APPLIED ENGINEERING SOLUTIONS

1.0 Executive Summary

The scope of the project is to complete a detailed feasibility study for the replacement of AC-2 and AC-3 and their associated systems. The assessment portion of the project found AC-2 and AC-3 in extremely poor condition with replacement over 30 years overdue and failure imminent.

The first product of this study was a set of signed and sealed construction documents for the expedient replacement of the AC-2 supply fan with an array of direct drive fans. This product was added to the scope because the original scope item to provide a schematic design for the installation of temporary cooling for AC-2 was determined to be too impractical and because the failure of the AC-2 supply fan is inevitable. The design documents were delivered in January 2016.

After a presentation of project alternatives by the AE the VA Medical Center Engineering Staff and the project COR elected to pursue a phased plan for system replacements using several roof-top air handling units. The plan presented in this report in schematic design form has some flexible both in terms of individual project size and order of projects, the specific plan the AE believes is optimal is as follows:

1. Install AC-3 East and connect to existing air distribution: $1,200,000 and 6 months.
2. Install AC-3 West and connect to existing air distribution: $1,300,000 and 6 months.
3. Install AC-3 heating system and convert 5th floor to VAV: $1,730,000 8 months.
4. Additional projects to convert systems served by AC-3 East and West to VAV can continue in almost any order and schedule. The estimated total cost is $6,728,000.
5. Install new ICU AHU, its heating water system, and convert ICU to VAV: $623,000 and 5 to 6 months.
6. Install AC-2 North and install VAV in waiting room area: $1,135,000 and 6 to 8 months.
7. Install AC-2 South and install VAV in first floor south east area about 10,000SF: $1,400,000 and 12 months.
8. Additional projects to convert systems served by AC-2 South and North to VAV can continue in specific order from furthers to closest to existing AC-2. The estimated cost is $3,765,000.
9. After all other AC-2 related work, demolish AC-2 and install system for auditorium. The estimated cost is $560,000 and 10 months.

The total cost of the above projects in today's economy is $20,811,000.

Lastly, the AE recommends the VA Medical Center Gainesville Florida implement a project to install a water side cooling economizer on their chiller plant thereby eliminating the energy code need to provide air side economizers on their new air handling units. This will result in smaller, lighter, and more reliable air handling units. It will also provide real energy savings and reduce the cost of the air handling units by about 30% each.

2.0 Scope of Work

The scope of this project calls for a thorough, detailed feasibility study containing the following three main elements:

A. Conduct a feasibility study which contains the following requirements:
   1) Review existing HVAC Feasibly Study entitled Malcom Randall VA Medical Center, Gainesville, Florida VA Project Number 573-05-115
   2) Calculate generalized heating, cooling and ventilating loads for the building spaces served by AC-2 and AC-3.
   3) Conduct pre-design test and balance (TAB) on air side and water side of both units to determine current operating parameters.
   4) Examine the condition of both systems.
   5) Identify and evaluate alternatives for the replacement of both systems.

B. Complete a schematic level design for feasible alternatives. The schematic design shall contain the following minimum requirements:
   1) Complete architectural demolition reflected ceiling plans.
   2) Complete HVAC demolition plans.
   3) Complete electrical demolition plans.
   4) Structural calculations.
   5) Schematic design for all applicable disciplines.
   6) Phasing plan for the replacement work.
   7) Cost estimates for all disciplines.
   8) List of specifications.

C. Provide complete schematic level design for interim HVAC services for the areas served by AC-2 to be used to implement temporary heating, cooling and ventilation in the event that AC-2 fails prior to its replacement. This requirement was later changed to providing contract documents for the repair of the supply fan for AC-2. Those documents were provided to the VA under separate cover on January 8, 2016. At the time of this report the replacement of the supply fan has not taken place.

3.0 Methodology

To accomplish the scope of work the A/E and their consultants will complete the following tasks:

A. Review the 2005 facility wide HVAC feasibility study completed by Moses & Associates, Inc. Evaluate the findings of that report and compare them to the current situation on campus.
B. Complete space field survey to include updating of the floor plan, completion of reflected ceiling plan, verification of existing HVAC and electrical system components and verification of space conditions with respect to HVAC load calculations.
C. Complete space load calculations using the Trane Trace HVAC software package.
D. Complete pre-test and balance of AC-2 and AC-3 to establish a bench mark for the current system operating conditions and to establish the condition of the respective duct and piping systems.
E. Complete VA Table 2-1 load and air flow calculations for both systems.
F. Complete preliminary recommendations of possible solutions to the replacement of AC-2 and AC-3 complete with preliminary total life cycle analysis, and description of the required work including the option for temporary HVAC for emergency coverage of AC-2
G. Review the possible alternatives with the Government and select alternatives for further development.
H. Complete schematic level design of selected alternatives complete with demolition drawings, phasing plans, list of specifications, cost estimates and revised life cycle cost analysis.
I. Complete contract documents for the repair of AC-2. Initially this line read: “Complete schematic level design for temporary HVAC for AC-2.” However, by the 50% submittal it was determined that there did not exist any good options for the provision of temporary HVAC for spaces served by AC-2, but that a good option existed for repairing the supply fan. At that point the VA elected to proceed with design documents for that work and those documents were provided to the VA for procurement on January 8, 2016. At the time of this report the fan replacement had not been completed.

4.0 Review of Previous Study and Documents

4.1 General

The feasibility report document being reviewed is a comprehensive facility wide HVAC systems feasibility study completed by Moses &Associates Inc.(M&A) in 2005 with the assistance of W. W. Gay Test and Balance. The title of that report is. HVAC Feasibility Study, Malcom Randall VA Medical Center Gainesville, Florida, VA Project Number 573-05-115.

Due to scope of this project and the age of the M&A. report our review of the document focuses almost exclusively on the recommendations that deal with AC-2 and AC-3 - obviously the remainder of the systems are not in the current scope, and since our scope includes a condition assessment, the 2005 assessment by M&A in for the most part irrelevant. The exception to this is the test and balance data reported in the earlier study which we can compare to the data gathered during our investigation. This comparison can indicate the current state of the equipment versus the state in 2005. Furthermore, the quantity of testing completed in that report exceeds what is being done in this project so the additional data is useful for the purpose of condition assessment and are noted in condition assessment sections of this report (5.0 Condition Assessment AC-2 and 6.0 Condition Assessment AC-3).

