# Final Report

**North Pocono High School**

**Covington Township, PA**


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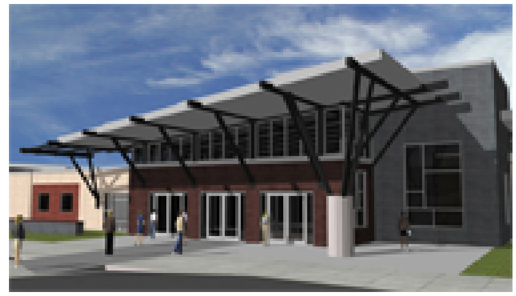
# NORTH POCONO HIGH SCHOOL

## Covington Township, PA

## Building Statistics

| | |
|---|---|
| Building Occupant: | North Pocono School District |
| Occupancy Type: | Educational |
| Building Size: | 230,000 sq. ft. |
| Total Levels: | Three |
| Approximate Bid: | 29,000,000 |
| Ground Breaking: | July 2007 |
| Completion Date: | September 2009 |



## Project Team

| | |
|---|---|
| Owner: | North Pocono School District |
| Architects: | Crabtree Rohrbaugh, and Associates |
| Design Engineers: | Greenman and Pederson Inc. |
| Construction Managers: | Lobar Inc. |

## Architecture

North Pocono is a three level educational facility. The exterior of the school is a brick veneer that curves inward at the front of the building. Within the school there is: a standardized gymnasium, a weight room, an aerobics room, and an auditorum that seats 900 people, as well as modern computer and science labs. The roof is flat with a slanted equipped with sure-seal moisture protection. It also has a slanted overhang above the entrance.

## Structural Overview

Cast in place reinforced concrete footings
8” CMU’s or 12” cast in place concrete make up the exterior load bearing walls.
Interior steel framing
Slab on grade concrete floor systems.
The roof is 4” LW concrete on 0.5” steel decking with 3” insulation

## Mechanical Overview

2-7000 Btu oil based boilers provide hot water
16 DX-AHU with hot water heating coils provide air and ventilation to serve VAV terminal reheat units
8-Condensing units provide the cooling capacity to several of the AHU

## Electrical Overview

4-Dry type transformers step down the voltage from 480-3 phase to 120/208-3 phase
1-Dry type transfomrer steps down the voltage from 480-3 phase to 277/480-3phase
1-350 KW emergency generator @ 480/277V
The ligthing system consists of linear and compact flourescent lights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http://www.engr.psu.edu/ae/thesis/portfolios/2009/dfh124/buildingabstract.htm

# Contents

# Acknowledgments

I would like to thank the North Pocono School District for allowing me to use their new high school as my senior thesis project. I would especially like to acknowledge Dr. Kurt Eisele, the superintendent, Dennis Cawley and Carole Kovalchik, the business managers, for granting me the permission to use North Pocono High School.

Next, I would like to thank the engineers at Greenman and Pedersen Inc. (GPI) and the architects of Crabtree and Rohrbaugh (CR). With their guidance and expertise the analysis for this project was possible. Mr. Ryan Wanko who was my contact at GPI deserves recognition for clarifying any issue that arose with the analysis. Thanks to Mr. Randy Davis of CR for providing renderings that were used throughout the project.

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Finally, I would like to express my deepest gratitude to my family and friends, with their support my time at Penn State was a successful and enjoyable experience. My parents, Daniel and Maureen, deserve all the credit that two people can be given for providing support without question throughout the years. My siblings deserve credit for their encouragement and never letting me lose sight of what was important, and my friends for providing the comic relief when it was needed.

# Executive Summary

North Pocono High School is a three level 230,000 $ft^2$ building located in Covington Township, Pennsylvania. It is designed for grades nine through twelve with a variety of classroom spaces. The current mechanical system meets the requirements of the design criteria established by the owner and design engineer. The existing design was limited by a strict budget and while the system adequately conditions the school, there is potential for improvement.

The goals of the HVAC redesign were to increase efficiency, decrease life cycle cost, educational purposes, and find savings in other building systems by modifying them to fit the mechanical system redesign. The 16 Direct Expansion (DX) rooftop air handling units were replaced by dedicated outdoor air systems (DOAS) with ground source heat pumps (GSHP) as a parallel system. The new system was not held to the same budget as the existing system. The new systems equipment cost was $46 million more than the overall cost for the current design. An energy model generated by the Trane *TRACE 700* program showed that the yearly energy use was reduced by 75% saving the North Pocono School District $187.4 thousand a year in utility costs. This results in a 245 year payback period for the new system.

