
V-031212-950	000147 ALLIANT ENERGY	113175	49300984580-03		N		836.51	FEB GAS-SOUTH FIRE	A
V-033012-096	000147 ALLIANT ENERGY	113359	49300559511-01		N		499.25	FEB GAS-ART	A
V-033012-096	000147 ALLIANT ENERGY	113359	49301674840-02		N		53.79	FEB GAS-PSB FIRE	A
V-033012-096	000147 ALLIANT ENERGY	113359	49301677420-01		N		1,632.39	FEB GAS-CITY HALL	A
V-033012-096	000147 ALLIANT ENERGY	113359	49301677810-02		N		94.94	FEB GAS-LOT 8 GARAGE	A
V-041612-185	000147 ALLIANT ENERGY	113593	49300519585-01		N		833.56	MAR GAS-LIB	A
V-042712-265	000147 ALLIANT ENERGY	113796	49300559511-01		N		310.54	MAR GAS-ART	A
V-042712-265	000147 ALLIANT ENERGY	113796	49300916905-01		N		74.26	APR GAS-SO FIRE	A
V-042712-265	000147 ALLIANT ENERGY	113796	49301674840-02		N		56.69	MAR GAS-PSB FIRE	A

SOURCE-JE-ID	VENDOR/CUSTOMER/EXPLANATION	REF/REC/CHK	INVOICE	P.O.	F	9	AMOUNT	DESCRIPTION	FIL
		ANNUAL AMENDED BUDGET	ENCUMBERED	ACT MTD POSTED AND IN PROCESS	ACT YTD POSTED AND IN PROCESS		REMAINING BALANCE	PCT	
1000	GENERAL FUND								
1151	BUILDINGS AND GROUNDS COMMUNICATIONS AND UTILITIES								
65310	GAS								
V-042712-265	000147 ALLIANT ENERGY	113796	49301677420-01		N		160.39	MAR GAS-CITY HALL—	A
V-042712-265	000147 ALLIANT ENERGY	113796	49301677810-02		N		29.22	MAR GAS-LOT 8 GARAGE	A
V-051112-328	000147 ALLIANT ENERGY	113980	49300519585-01		N		835.31	APR GAS-LIB	A
V-053112-496	000147 ALLIANT ENERGY	114181	49300559511-01		N		61.43	APR GAS-ART CTR—	A
V-053112-496	000147 ALLIANT ENERGY	114181	49300916905-01		N		31.99	MAY GAS-SOUTH FIRE	A
V-053112-496	000147 ALLIANT ENERGY	114181	49301674840-02		N		48.57	APR GAS-PSB FIRE	A
V-053112-496	000147 ALLIANT ENERGY	114181	49301677420-01		N		72.81	APR GAS-CITY HALL—	A
V-053112-496	000147 ALLIANT ENERGY	114181	49301677810-02		N		26.69	APR GAS-LOT 8 GARAGE	A
V-061812-573	000147 ALLIANT ENERGY	114421	49300519585-01		N		430.23	MAY GAS-LIB	A
C-063012-920	YEAR END CLOSING						24,548.98-	GAS	A
V-063012-678	000147 ALLIANT ENERGY	114694	49300559511-01		N		24.48	MAY GAS-ART—	A
V-063012-678	000147 ALLIANT ENERGY	114694	49300916905-01		N		25.67	JUN GAS-SOUTH FIRE	A
V-063012-678	000147 ALLIANT ENERGY	114694	49301674840-02		N		51.89	MAY GAS-PSB FIRE	A
V-063012-678	000147 ALLIANT ENERGY	114694	49301677420-01		N		22.40	MAY GAS-CITY HALL—	A
V-063012-678	000147 ALLIANT ENERGY	114694	49301677810-02		N		24.81	MAY GAS-LOT 8 GARAGE	A
V-063012-762	000147 ALLIANT ENERGY	114899	49300519585-01		N		615.51	JUN GAS-LIB	A
V-063012-874	000147 ALLIANT ENERGY	115115	49300559511-01		N		21.67	JUN GAS-ART—	A
V-063012-874	000147 ALLIANT ENERGY	115115	49301674840-02		N		52.39	JUN GAS-PSB FIRE	A
V-063012-874	000147 ALLIANT ENERGY	115115	49301677810-02		N		24.33	JUN GAS-LOT 8 GARAGE	A
TOTAL:	COMMUNICATIONS AND UTILITIES	26,000.00	0.00	1,293.38	24,548.98		1,451.02	94 ---------	
TOTAL:	BUILDINGS AND GROUNDS	26,000.00	0.00	1,293.38	24,548.98		1,451.02	94 ---------	
TOTAL:	GENERAL FUND	26,000.00	0.00	1,293.38	24,548.98		1,451.02	94 ---------	