4.2 AC-2 Report

The M&A report identify AC-2 as AHU 1-2. This dual duct unit was installed in 1964 and in 2005 it tested at 82,025 CFM compared to its original design flow of 91,750 CFM. The two recommendations in the M&A report are to (1) replace the unit in kind and (2) install the new unit at an alternate location and duct the replacement unit to the existing ductwork for the current unit. The first option will require that a temporary unit be connected to the supply ductwork to cool and heat the spaces while the existing unit is being replaced – otherwise the spaces served by the unit would not be useable while the unit was being replaced. The second option requires a new permanent location for the new unit and will also require a shutdown period to connect the new unit to the existing ductwork. The M&A report has option 1 priced at $875,200 and option 2 at $1,902,000, however when we reviewed the cost estimates we noted that the cost estimate for option 1 and option 2 both include $25,000 for temporary air conditioning. In our opinion that number is too low and would not be the same for both options. In option 1 temporary cooling is needed for about a month and in option 2 for about a week or may not be needed at all depending on the phasing.

In the M&A report the only location suggested for the replacement unit is the current location for building 8 with their recommendation being removal of building 8. This is location has potential, however, there are several other options which should be considered including the roof of building 8 and the second floor roof of the main building.

Photo 4-1: Aerial photograph showing location where 2005 Moses & Associates HVAC Feasibility Report proposed locating a new replacement AC-2 air handling unit.

There are two other significant issues the M&A report donot address, first it does not look at the outside air requirements of the spaces being served, do the spaces really require 100% outside air or can the system be converted to a system with a mixture of outside and return air? Second the report does not consider or discus converting the dual duct system to a variable air volume system. We shall consider these issues in the current report.

4.3 AC-3 Report

The M&A report identify AC-3 as AHU 1-3. This 100% outdoor air ventilation unit was installed in 1964 and was originally intended to serve for ventilation only with the spaces being heated and cooled by radiant ceiling panels. The original CFM for this unit was 53,750 CFM and according to the M&A report the unit CFM was increased to around 75,700 CFM so that the unit could serve as a cooling unit since the radiant ceiling panels did not operate correctly. In 2005 the unit tested at 75,700 CFM. The two recommendations in the M&A report are to (1) replace the unit and (2) replace the radiant cooling panels. The M&A report offer several recommendations for correcting the problems associated with AC-3 systems. These are:

1. Multiple air handling units in the court yards, with new mechanical towers (chases) in the court yards.
2. Renovate the radiant cooling panels.
3. Fan coil units through floors 2 through 5.
4. VAV air handling units to serve the first floor.

The M&A report dismissed options 2 and 3 due to reliability and space issues leaving options 1 and 2 and a combination of them to be considered in four different schemes. The schemes vary in number of air handling units and location of units and the associated costs are as follow:

Option AHU 1-3.A: Eighteen new air handling units and associated VAV distribution system. Cost $20,550,000

Option AHU 1-3.B: Five new air handling units and associated VAV distribution system. Cost $20,170,000

Option AHU 1-3.C: Two new air handling units and reusing existing distribution ductwork. Cost $12,210,000

Option AHU 1-3.D: New AC-3 and new fan coil unit system. Cost $6,598,000

In our opinion option D is not allowed by the VA HVAC Design Manual and option C does not provide adequate control of space temperature and does not address the issue of 100% outside air being used in the building where it is not required.

5.0 Condition Assessment AC-2

5.1 Physical Condition of AC-2:

The referenced 2005 M&A report covers the details of the physical condition of this unit in good detail and it does not appear that much has been repaired since that report was completed so that report is still accurate. This unit was installed in 1964 which makes it at this time a 51 year old unit. Table 5-1 below makes a comparison between the age of this unit and the median service life of the components. The median service life, published in chapter 37 of the ASHRAE 2015 Handbook of HVAC Applications is the median economic service life beyond which it is no longer financially advantageous to repair the system rather than replace it. This service life takes into consideration not only the maintenance cost of the system versus replacement cost, but also the cost of energy waste associated with the substandard performance of a worn out system.

Table 5-1 – Median Service Life of AC-2 Air Handling Unit and System Components.

Component	Median Service Life (years)
Diffusers, grills, and registers.	27
Ductwork	30
Centrifugal fans	25
Steam coils	20
Chilled water coils	20
Dual duct terminals	20
Dampers	20

Comparing Table 5-1 data to the 50 plus years AC-2 has been in service shows that the unit and system are both 20 to 30 years past their normal replacement age. Appendix A contains the result of water and air side test conducted by Thomas Balancing Service, Inc for this project and also indicates the poor condition of the unit. Table 5-2 below compares the air and water side performance of this system to original design conditions and to the test conducted for the 2005 M&A report.

Table 5-2 – Air and Chilled Water Flow Performance of AC-2

Quantity	Design Value	Value Reported in 2005 M&A Study	Current Value
Supply Air CFM	91,750 CFM	82,025 CFM	72,445 CFM
Supply ESP	About 4 in WC	2.02	2.17 in. WC
Chilled Water Flow	1,160 GPM	Not measured	730 GPM

5.2 Operational Condition of AC-2:

While the physical condition, age, and performance of AC-2 are bad, it is the operational condition issues which make it imperative for this system to be replaced. First and foremost for some unknown reason the original building was designed entirely as a 100% outdoor air single pass system. All of the air that is distributed in the building is outside air and it is then exhausted to the outside. This is not only unnecessary, but energy wasteful.

Second this system is a dual duct system. A dual duct system as the name implies has two supply ducts. One is carrying cold air the outer warm air. By closing one or the other supply duct at each temperature control zone the system can supply cooling to some spaces and heating to others all at the same time. Per VA Master Specifications found in the TIL dual duct systems are prohibited in new and renovation work. Also ASHRAE Standard 90.1-2010 provisions also disallow the use of dual duct systems.

The third operational issue is filtration and the internal condition of AC-2. As can be noted both by the report at Appendix A and the 2005 M&A report the unit has considerable issues with internal cleanliness and mold growth, the unit also does not have final filters as is required by current health care HVAC standards (both VA and private sector), therefore, mold spores and other pathogens in the air handling unit are not filtered from the air stream before it leaves the unit.

Lastly this unit is too large and conditions too large a percentage of the medical center's floor space. If this unit were to fail the impact on the mission would be catastrophic. Note that current VA criteria calls for units no larger than 50,000 CFM.

The above issues are not subjective, they can all be quantified in different ways, the impact of the first and second items noted are excessive and needless energy use. Appendix C contains energy and water use simulations comparing a generalized version of AC-2 in its current 100% outside air dual duct configuration to a generalized version of AC-2 with the allowable air recirculation in a variable air volume system. The results are summarized in Table 5-3 below:

Table 5-3 Estimated AC-2 Energy and Water Savings After Complete System Replacement.