The two other systems directly affected by the HVAC redesign were the structural system and electrical system. Replacing the 16 rooftop air handlers and eliminating 6 condensing units with lighter DOAS units reduced the roof load by 55%. The reduction in load meant a lighter framing system which saved 17%for material and construction costs. Also, the 4 electrical panels that serve the major mechanical equipment were able to be reduced in frame size because the electrical load needed to run the DOAS units compared to the DX units was reduced by 55%. The savings from this system was included in the $14.3 million yearly operational cost.

# General Building Information

North Pocono High School is a 230,000 square foot building located in Covington Township, Pennsylvania. The building consists of three levels of single use and mixed use spaces and will accommodate 3,000 students from grades nine through twelve. Construction began in the summer of 2007 and is scheduled to be completed in the fall of 2009.

The project team consisted of the owners, North Pocono School District, architects, Crabtree and Rohrbaugh Ass., design engineers, Greenman and Pedersen Inc., and the general contractor, Lobar Inc. The project was delivered as a design bid build with the winning bid being $30 million dollars.

# Building Systems Synopsis

## *Architectural Overview*

North Pocono High School is a three level building. The front of the building has a curved facade that extends the whole length on the building. The exterior façade is red brick veneer with a CMU wall. The entrance contains a vestibule attached to all of the administrative offices. Then you enter a lobby where you find your way throughout the rest of the building. The school contains a standard size gymnasium, a library, computer and science labs, and a food court.

## *Structural Overview*

North Pocono's structural system consists of a steel frame that rests on load bearing masonry walls. There are 9 different types of reinforced wall footings that support the walls. They range from 3' to 7' in width. The most common type of rebar used in the wall footings is #5. The steel columns however rest on 4 different types of piers that then transfer the load to one of 14 different types of footings. The piers range in size from 22"x22" to 36"x28" with #6 and #8 bars for vertical reinforcing and #3 bars used as stirrups. The footings have a bearing pressure of 4,000 psf and range in size from 4'x4' to 11'x11'; they go from 12" deep to 29" deep. All the concrete is specified to having strength of 3,000 psi and the steel reinforcing has strength of 60,000psi. Typical floor construction consists of 4" slab-on-grade with normal weight and strength of 4,000 psi, with 6x6-W1.4x1.4 WWF reinforcing. The upper level floor construction is 2" normal weight concrete with 3,000 psi and reinforced with 6x6 W2.0x2.0 WWF on 1"-26 gage galvanized form deck. The total floor thickness is 3". North Pocono has two different exterior wall types. The first is 4" brick veneer that is supported by 8" CMU's that have a compressive strength of 2,800 psi on the net area of the block, the second is a 12" cast in place concrete wall that supports the 4" brick veneer, again with strength of 4,000 psi. The steel frame typically consists of 24K7 or 20K8 joists for the classrooms and 10K1 joists for the corridors. The gym uses 22K7 joists on the side while 56DLH15 joists span the middle section and they all transfer the load to 96G12N32K joist girders. The auditorium uses 56DHL17 joists that then transfer the load to the 12" concrete wall on either side of the auditorium. The roof deck is typically 1.5" 20 gauge galvanized steel decking with a self weight of 7.0 psf, the gymnasium and auditorium however are have 3” concrete deck with 20 gauge galvanized decking.

### Electrical Overview

North Pocono’s electrical service is provided by the utility company PP&L. The utility serves a 4,000A - 480/277 3 Phase 4 Wire main switchboard. The switchboard then sends the service to the other panel boards and 5 Dry type transformers that step down the voltage from the 480V to 120/208V 3 phase power.

The emergency generator is 350 KW and supplies 480/277V power to the fire pumps and elevators along with the exit lights and most of the kitchen equipment. The generator also supplies the main electrical room along with the school’s main telecommunications and data room.

### Lighting Overview

North Pocono’s lighting system consists mostly of recessed linear fluorescent lights. The auditorium has dimming system over the seating as well as a theatrical lighting set on stage. The gymnasium features hi-bay linear fluorescent pendant fixtures.

### Telecommunication Overview

North Pocono has a voice and data communications systems. They also have a closed-circuit television system that is available in all classrooms. It has a public announcement system in the gymnasium as well as in the auditorium.