ART CENTER
$ 3,624.95 (MUSEUM/CARRIAGE HOUSE)

CITY HALL
$ 8,474.25

SOURCE-JE-ID	VENDOR/CUSTOMER/EXPLANATION	REF/REC/CHK	INVOICE	P.O.	F	9	AMOUNT	DESCRIPTION	FIL
		ANNUAL AMENDED BUDGET	ENCUMBERED	ACT MTD POSTED AND IN PROCESS			ACT YTD POSTED AND IN PROCESS	REMAINING BALANCE PCT	
1000	GENERAL FUND								
1151	BUILDINGS AND GROUNDS COMMUNICATIONS AND UTILITIES								
65310	GAS	26,000.00	0.00	0.00			26,848.49	848.49- 103	
V-073112-978	000147 ALLIANT ENERGY	115307	49300916905-01		N		22.62	JUL GAS-SOUTH FIRE	A
V-083012-132	000147 ALLIANT ENERGY	115538	49300559511-01		N		21.00	JUL GAS-ART—	A
V-083012-132	000147 ALLIANT ENERGY	115538	49300916905-01		N		30.33	AUG GAS-SOUTH FIRE	A
V-083012-132	000147 ALLIANT ENERGY	115538	49301674840-02		N		52.61	JUL GAS-PSB FIRE	A
V-083012-132	000147 ALLIANT ENERGY	115538	49301677810-02		N		23.69	JUL GAS-LOT 8 GARAGE	A
V-091412-239	000147 ALLIANT ENERGY	115785	49300519585-01		N		697.24	AUG GAS-LIB	A
V-091412-239	000147 ALLIANT ENERGY	115785	49301674840-02		N		53.33	AUG GAS-PSB FIRE	A
V-091412-239	000147 ALLIANT ENERGY	115785	49301677810-02		N		24.47	AUG GAS-LOT 8 GARAGE	A
V-092412-366	000147 ALLIANT ENERGY	115992	49300559511-01		N		23.85	AUG GAS-ART—	A
V-093012-366	000147 ALLIANT ENERGY	115992	49300916905-01		N		37.59	SEP GAS-SOUTH FIRE	A
V-101212-445	000147 ALLIANT ENERGY	116228	49300519585-01		N		777.27	SEP GAS-LIB	A
V-101212-445	000147 ALLIANT ENERGY	116228	49301677420-02		N		29.97	AUG GAS-CITY HALL—	A
V-102512-551	000147 ALLIANT ENERGY	116493	49300559511-01		N		20.17	SEP GAS-ART—	A
V-102512-551	000147 ALLIANT ENERGY	116493	49300916905-01		N		84.75	OCT GAS-SOUTH FIRE	A
V-102512-551	000147 ALLIANT ENERGY	116493	49301674840-02		N		55.03	SEP GAS-PSB FIRE	A
V-102512-551	000147 ALLIANT ENERGY	116493	49301677420-02		N		48.27	SEP GAS-CITY HALL—	A
V-102512-551	000147 ALLIANT ENERGY	116493	49301677810-02		N		29.82	SEP GAS-LOT 8 GARAGE	A
V-110812-649	000147 ALLIANT ENERGY	116675	49300519585-01		N		968.88	OCT GAS-LIB	A