System	Electric Cost $/year	Gas Cost $/year	Cooling Tower Water Use $/year
AC-2 as is	$270,504	$37,668	$62,652
AC-2 VAV with recirculation of air	$76,369	$15,890	$22,939
Annual Savings	$194,135	$21,778	$39,713
Percent Reduction	72%	58%	63%

The energy and water cost data used for Table 5-3 were provided by the Task 1 Baseline and Benchmarking Report Gainesville VA Medical Center, Gainesville, Florida Task Order VA701-14-F-0148report by RetroComX Energy Strategies, December 17, 2014. The values used are $0.136 per KWH electrical, $0.66 per therm natural gas, and $10.61 per kilo gallon water. It is also interesting that although ASHRAE Standard 90.1-2010 requires new systems in Gainesville, Florida to be equipment with outside air economizers, our simulation yielded zero benefit for using that option.

Table 5-4 below summarizes the problems and impacts of the problems with AC-2:

Table 5-4 Summary of AC-2 System Problems

Condition	Impact	Violates
100% outdoor air system	Contributes to needless energy and water use.	ASHRAE 90.1-2010 and VA HVAC Design Manual
Dual duct system	Contributes to needless energy and water use.	ASHRAE 90.1-2010 and VA HVAC Design Manual
Age is excess of 2 times normal life	Contributes to needless energy and water use, poor occupant comfort and system reliability.	
System is 2 times larger than currently allowed.	Contributes to the risk of system failure.	VA HVAC Design Manual
No final filtration	Health hazard	VA HVAC Design Manual and ASHRAE 170-2008
Unit dirty and overgrown with molds internally.	Health hazard	ASHRAE 170-2008

6.0 Condition Assessment AC-3

6.1 Physical Condition of AC-3:

The referenced 2005 M&A report covers the details of the physical condition of this unit in good detail and it does not appear that much has been repaired since that report was completed so that report is still accurate. This unit was installed in 1964 which makes it at this time a 51 year old unit. Table 6-1 below makes a comparison between the age of this unit and the median service life of the components. The median service life, published in chapter 37 of the ASHRAE 2015 Handbook of HVAC Applications is the median economic service life beyond which it is no longer financially advantageous to repair the system rather than replace it. This service life takes into consideration not only the maintenance cost of the system versus replacement cost, but also the cost of energy waste associated with the substandard performance of a worn out system.

Table 6-1 – Median Service Life of AC-3 Air Handling Unit and System Components.

Component	Median Service Life (years)
Diffusers, grills, and registers.	27
Ductwork	30
Centrifugal fans	25
Steam coils	20
Chilled water coils	20
Dampers	20

Comparing Table 6-1 data to the 50 plus years AC-3 has been in service shows that the unit and system are both 20 to 30 years past their normal replacement age. Appendix B contains the result of water and air side test conducted by Thomas Balancing Service, Inc for this project and also indicates the poor condition of the unit. Table 6-2 below compares the air and water side performance of this system to original design conditions and to the test conducted for the 2005 M&A report. In addition to what is shown in the table below we also detected a condition in the existing AC-3 whereby leaks in the cabinet downstream of the filters and of the cooling coil are so great that the unit air intake bypasses the air filters and cooling coils and comes in through cracks in the cabinet. This fact is confirmed by the extreme low pressure in the service vestibule. It is also significant to note the difference between the measurements from the M&A 2005 report and our current measurements. It is very possible this difference existing due to the extremely dirty condition of the air intake filters.

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Table 6-2 – Air and Chilled Water Flow Performance of AC-3

Quantity	Design Value	Value Reported in 2005 M&A Study	Current Value
Supply Air CFM	53,750 CFM	75,700 CFM	54,140 CFM
Supply ESP	About 2 in WC	0.75 in.WC	0.99 in. WC
Chilled Water Flow	565 GPM	Not measured	651 GPM

6.2 Operational Condition of AC-3:

As with AC-2, the operational condition issues found in AC-3 are far more detrimental than the poor physical condition and advance age of the equipment. The system design for AC-3 was advanced for its time and from all evidence did not work well. In the original system AC-3 provided 100% ventilation air which was then exhausted 100% without recirculation. This ventilation air provided dehumidification and some of the cooling, but the bulk of the heating and cooling and certainly the temperature control was initially provide by a radiant heating and cooling ceiling panel system served by a three pipe distribution system that provided heated water, chilled water, and an energy wasteful common return. This type of system I.E. the radiant cooling and heating panels has not been in wide use even today although it is starting to make gains in the HVAC market. Anecdotal evidence provided by the VA Gainesville HVAC maintenance staff and by the 2005 M&A report suggest that the system never worked well at this facility and that at some point the air flow quantity of AC-3 was increased to the cabinet's limit and beyond to help cool and heat the spaces served by the unit.

As with AC-2, AC-3's filtration I.E. lack of final filters and the dirty conditions inside the unit are a health risk issue and the 100% outside air flow is an energy waste issue. AC-3 also has the additional problem that it is essentially a single zone system serving five floors – therefore there is no temperature control. Spaces will be hot or cold and there is little that can be done about it because the system is not suited for temperature control. Also as with AC-2 this system is larger than 50,000 CFM which puts the medical center at a higher risk than necessary if this system were to fail.

To quantify the energy use impact of this antiquated system appendix D contains energy and water use simulations comparing a generalized version of AC-3 in its current 100% outside air dual duct configuration to a generalized version of AC-3 with the allowable air recirculation in a variable air volume system. The results are summarized in table 6-3 below:

Table 6-3 Estimated AC-3 Energy and Water Savings after Complete System Replacement

System	Electric Cost $/year	Gas Cost $/year	Cooling Tower Water Use $/year
AC-3 as is	$227,720	$30,590	$52,106
AC-3 VAV with recirculation of air	$64,903	$12,346	$18,705
Annual Savings	$162,817	$18,244	$33,401
Percent Reduction	71%	60%	64%

The energy and water cost data used for Table 6-3 were provided by the Task 1 Baseline and Benchmarking Report Gainesville VA Medical Center, Gainesville, Florida Task Order VA701-14-F-0148 report by RetroComX Energy Strategies, dated December 17, 2014. The values used are $0.136 per KWH electrical, $0.66 per therm natural gas, and $10.61 per kilo gallon water. As with AC-2, simulating and enthalpy controlled economizer yielded no benefit.