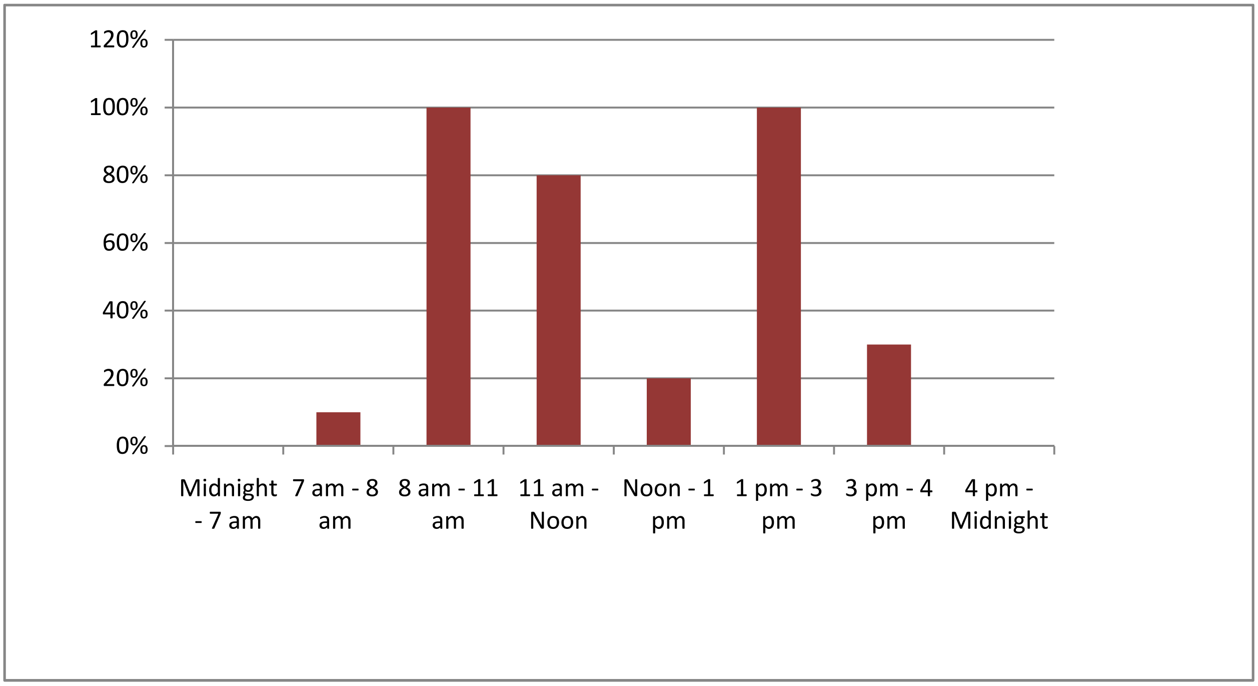
# Mechanical System Existing Conditions

The mechanical design for North Pocono was based on initial cost saving. The goals of the designer were to create a system that met the school district’s budget while providing a system that would meet the 2005 International Mechanical Code and provide a comfortable environment for the occupants.

### Design Conditions

The indoor design conditions were developed by the Greenman and Pedersen Inc. engineers. The designer determined the heating and cooling dry bulb temperatures, and the maximum relative humidity level for the school. They determined the most comfortable level for the school was to condition the spaces to 72 $^{o}$F degree dry bulb temperature for heating and cooling with a maximum relative humidity at 50%. Next, the occupancy schedule for the building’s design day was entered into the program. Chart 1 is an hourly breakdown of the occupancy schedule on the design day.

Chart 1 – Occupancy Schedule




The outdoor design conditions were taken from Wilkes-Barre, Pennsylvania since there is no weather data for Covington Township, PA. Table 1 summarizes the weather data that was used for design modeling.

Table 1- Wilkes-Barre Design Conditions

| | |
|---|---|
| Latitude | 41.14° |
| Longitude | 75.52° |
| Elevation | 550 ft. |
| Cooling Design DBT | 87° |
| Heating Design DBT | 5° |

## *System Description*

The school is served by 16 direct expansion air handlers (DX), with duct mounted hot water heaters. Twelve of the AHUs serve approximately 100 variable air volume (VAV) terminal units with hydronic reheat coils. They serve the majority of the school. The other 4 are constant volume (CV) air handlers which are for economizer. One CV unit serves the locker room area, two supply a large multi-use space, and the last one serves the auditorium. The units mix return air with outside air then condition and supply it to the zones. Figure 1 is schematic of the VAV systems and Figure 2 is a schematic of the CV systems. Four condensing units serve the CV air handlers to provide additional cooling capacity. The air handler that serves the gym also has two condensing units that provide cooling capacity.