V-112812-752	000147 ALLIANT ENERGY	116881	49300559511-01		N		256.36	OCT GAS-ART—	A
V-112812-752	000147 ALLIANT ENERGY	116881	49300916905-01		N		254.06	OCT GAS-SO FIRE	A
V-112812-752	000147 ALLIANT ENERGY	116881	49301674840-02		N		48.42	OCT GAS-PSB FIRE	A
V-112812-752	000147 ALLIANT ENERGY	116881	49301677420-02		N		453.39	OCT GAS-CITY HALL—	A
V-112812-752	000147 ALLIANT ENERGY	116881	49301677810-02		N		43.18	OCT GAS-LOT 8 GARAGE	A
V-113012-752	000147 ALLIANT ENERGY	116881	49300984580-03		N		79.15	NOV GAS-SO FIRE ARMY RES	A
V-121412-850	000147 ALLIANT ENERGY	117119	49300519585-01		N		1,535.13	NOV GAS-LIB	A
V-121412-850	000147 ALLIANT ENERGY	117119	49301674840-02		N		62.33	NOV GAS-PSB FIRE	A
V-121412-850	000147 ALLIANT ENERGY	117119	49301677420-02		N		896.07	NOV GAS-CITY HALL—	A
V-121412-850	000147 ALLIANT ENERGY	117119	49301677810-02		N		82.65	NOV GAS-LOT 8 GARAGE	A
V-122612-914	000147 ALLIANT ENERGY	117316	49300559511-01		N		574.34	NOV GAS-ART—	A
V-011113-030	000147 ALLIANT ENERGY	117464	49300916905-01		N		429.74	DEC GAS-SOUTH FIRE	A
V-011113-030	000147 ALLIANT ENERGY	117464	49300984580-03		N		396.20	DEC GAS-SOUTH FIRE(RSRV)	A
V-012113-179	000147 ALLIANT ENERGY	117673	49300519585-01		N		1,678.80	DEC GAS-LIB	A
V-012813-179	000147 ALLIANT ENERGY	117673	49300559511-01		N		833.74	DEC GAS-ART—	A
V-012813-179	000147 ALLIANT ENERGY	117673	49301674840-02		N		68.01	DEC GAS-PSB FIRE	A
V-012813-179	000147 ALLIANT ENERGY	117673	49301677420-02		N		1,566.93	DEC GAS-CITY HALL—	A
V-012813-179	000147 ALLIANT ENERGY	117673	49301677810-02		N		152.89	DEC GAS-LOT 8 GARAGE	A
V-013113-179	000147 ALLIANT ENERGY	117673	49300916905-01		N		736.57	JAN GAS-SOUTH FIRE	A
V-013113-179	000147 ALLIANT ENERGY	117673	49300984580-03		N		862.09	JAN GAS-SOUTH FIRE-RESRV	A
V-021313-275	000147 ALLIANT ENERGY	117903	49300519585-01		N		1,498.65	JAN GAS-LIB	A
V-021313-275	000147 ALLIANT ENERGY	117903	49300947250-02		N		1,222.84	JAN GAS	A