One additional issue that affects AC-2, AC-3 and AC-1 is that these units are intertwined in the sense that they serve spaces adjacent to each other. For example one would reasonable expect that AC-3 because it is roof mounted on the 5th floor would serve floors 2 through 5 in their entirety. However that is not the case, AC-3 servers floors 1 through 5 and so do AC-1 and AC-2. From a practical point of view this makes very little sense when it comes to replacing the systems.

Table 6-4 below summarizes the problems and impacts of the problems with AC-3:

Condition	Impact	Violates
100% outdoor air system	Contributes to needless energy and water use.	ASHRAE 90.1-2010 and VA HVAC Design Manual
Single zone system	Contributes to needless energy and water use and total lack of local temperature control.	ASHRAE 90.1-2010 and VA HVAC Design Manual
Age is excess of 2 times normal life	Contributes to needless energy and water use, poor occupant comfort and system reliability.	
System is 2 times larger than currently allowed.	Contributes to the risk of system failure.	VA HVAC Design Manual
No final filtration	Health hazard	VA HVAC Design Manual and ASHRAE 170-2008
Unit dirty and overgrown with molds internally.	Health hazard	ASHRAE 170-2008

7.0 Analysis

7.1 Preliminary Recommendations:

On October 30, 2015 the Power Point presentation contained in Appendix E was presented to the COR for this project and to several other members of the VAMC Gainesville Engineering and Maintenance staff. Our goal for that presentation was to provide the Veterans Administration with all practical and possible alternatives and to present the pros and cons of each. The options range from in-kind unit replacements to complete system replacements. In addition to presenting technical solutions the presentation emphasized that the technical options could also be further subdivided into several project procurement options which would be easier to fund than would a large single project.

7.2 Strategic Plan Solution:

Of the solutions presented the one which the VAMC Gainesville Engineering Staff agreed was most feasible both from a technical and funding point of view is the strategic plan solution which seeks to setup a strategic plan for the replacement of all AC-2 and AC-3 HVAC systems with 100% new terminal reheat variable air volume systems. The change also includes converting the systems from 100% outside air systems to the allowed and preferred recirculation systems with approximately 20% ventilation air overall.

7.3 Strategic Plan Already In Progress:

While this plan will not result in immediate overall improvements, it does provide a strategy to eventually modernize the HVAC in all the spaces served by AC-2 and AC-3. Based on our observations and on our experience with other projects we have completed at the medical center the idea of breaking the larger system replacement into smaller more manageable projects is already taking place. Projects such as the USP 797 Pharmacy, the Oncology Clinic Renovation, Expand ICU, and Expand ICU – 2D, ICU Step Down Unit all have taken spaces previously conditioned by AC-1, AC-2, or AC-3 and have converted them to VAV cooling with air handling units that are fully compatible with the VA HVAC Design Manual and ASHRAE Standard 90.1-2010. The results of this is that more and more spaces are compliant with modern standards and fewer spaces are dependent on the outmoded worn out systems installed 50 years ago.

7.4 Mechanical Considerations:

A. Presentation of Alternatives: On October 30, 2015 the AE presented to the Veterans Administration several alternatives for dealing with the dire situation that exists with AC-2 and AC-3. The decisions that were made were as follow:

1. The AE was charged with providing, as soon as possible a set of design documents for the replacement of AC-2 supply fan. This decision was made because AC-2 's supply fan is close to failure and because there are not any practical options for connecting the AC-2 duct system to a temporary cooling system that can serve the spaces until AC-2 can be replaced. The signed and sealed design documents for replacing the existing DWDI supply fan with an array of direct drive fans was delivered to the Veterans Administration on January 8, 2016.

2. The AE was charged with developing a schematic design for the gradual replacement of AC-2 and AC-3 and their entire duct systems with new variable air volume air handling units located at various roof-top locations. The main rationale behind this decision is the fact that out of the necessity to provide effective and health care compliant HVAC systems the VA Medical Center in Gainesville has been steadily doing this very thing on a smaller basis by adding new relatively small air handling units to serve newly remodeled spaces such as oncology, ICU, operating rooms, mental health ward, and USP 797 compounding space. The difference between this decision and what has been taking place is that in this case the HVAC will be planned for future implementation as opposed to the HVAC design resulting as a reaction to a space need.

B. Schematic Design: The schematic design has been developed and contains the following elements:

1. HVAC Existing Conditions: The HVAC system existing conditions for AC-2 and AC-3 have been field verified and are presented in the companion HVAC system demolition drawings that accompany this report. These will serve as the basis for demolition drawings on the multiple projects that will be implemented to replace the two systems.

2. Load Calculations: Appendix F contains the Trane Trace Load Calculations for the spaces affected by this study. This includes all spaces currently served by AC-2 and AC-3.

3. System Zoning and Air Flow: Appendix G takes the load calculation data from Appendix F and analyses it in spread sheets developed using the model provided on Table 2-1 found on page 2-17of the VA HVAC Design Manual 2011. This spread sheet considers the building loads, and the ventilation requirements found in chapter six of the VA HVAC Design Manual 2011 for each type of space and calculates the required minimum and maximum variable air volume air flows, outside air flows and exhaust requirements. In this spread sheet we also consider the load diversity calculated in the Trane Trace software and apply it to the modified flows generated by Table 2-1. While working these spread sheet we completed numerous iteration of space to system assignments taking into consideration the physical constraints of available vertical chases, air handling unit size and available structure capacity. Sheets M100 though M105 indicate which areas are served by which air handling units.

4. Air Handling Unit Selections: In selecting the new VAV air handling units for this study we took into consideration the results of Table 2-1 calculations at Appendix G and applied safety factors due to the fact that these calculations are for future implementation possibly a decade into the future. The air

handling unit psychrometric calculations are found in Appendix H, air handling units and other equipment are scheduled on sheet M601, and air handling unit cut sheets are found in appendix I. In addition to loads, available chases and building structural capacity the study considered the need for emergency power serving certain units and the scheduling needs of some spaces. Dues to these considerations two smaller air handling units were provided in the design. One to serve the auditorium which would allow for complete shutdown of ventilation and or CO2 demand ventilation in the auditorium and one to serve the ICU spaces currently served by AC-2. The ICU spaces are required to have an HVAC system served by emergency power.