Figure 1 – VAV Air Flow diagram

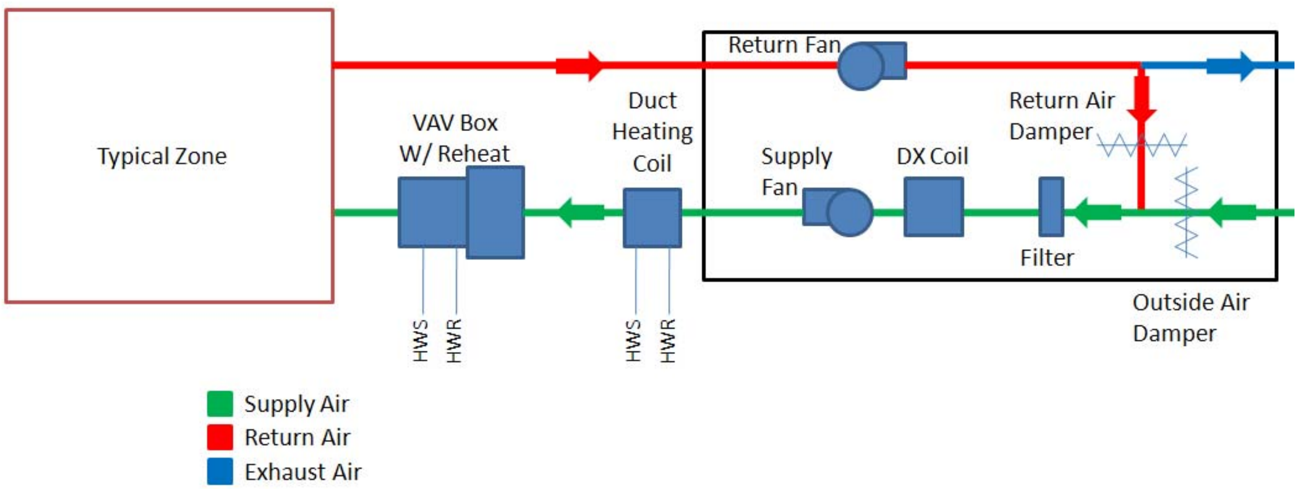
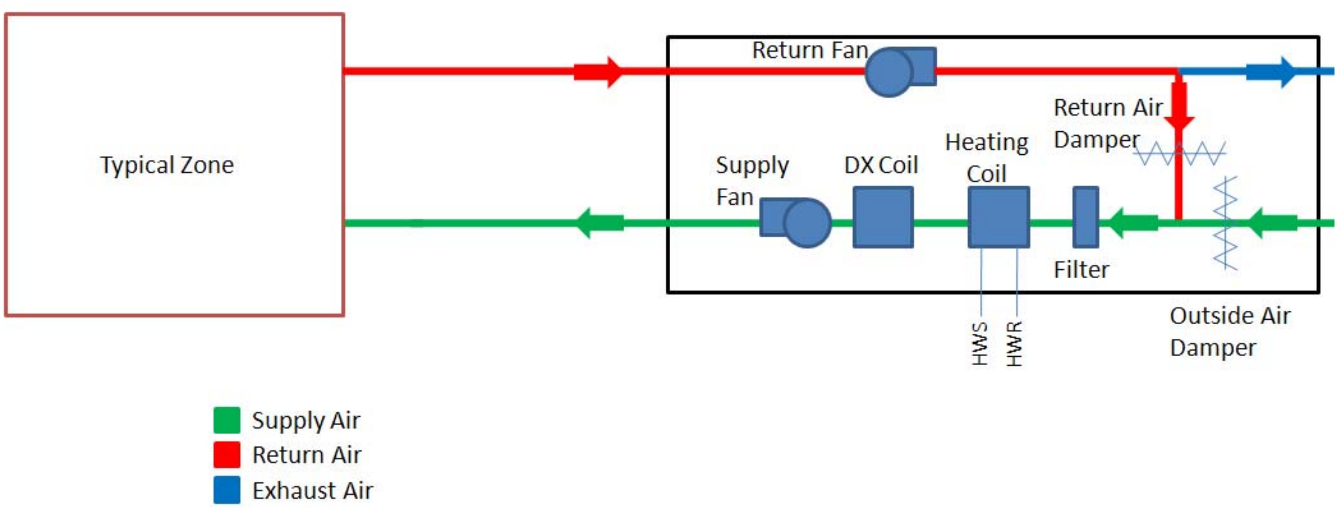



Figure 2 – CV Air Flow Diagram




The hydronic heating system for North Pocono is centralized in the mechanical room. It consists of two oil fired boilers, three centrifugal water pumps, the duct mounted heating coils, and the reheat coils contained in the VAV terminal units.