SOURCE-JE-ID	VENDOR/CUSTOMER/EXPLANATION	REF/REC/CHK	INVOICE	P.O.	F	9	AMOUNT	DESCRIPTION	FIL
		ANNUAL AMENDED BUDGET	ENCUMBERED	ACT MTD POSTED AND IN PROCESS			ACT YTD POSTED AND IN PROCESS	REMAINING BALANCE PCT	
1000	GENERAL FUND								
1151	BUILDINGS AND GROUNDS								
	COMMUNICATIONS AND UTILITIES								
65310	GAS								
V-022813-359	000147 ALLIANT ENERGY	118104	49300559511-01		N		939.22	FEB GAS-ART—	A
V-022813-359	000147 ALLIANT ENERGY	118104	49300916905-01		N		591.50	FEB GAS-SO FIRE	A
V-022813-359	000147 ALLIANT ENERGY	118104	49301674840-02		N		60.47	FEB GAS-PSB	A
V-022813-359	000147 ALLIANT ENERGY	118104	49301677420-02		N		1,525.01	FEB GAS-CITY HALL—	A
V-022813-359	000147 ALLIANT ENERGY	118104	49301677810-02		N		143.44	FEB GAS-LOT 8 GARAGE	A
V-031213-451	000147 ALLIANT ENERGY	118270	49300984580-03		N		261.40	FEB GAS-SO FIRE RESERVE	A
V-031513-451	000147 ALLIANT ENERGY	118270	49300519585-01		N		1,634.18	FEB GAS-LIB	A
V-033113-522	000147 ALLIANT ENERGY	118474	49300559511-01		N		720.31	MAR GAS-ART—	A
V-033113-522	000147 ALLIANT ENERGY	118474	49300916905-01		N		544.23	MAR GAS-SO FIRE	A
V-033113-522	000147 ALLIANT ENERGY	118474	49301674840-02		N		72.81	MAR GAS-PSB FIRE	A
V-033113 522	000147 ALLIANT ENERGY	118474	49301677420-02		N		1,329.68	MAR GAS-CITY HALL—	A
V-033113-522	000147 ALLIANT ENERGY	118474	49301677810-02		N		127.46	MAR GAS-LOT 8 GARAGE	A
V-041013-616	000147 ALLIANT ENERGY	000000	49300984580-03		N		16.82	MAR GAS-SO FIRE 2122	A
V-041513-616	000147 ALLIANT ENERGY	000000	49300519585-01		N		469.31	MAR GAS-LIB	A
V-042613-703	000147 ALLIANT ENERGY	000000	49301674840-02		N		34.32	MAR GAS-PSB	A
V-042613-703	000147 ALLIANT ENERGY	000000	49301677420-02		N		815.86	MAR GAS-CITY HALL—	A
V-042613-703	000147 ALLIANT ENERGY	000000	49301677810-02		N		61.64	MAR GAS-LOT 8 GARAGE	A
V-042613-703	000147 ALLIANT ENERGY	000000	49300559511-01		N		474.73	MAR GAS-ART—	A
V-042613-703	000147 ALLIANT ENERGY	000000	49300916905-01		N		293.67	APR GAS-SO FIRE 2124	A
TOTAL:	COMMUNICATIONS AND UTILITIES	26,000.00	0.00	0.00			26,848.49	848.49- 103 ----------	
TOTAL:	BUILDINGS AND GROUNDS	26,000.00	0.00	0.00			26,848.49	848.49- 103 ----------	
TOTAL:	GENERAL FUND	26,000.00	0.00	0.00			26,848.49	848.49- 103 ----------	

July 2012 – MARCH 2013

ART CENTER (MUSEUM + CARRIAGE HOUSE)

$ 3,863.72

City Hall

$ 6,465.18

rom Tank to Pump

tion Lift of 10 ft

5	200	250	300
2	3/4	3/4	1
4	3/4	3/4	1
4	1	1	1
	1	1	1-1/4
	1	1-1/4	1-1/4
	1-1/4	1-1/4	1-1/4
/4	1-1/4	1-1/4	2
/4	1-1/4	1-1/4	2

from Tank to Pump

tion Lift of 15 ft

75	200	250	300
2	2	2-1/2	2-1/2
1/2	2-1/2	2-1/2	3
1/2	2-1/2	3	3
3	3	3	3
3	3	3	4
3	3	4	4
3	4	4	4
4	4	4	4

th residual grade fuel oils.
tank return may be reduced by
.