5. Air Handling Unit Air Side Economizer: We also completed the selections of air handling units in strict accordance with ASHRAE Standard 90.1-2010 which requires air side economizer operation for all systems except those located in Dade and Collier counties in the south of Florida. Adding economizers to these systems increases their cost, size, and weight each by about 40%, increase the complexity of the controls and decrease their reliability. In our experience we have found Federal Government entities advising us that they do not follow these requirements of ASHRAE 90.1-2010 in locations as far north as Warner Robins, Georgia. The significance of this is that the benefit of air side economizers increases the further north the system is – the colder the winter the more benefit the system provides. In our professional opinion total life cycle data does not support using air side economizers in Gainesville Florida, however, the final decision on this matter rest on the VA Medical Center. One strictly code compliant option at the VA Medical Center's disposal is that if the chiller plant is provided with a water side economizer between the chillers and cooling towers, then the air systems are no longer required to have air side economizer. Note in the structural analysis that some structural reinforcement is needed due to the weight of the air handling units. Reducing their weight could remove this requirement.

6. Re-Heating Water Systems: In addition to containing air handling unit catalog sheets, Appendix I contains calculations for reheat water systems and catalog sheets for selected heat exchangers, pumps, and expansion tanks. All of these calculations are based on comparisons to this AE's design for the replacement of AC-1 in this building. Due to the schematic nature of this design 10% safety factors have been applied to flow and system volume. The selected basis of design components are scheduled on sheet M601.

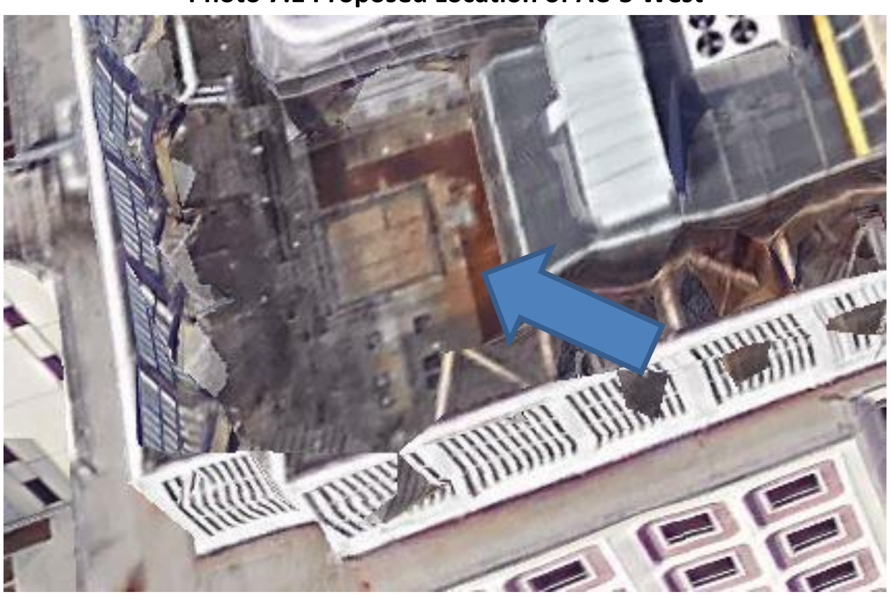
7. Description of Proposed Systems: The schematic design consists of the following elements with the indicated individual cost estimates. Detailed cost estimates are located in appendix J and cost estimates for recommended projects are in paragraph 7.4-C below:

AC-3 Replacement: AC-3 will be replaced by two separate systems. The reason for this is that AC-3 was originally a ventilation only unit which provided ventilation air only for rooms that were originally cooled by radiant ceiling panels. As the panels became clogged and stopped working the spaces needed additional cooling from AC-3 and AC-3 was upgraded to deliver additional air. To completely get rid of the ceiling panels and provide a VAV system consistent with current VA practice AC-3 has to go up to about 110,000 CFM. The existing unit currently provides only 54,000 CFM. So there are several reasons for splitting up the unit:

a. There is not enough space on the roof for a single unit of that size.
b. The structure would require considerable more reinforcement to hold up a unit that size.
c. Two smaller units, even with fan arrays provide more diversity and come closer to meeting all VA guidelines.
d. Placing units on two side of the roof allows for less ductwork exposed on the roof.
e. Two units allow for one unit (one project) to be completed at a time so that it will be easier to fund.
f. By installing one unit to begin with that provides the same air flow as the current AC-3 currently provides the single project serves the immediate purpose of providing a new reliable energy efficient unit and makes it unnecessary to provide a temporary unit so the project cost is reduced. In fact we have slightly upsized the AC-3 replacements so that if one unit is installed to begin with it will provide better cooling than AC-3 currently provides.

AC-3 West: The proposed location of AC-3 West is shown on sheet M106 in the photo below and accurately described in the structural calculations. For support new structural steel platforms will be needed and some existing columns will need reinforcement. The proposed vertical duct locations are also shown on sheet M106. The proposed design uses the existing west end AC-3 supply duct for supply and three other shafts including one new one story shaft and a shaft cleared by the removal of the incinerator stack for return. The cost of asbestos abatement of the stack in included in our project cost estimates. Shafts are shown on sheet M701. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.1 Proposed Location of AC-3 West



AC-3 East: The proposed location of AC-3 East is shown on sheet M106, in the photo below and accurately described in the structural calculations. For support new structural steel platforms will be needed. The proposed vertical duct locations are also shown on sheet M106. The proposed design uses the existing AC-3 east end supply duct for supply and a new shaft in the Trayveyor shaft for return. Shafts are shown on sheet M701. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.2 Proposed Location of AC-3 East

Reheat Water System for AC-3 Zones: This system will be installed on the platform currently occupied by AC-3. See sheet M106 and photo 7.3 below. It can be installed as soon as AC-3 East or West is installed but in order to have a functional project the installation of this system needs to be part of the first project to connect VAV duct systems to either AC-3 East or AC-3 West. The vertical piping for this unit should be installed in the service elevator lobby by creating a new chase along one of the walls between the elevator lobby and the corridor. This makes it centrally located to the entire floor. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.3 Proposed Location of Heating Water System for AC-3.

AC-2 Replacement: AC-2 will be replaced by four separate systems. The primary reason for this is that replacing AC-2 in its current location would require several months of work and providing temporary cooling while the construction was underway is impractical and would be very costly. Additionally access to the existing location of AC-2 with return and supply ductwork would be very difficult. Hence our recommendation is to provide four separate air handling units to each serving different areas. Initially our idea was to use two units. However providing a separate unit for the auditorium makes sense because of the type of facility that is. Since the occupancy in the auditorium can vary providing that system with a demand controlled ventilation system will save energy as will being able to set that system back to nearly zero flow when it is unoccupied. The other system we eventually decided to add is the ICU system. There are several rooms in the C244 area that are listed as ICU and isolation rooms which per VA design criteria need to be conditioned by HVAC systems in emergency power. Providing AC-2 South with emergency power just for these small spaces is not a good option so we opted for providing a small unit just for this purpose. This brings up the point that this study is accurate for the current space usage and may have changes if spaces are to be utilized for other functions at a later date.

AC-2 North: The proposed location of AC-2 North is shown on sheet M101R, in the photo below, and accurately described in the structural calculations. For support new structural steel platforms will be needed. Sheet M101R also shows the proposed vertical duct locations and the shafts are shown on sheet M701. Since this unit will not connect back to existing AC-2 ductwork the installation of this unit will have to be completed concurrently with the installation of some ductwork and the installation of the heating water system. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.4 Proposed Location of AC-2 North

AC-2 South: The proposed location of AC-2 South is shown on sheet M101R, in the photo below, and accurately described in the structural calculations. For support new structural steel platforms will be needed. Sheet M101R also shows the proposed vertical duct locations and the shafts are shown on sheet M701. This unit will not connect to existing AC-2 ductwork so the installation of this unit will have to include the HVAC renovation of some spaces. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.5 Proposed Location of AC-2 South

Reheat Water System for AC-2 Zones: To have a fully functional project this water system will have to be installed in conjunction with AC-2 South or AC-2 North and in conjunction with some space ductwork replacement. The proposed location for this unit can vary somewhat. We are currently showing it centrally located at the roof near the current location for AC-2 but that can be changed to a location closer to one of the units. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.6 Proposed Location of Heating Water System for AC-2.

Auditorium Air Handling Unit: The proposed location of this unit is shown on sheet M100 and in photo 7.7 below. Since this unit does not connect to existing AC-2 ductwork it will have to be installed as part of a larger project to ensure a functional system. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.7 Proposed Location of Auditorium Air Handling Unit.

AC-2 ICU Air Handling Unit: The proposed location of this unit is shown on sheet M101R and in photo 7.8 below. Since this unit does not connect to existing AC-2 ductwork it will have to be installed as part of a larger project to ensure a functional system. See paragraph 8.0 Project Recommendations and Cost Estimate Results and Appendices J1 and J2 for cost estimates.

Photo 7.7 Proposed Location AC-2 ICU Air Handling Unit.

D. Other Disciplines: In addition to the HVAC portion of the schematic design, this study and the companion drawing set address existing and replacement ceilings, electrical schematic design, and structural analysis and schematic design for the implementation of these projects. Narratives pertinent to these issues are found in the following sections 7.5, 7.6 and 7.7.

7.5 Architectural Considerations:

1. Goals and Needs: Provide Architectural design to support the replacement of air handling equipment in areas of the Gainesville VA Hospital served by AHU's 2 and 3. More specifically, the design effort includes removal and reinstallation of acoustic tile and gypsum ceilings in areas as required for new equipment and/or ducting.

2. Existing Conditions: As described above, the existing AC-2 and AC-3 are well beyond their useful life and need to be replaced. This will require access above the ceilings for removal of old equipment and installation of new equipment. Many ceilings appear to be the original 12"x24" perforated metal (scored to appear like a 12"x12" tile) that likely dates to the opening of the hospital. But many rooms and corridors have been updated with newer 2'x2' or 2'x4' lay-in ceilings and grid. There are also areas with painted gypsum board ceilings such as restrooms, soffits, and shower areas. A great many offices

with the original 12”x24” ceiling panels appear to have been remodeled leaving the ceiling with scars or gaps indicating that walls were moved.

3. Scope of Demolition: To accommodate new VAV boxes, hot and cold water piping, and ductwork, existing ceilings must be removed in the majority of spaces. Ceiling mounted items will be salvaged and reinstalled with new support grid. The work will be performed in phases. No work is planned for areas served by AHU #1. Some of the smaller rooms may not require complete demolition and replacement as the mechanical work required may be possible to do without removal. To avoid unnecessary demolition this will be explored as conditions warrant.

4. Scope of New Work: Suspended ceilings which are removed will be replaced with 2x2 grid to allow more flexibility in placing lighting, HVAC components, and other ceiling mounted devices. To the greatest extent practical, existing lights, diffusers, returns, fire alarms, smoke detectors, WIFI, cell phone antenna, mirrors, and other ceiling mounted items will be salvaged and reinstalled. Acoustical ceiling tile products will be replaced with the same or similar products that are in place. Gypsum board surfaces shall receive latex paint. Existing finishes damaged during the work will be repaired as necessary, including flooring, base, and wall surfaces.

5. Cost: The cost estimate assumes that all ceilings in the study area will be removed and replaced. As stated above it may not be necessary to remove all ceilings, but the actual scope of demolition cannot be known until a more thorough analysis of the existing and new mechanical system is performed.

6. Architectural Work shall be Designed and Constructed Under the Following Codes and Standards:

- VA Architectural Design Manual; August 1, 2014
- NFPA 99: Health Care Facilities Code - Latest Edition adopted by State
- NFPA 13: Standard for the Installation of Sprinkler Systems – Latest Edition adopted by State

7.6 Electrical Considerations:

A. Electrical power supporting the new HVAC systems is to be provided from both the existing electrical distribution system and from new electrical distribution equipment added to the existing system. The existing distribution system does not have adequate capacity for the new HVAC units being installed on the first floor roof or the fifth floor roof.

B. Power to the new roof top HVAC unit ICU AC and AC-2 Pumps A & B on the first floor roof is provided from a new EES Equipment Branch 225A/3P/480V/NEMA 3R panelboard. New panelboard is served from existing panelboard PBDQA in the main electrical room D091-A. The VA Electrical Design Manual requires ICU heating and ventilation equipment be connected to The Essential Electrical System (EES) for hospitals and shall comply with the Type 1 system as defined in NFPA 99. Pumps serving this unit are also required to be served from Emergency power to meet the VA design guidelines.

C. The VA Electrical Design Manual does not require the areas served by AC-2 to be on emergency power. Adequate normal power does not currently exist on the first floor roof to support the new HVAC equipment. Power to the new roof top HVAC units AC-2 North and AC-2 South on the first floor roof is provided from a new normal power 800A/3P/480V/NEMA 3R panel served from existing main switchgear in main electrical room D091-A.