Estimating Maintenance Costs

The following method may be used for estimating or comparing the total office building HVAC maintenance costs. The premise of this method assumes that the base HVAC system in the building consists of fire-tube boilers for heating equipment, centrifugal chillers for cooling equipment, and VAV distribution systems. The total building HVAC maintenance cost for this system is 84.70 ¢/ft^2. Adjustment factors from the table are then applied to this base cost to account for building age and variations on type of HVAC equipment as follows:

C = Total building HVAC maintenance cost (¢/ft^2)
= Base system maintenance costs
+ (Age adjustment factor) × (age in years n)
+ Heating system adjustment factor h
+ Cooling system adjustment factor c
+ Distribution system adjustment factor d
or $C = 84.70 + 0.18n + h + c + d$

HVAC Maintenance Cost Adjustment Factors
(in cents per square foot, 2009 U.S. dollars)

Heating Equipment *h*	
Water tube boiler	+1.96
Cast iron boiler	+2.38
Electric boiler	−6.77
Heat pump	−24.58
Electric resistance	− 33.76
Cooling Equipment *c*	
Reciprocating chiller	−10.15
Absorption chiller	+25.00
Water source heat pump	−11.97
Distribution System *d*	
Single zone	+21.04
Multizone	−11.67
Dual duct	−0.74
Constant volume	+22.3
Two-pipe fan coil	−7.04
Four-pipe	+14.71
Induction	+17.31

Table G-I—Office Occupancy

Hour of Day (Time)	Schedule for Occupancy Percent of Maximum Load			Schedule for Lighting Receptacle Percent of Maximum Load			Schedule for HVAC System			Schedule for Service Hot Water Percent of Maximum Load			Schedule for Elevator Percent of Maximum Load		
	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun	Wk	Sat	Sun
1 (12-1 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
2 (1-2 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
3 (2-3 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
4 (3-4 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
5 (4-5 am)	0	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
6 (5-6 am)	0	0	0	10	5	5	Off	Off	Off	8	8	7	0	0	0
7 (6-7 am)	10	10	5	10	10	5	On	On	Off	7	7	4	0	0	0
8 (7-8 am)	20	10	5	30	10	5	On	On	Off	19	11	4	35	16	0
9 (8-9 am)	95	30	5	90	30	5	On	On	Off	35	15	4	69	14	0
10 (9-10 am)	95	30	5	90	30	5	On	On	Off	38	21	4	43	21	0
11 (10-11 am)	95	30	5	90	30	5	On	On	Off	39	19	4	37	18	0
12 (11-12 pm)	95	30	5	90	30	5	On	On	Off	47	23	6	43	25	0
13 (12-1 pm)	50	10	5	80	15	5	On	On	Off	57	20	6	58	21	0
14 (1-2 pm)	95	10	5	90	15	5	On	On	Off	54	19	9	48	13	0
15 (2-3 pm)	95	10	5	90	15	5	On	On	Off	34	15	6	37	8	0
16 (3-4 pm)	95	10	5	90	15	5	On	On	Off	33	12	4	37	4	0
17 (4-5 pm)	95	10	5	90	15	5	On	On	Off	44	14	4	46	5	0
18 (5-6 pm)	30	5	5	50	5	5	On	On	Off	26	7	4	62	6	0
19 (6-7 pm)	10	5	0	30	5	5	On	Off	Off	21	7	4	20	0	0
20 (7-8 pm)	10	0	0	30	5	5	On	Off	Off	15	7	4	12	0	0
21 (8-9 pm)	10	0	0	20	5	5	On	Off	Off	17	7	4	4	0	0
22 (9-10 pm)	10	0	0	20	5	5	On	Off	Off	8	9	7	4	0	0
23 (10-11 pm)	5	0	0	10	5	5	Off	Off	Off	5	5	4	0	0	0
24 (11-12 am)	5	0	0	5	5	5	Off	Off	Off	5	5	4	0	0	0
Total/Day	920	200	60	1040	280	120	1600	1200	0	537	256	113	555	151	0
Total/Week		48.60 hours			56.00 hours			92.00 hours			30.54 hours			29.26 hours	
Total/Year		2534 hours			2920 hours			4797 hours			1592 hours			1526 hours	

Wk = Weekday

Schedules for occupancy, lighting, receptacle, HVAC system, and service hot water are from ASHRAE Standard 90.1-1989 and addendums, except that 5% emergency lighting has been added for all off hours. Elevator schedules, except for restaurants, are from the U.S. Department of Energy Standard Evaluation Techniques except changed to 0% when occupancy is 0%. These values may be used only if actual schedules are not known.