D. The VA Electrical Design Manual does not require the areas served by AC-3 to be on emergency power. Adequate normal power does not currently exist on the 5th floor roof to support the new HVAC equipment. Power to the two new roof top HVAC units AC-3 East and AC-3 West on the 5th floor roof from new 600A/3P/480V panelboard located in penthouse equipment room. AC-3 Pumps A & B will also be served from the new 600A panelboard. New 600A panelboard will be served from existing Main Switchgear MSGR-A in the main electrical room D091-A. Existing AC-3 currently served from emergency power is to be removed.

E. Power to the new Variable Air Volume (VAV) boxes throughout the service areas of AC-2 and AC-3 will be powered by new 20A/1P circuits as required for the new loads from existing panelboards on the respective floors as indicated on the plans.

F. Electrical work shall be designed and constructed under the following codes and standards:

- NFPA 70 (2011), National Electrical Code
- NFPA 70E Standard for Electrical Safety in the Workplace
- NFPA 101 (2009), Life Safety Code

7.7 Structural Considerations:

Based on a review of the original structural construction documents, we propose the following structural systems for consideration:

General Design Criteria:

Applicable Codes:

- Florida Building Code, 5th Edition, 2014
- Florida Building Code, Existing Buildings, 5th Edition, 2014
- Specification for Structural Steel Buildings AISC 360-10
- Building Code requirements for Structural Concrete ACI 318-11
- Building Code Requirements for Masonry Structures ACI 530-11

Wind Loading Criteria

- Basic Wind Speed — V_{ULT} = 140 mph
- Risk Category — II
- Wind Exposure Category — B

- Internal Pressure Coefficient GC_{PI} = +/- 0.18

Proposed Equipment Operating Weights

- AC2-South = 39,342 lbs
- AC2-North = 39,342 lbs
- AC3-East = 53,165 lbs
- AC3-West = 53,165 lbs
- AC3-West (Alt) = 53,165 lbs

Material Properties:

- WF columns and beams: ASTM A992, Fy = 50 ksi
- HSS/Tubes: ASTM A500, Grade B Fy = 46 ksi
- Other steel, unless noted otherwise: ASTM A36, Fy = 36 ksi

Structural System Description:

According the original construction documents, the existing concrete roof slabs are designed for a roof live load of 20 psf and are not suitable for direct support of the mechanical units listed. To minimize structural reinforcing that may be required; the units will need to be supported on steel frames bearing directly over existing structural columns. Please see Appendix S1 for preliminary schematic drawings of the proposed frames. Please See Appendix S2 for the structural calculations for each of the steel frames considered.

We have analyzed the information available in the original structural construction documents to determine if sufficient capacity is available for the support of the proposed mechanical systems. At each proposed support location, the size and reinforcing of the existing column was compared to other columns of the same size, reinforcing, and configuration in order to estimate an original maximum gravity design load. Where this original maximum design gravity load is exceeded by more than 5%, column reinforcing will be required in accordance with the Florida Building Code for Existing Buildings. Please see Appendix S3 for existing column calculations.

Where the maximum design gravity load is exceeded by 5%, strengthening is required unless the original design can be shown to meet the current building code, under the proposed loading. Where strengthening is required, Fiber reinforced polymer (FRP) strengthening should be considered. FRP composites are comprised of high strength continuous fibers embedded in epoxy resins and applied directly to the surface of the prepared concrete substrate. Please see the preliminary schematic drawings in Appendix S1 for extent of FRP reinforcing.

Some assumptions, while preliminary in nature, have been necessarily conservative. As information becomes available during subsequent phases, these recommendations will change accordingly.

Please see appendix J1 for structural cost estimates at each unit location.

We have assumed that unit locations can be shifted to avoid substantial modifications to the architectural screen wall on the high roof. As such modifications to the screen wall are not included in this analysis.

The following comments specifically address the proposed unit AC3 West. The reviewers should note that the steel frame in this area bears on exterior columns. The architectural impact of the steel frame near the exterior wall should be considered. In addition, we estimate that two columns will require structural reinforcement on the upper levels (L13 & M13). Reinforcing an exterior column will be substantially more costly as it poses particular challenges with both access and exterior wall panels.

8.0 Project Recommendations and Cost Estimate Results

8.1. Description of Proposed Projects: Since the required work cannot be completed in one massive project our feasibility study offers the following recommended project in what we believe is the best order. Detailed cost estimates for the individual items that make up the projects are found in Appendix J1 and the cost estimates for each recommended project are found in Appendix J2.

Project 1 Replace AC-3: Since the supply fan on AC-2 is in the process of being replaced it is our opinion that replacing AC-3 should be the first priority because it will remain a 50 year old fan. Also, replacing AC-3 by installing one or both of the replacement units is a complete project unto itself which immediately serves to provide cooling. There are two options for replacing AC-3, one unit at a time or both units at the same time. In either case interim measures will need to be taken to ensure the supply fan speed on the new units is kept low enough not to overburden the steam and chilled water systems. Once the units are connected to return fan systems the fan speeds can be allowed to go to maximum. This is because the combined flow of the replacement units exceeds the flow of the existing AC-3

Install AC-3 East: Cost and time = $1,200,000 including 10% contingency – 6 month project time.

Install AC-3 West: Cost and time = $1,300,000 including 10% contingency – 6 month project time.

Replace AC-3 East and West in one project: Cost and time = $2,370,000 including 10% contingency – 6 month project time.

Project 2 Install Heating Water System for AC-3: This project can be done only after the existing AC-3 is demolished and that should only take place after at least one of the AC-3 replacements are in place. Also, the installation of the heating water system should be combined with the replacement of the HVAC system in at least one area. This is because if the heating water system is installed by itself the end product will not be a fully functional project. So below we have assumed that the heating water system will be installed along with the replacement of the existing dual duct system on the fifth floor.

Install AC-3 Heating Water System and Replace Fifth Floor Dual Duct System with VAV: Cost and time = $1,730,000 including 10% contingency – 8 month project time. Note that the area converted can be reduced to about half. This would drop the project cost to $1,070,000 including a 10% contingency.

Additional AC-3 Projects: Because AC-3 is technically a makeup air system, once both replacement units and the heating water system are in place and connected to the existing AC-3 supply ducts as is the intent, there is no time table for the remainder of the projects. The conversion of the existing systems to VAV terminal reheat can take place at whatever schedule is convenient to the medical center. The changes can be made using projects whose sole intent is to replace the air distribution or they can be made collateral to space renovation projects. The fact is the infrastructure is in place for any AE to connect to and use for whatever renovation project comes along. The cost of HVAC replacement projects including demolition and new work pertaining to ceilings, electrical, ductwork, piping, controls etc. is about $43 per square foot plus work in the chases and general condition costs.