Recommended Economic Lifetimes of Various Mechanical Systems

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
absorption liquid chilling system	20
air compressors	20
air conditioner single package, air-cooled, hermetic	10
air conditioner with remote air-cooled condenser	10
air-cooled single package air conditioner, hermetic	10
air-cooled split system air conditioners	10
air handling units horizontal and vertical	20-25
air side equipment	20
boilers	20-25
burners	10
central station units	20
centrifugal chillers	20-30
centrifugal compressors, multistage	30
centrifugal compressors, single stage	20
centrifugal liquid chilling systems	20-30
chillers, absorption	20
chillers, reciprocating, up to 150 TR	12
chillers, reciprocating, 150 TR and up	14
coils, heating and cooling	indefinite
comm. air conditioners, remote a.c. condenser	10
comm. water-cooled conditioners, single package	10
compressors, reciprocating v/w, hermetic	12
compressors, reciprocating v/w, open	14
compressor units, vertical single-acting	30
condensers, evaporative, ammonia	20
condensers, evaporative	20
condensers, horizontal shell and tube, ammonia	20
condensers, horizontal shell and tube	20
condensers, remote air-cooled	12
condensing units, reciprocating v/w, hermetic	12
condensing units, reciprocating v/w, open	14
condensing units, vertical single-acting	30
controls, electric and pneumatic	20
cooling coils	indefinite
cooling towers, masonry fill	45
cooling towers, metal fill	15-20
cooling towers, wood fill	15-20
diesel engines	10-12
electric furnaces	10

continued

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
electric heating, add on	10
electric motors	20-25
evaporative condensers	20
evaporators, ammonia	30
evaporators, pinned coil, ammonia	20
evaporators, spiral pinned, ammonia	20
fans, backward curved (airfoil)	20
fans, coil multiple space conditions	20
fans, coil multiple space conditions	20
fan coil room conditions	20
fans, forward curved	20
fans, utility sets	20
float regulators, high pressure, ammonia	30
float regulators, low pressure, ammonia	30
furnaces, gas fired	10
furnaces, oil fired	10
gas fired furnaces	10
gasoline engines	10
heat pumps, single package, air-to-air	20*
heat pumps, single package, water-to-air	20*
heat pumps, split system, air-to-air	20*
hermetic year-round air conditioners	14
high pressure receivers	30
high pressure receivers, ammonia	30
horizontal shell and tube liquid chillers, ammonia	30
horizontal shell and tube condensers	30
horizontal shell and tube condensers, ammonia	30
induction room air units	indefinite
liquid chilling systems, centrifugal	20
liquid coolers, horizontal shell and tube	30
low temperature compressor units, recip. v/w, hermetic	12
low temperature compressor units, recip, v/w, open	14
multistage centrifugal compressors	30
multistage turbo compressors	20
multizone central station units	20
multizone rooftop units	10
multiple space fan coil units	20
oil fired furnaces	10
oil receivers	NA
packaged refrigeration units	12

continued

EQUIPMENT ITEM	ECONOMIC LIFE (yrs)
packaged terminal units	10
plug type, refrigeration units	12
produce storage units	12
product coolers	20
product coolers, ammonia	20
pumps, centrifugal	20-25
residential water-cooled conditioners, single package	10
remote air-cooled condenser	12
room air conditioners	8
room units	8
turbines (steam)	10-30