The total estimated cost to convert the space still to be converted after the previous projects is as follows:

Floor Spaces to Be Converted to Terminal Reheat VAV and Served by AC-3 West = $3,460,000. This amount can be distributed over a wide variety of projects of different sizes.

Floor Spaces to Be Converted to Terminal Reheat VAV and Served by AC-3 East = $3,268,000. This amount can be distributed over a wide variety of projects of different sizes.

Project 3: Begin Replacement of AC-2: Our understanding is that to be a valid project, the project has to be a complete functioning product. For example setting an air handling unit on the roof and not connecting it to any space systems is not valid because the unit is not serving a function. If this is a correct understanding on our part, then the first project to begin the replacement of AC-2 will require the installation of the heating water system, a replacement air handling unit, and the replacement of duct systems associated with that new air handling unit. One option for this is to install the eating water system, the AC-2 ICU air handling unit, and the ductwork for that ICU area.

Install AC-2 Heating Water System and Install AHU AC-2-ICU and its systems: Cost and time = $623,000 and 5 to 6 months.

Project 4: Install AC-2 North and Connect to Waiting Room Area: Once the heating water system for AC-2 is installed the subsequent project can be the installation of AC-2 North or AC-2 South.

Install AC-2 North and Waiting Room Terminal Reheat VAV System: Cost and time = $1,135,000 including a 10% contingency and 6 months project time.

Project 5: Install AC-2 South and Connect to South East Corner of First Floor: For a complete functional project the installation of AC-2 South requires that the unit be connected to some spaces. This option assumes the 10,320 SF in the south east corner of the first floor.

Install AC-2 South and South East First Floor Terminal Reheat VAV System: Cost and time = $1,400,000 including a 10% contingency and 12 months project time.

Additional AC-2 projects: Unlike the situation with AC-3 the AC-2 replacement plan requires that all spaces currently served by AC-2 be converted to terminal reheat VAV connected to AC-2 North, AC-2 South, and the ICU unit. Once all spaces other than the auditorium are being served by the new units, AC-2 can be demolished and the auditorium unit can be installed in its place to serve the auditorium. The cost of HVAC replacement projects including demolition and new work pertaining to ceilings, electrical, ductwork, piping, controls etc. is about $43 per square foot plus work in the chases and general condition costs.

The total estimated cost to convert the space still to be converted after the previous projects is as follows:

Floor Spaces to Be Converted to Terminal Reheat VAV and Served by AC-2 North = $2,125,000. This amount can be distributed over a wide variety of projects of different sizes.

Floor Spaces to Be Converted to Terminal Reheat VAV and Served by AC-2 North = $1,640,000. This amount can be distributed over a wide variety of projects of different sizes.

Final Project: After all spaces served by AC-2 except the auditorium are served by AC-North and AC-2 South the original AC-2 can be demolished and the auditorium system installed in its place and the auditorium distribution system replaced with terminal reheat VAV.

Install AC-2 Auditorium Unit and Replace Auditorium Distribution: Cost and time = $560,000 including a 10% contingency and 10 months project time.

8.2. Other Recommendations: In addition to the above the AE offers the following recommendations:

1. Consider installing water side economizer at the chiller plant to eliminate the need for providing air handling units with air side economizer. This would be a more effective energy conservation measure, would cost less than having economizers provided with each new air handling unit and will require less maintenance than what it would take to maintain the economizer on the six replacement air handling units.

2. Consider system replacement as part of general space renovations. The floor to floor space is shallow on floors 2 through 5 and coordination of the installed systems can be best accomplished during a general space renovation as opposed to HVAC replacement projects where ceilings are removed but other existing systems stay in the way.

3. Ensure projects include reducing exhaust from the renovated floors. Currently the systems are single pass. AC-2 and AC-3 bring in 100% outside air and the exhaust fans remove about 85% of it and dump it to the outside. As new systems with return ducts are installed the exhaust ducts on each floor will have to be reduced to just what is needed and the exhaust fans on the roof will have to be progressively slowed down and eventually replaced by smaller fans.

9.0 Life Cycle Analysis

9.1 Analysis:

The original building at this facility was built in 1963 with little consideration to energy utilization, using three 100% outside air single pass systems that were not mandated by any codes in effect at the time or since then. The three main HVAC systems, AC-1, AC-2, and AC-3 operate at 100% outside air with several large roof-top exhaust fans removing all the air from the building. AC-1 and AC-2 are dual duct systems which by their design create additional energy waste (mixing hot and cold air streams for temperature control) and AC-3 is a makeup air system with no inherent energy inefficiencies above and beyond the fact that it is a 100% outside air system. While even in 1963 it was not entirely uncommon to use air-to-air heat recovery in 100% outside air system that feature was not implemented in this building. Furthermore the fact that this building is located in an extremely hot and humid region makes the building that more expensive to operate. If the same building were located in Southern California for example the energy use would be about 40% less.

Since the 1970's variable air volume systems have steadily become the only practical system for modern use. These systems are not only the most energy efficient because they save energy not just on heating and cooling energy but on fan energy as well, but they are the most flexible system when it comes to renovating / repurposing of spaces, and the system most capable of providing individualized temperature control at a lower cost than other systems. In appendixes C and D we have placed Trane Trace 700 energy use comparisons between the existing AC-2 and AC-3 and fully renovated variable air volume systems that meet minimum ventilation requirements as opposed to the current 100% outside air systems. These analyses assume that the systems have been fully converted so they do not reflect intermediate conditions that will occur as the systems are modernized are by area. Note that in the process of saving cooling energy the systems also reduce the amount of water evaporated through the cooling towers thus saving operating dollars there as well. The following tables repeated from sections 5 and 6 show the results of the calculations:

Table 9-1 Estimated AC-2 Energy and Water Savings After Complete System Replacement

System	Electric Cost $/year	Gas Cost $/year	Cooling Tower Water Use $/year
AC-2 as is	$270,504	$37,668	$62,652
AC-2 VAV with recirculation of air	$76,369	$15,890	$22,939
Annual Savings	$194,135	$21,778	$39,713
Percent Reduction	72%	58%	63%

Table 9-2 Estimated AC-3 Energy and Water Savings After Complete System Replacement

System	Electric Cost $/year	Gas Cost $/year	Cooling Tower Water Use $/year
AC-3 as is	$227,720	$30,590	$52,106
AC-3 VAV with recirculation of air	$64,903	$12,346	$18,705
Annual Savings	$162,817	$18,244	$33,401
Percent Reduction	71%	60%	64%

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