The water supplied to the boilers is heated to 180 °F and then pumped through a two pipe system to the heating coils and terminal units. The boilers are programmed so that there is a lead boiler and when more heating is called for the second boiler is enabled. They alternate as the lead boiler every week. The three pumps also trade off being the lead pump. The temperature of the water is monitored by the Direct Digital Control system. Figure 3 is a flow diagram representing the hydronic system.

Figure 3 – Flow Diagram

# ASHRAE Standard 90.1

## *Building Envelope*

The buildings fenestration percentage is less than 40% the total wall area; therefore it was acceptable to use the Prescriptive Method. North Pocono is located in climate zone 5 and is a nonresidential building; therefore had to comply with table 5.5-6. Table 2 shows the opaque elements of the building. Table 3 shows the window compliancy.

Table 2 – Opaque Envelope Compliance

| Element | Insulation R-Value | Standard Min. R-Value | Compliant | Assembly U-Value | Assembly Max. U-Value | Compliant |
|---|---|---|---|---|---|---|
| Roof | 10 | 20 | No | 0.681 | 0.48 | No |
| Wall Type 1 | 10 | 11.4 | No | 0.67 | 0.09 | Yes |
| Wall Type 2 | 10 | 11.4 | No | 0.093 | 0.09 | No |
| Slab on Grade | NR | NR | NR | 0.213 | 0.73 | Yes |

Table 3 – Fenestration Compliance

| Fenestration | Assembly U-Value | Assembly Max. U-Value | Assembly SHGC | Max SHGC | Compliant |
|---|---|---|---|---|---|
| Metal Framing | 0.5 | 0.45 | 0.55 | 0.4 | No |

## *Building Equipment*

Since the building is larger than 25,000 $ft^2$ the Mandatory Provisions Method was followed in order to determine if the system was in compliance with 90.1 Section 6. The following tables are performance evaluations of the building's air handlers and boilers.

Table 4 – Boiler Efficiency

| Boiler | Net MBH Output | Gross MBH Input | Efficiency | Standard Efficiency | Compliant |
|---|---|---|---|---|---|
| B-1 | 5,880 | 7,000 | 84% | 78% | Yes |
| B-2 | 5,880 | 7,000 | 84% | 78% | Yes |

Table 5 – Air Handler Compliancy

| Unit | Air Flow (cfm) | CFM*0.0015 | Fan HP | Complaint |
|---|---|---|---|---|
| AHU-1 | 15,850 | 23.8 | 25 | No |
| AHU-2 | 16,415 | 24.6 | 25 | No |
| AHU-3 | 36,000 | 54.0 | 25 | Yes |
| AHU-4 | 3,700 | 5.6 | 5 | Yes |
| AHU-5 | 6,800 | 10.2 | 15 | No |
| AHU-6 | 19,500 | 29.3 | 20 | Yes |
| AHU-7 | 13,500 | 20.3 | 20 | Yes |
| AHU-8 | 12,650 | 19.0 | 20 | No |
| AHU-9 | 14,195 | 21.3 | 25 | No |
| AHU-10 | 8,565 | 12.8 | 15 | No |
| AHU-11 | 3,000 | 4.5 | 5 | No |
| AHU-12 | 3,800 | 5.7 | NA | NA |
| AHU-13 | 18,200 | 27.3 | 30 | No |
| AHU-14 | 10,300 | 15.5 | 10 | Yes |
| AHU-15 | 15,300 | 23.0 | 25 | No |
| AHU-16 | 3,000 | 4.5 | 5 | No |

Table 3 shows that only 5 of the 16 air handlers comply with Standard 90.1 2007 edition. However, they do comply with the 2004 Standard used during the design of the system.

# ASHRAE Standard 62.1

Section of Standard 62.1, Ventilation for Acceptable Indoor Air Quality, sets forth a procedure to determine the amount of ventilation air required in the building. Table 6 compares the amount of ventilation required to the amount of ventilation each air handler brings in. Appendix A lists each and air handler and the spaces they serve along with the designed ventilation value and the ASHRAE ventilation value.

Table 6 – Computed Ventilation vs. Designed Ventilation

| Label | ASHREA Standard (cfm) | Designer Value (cfm) |
|---|---|---|
| AHU-1 | 4,195 | 4,355 |
| AHU-2 | 5,025 | 7,360 |
| AHU-3 | 4,810 | 10,270 |
| AHU-5 | 2,750 | 3,860 |
| AHU-6 | 2,865 | 19,500 |
| AHU-7 | 4,525 | 4,800 |
| AHU-8 | 3,895 | 4,315 |

Table 6 – cont.

| | | |
|---|---|---|
| AHU-9 | 5,370 | 6,225 |
| AHU-10 | 1,670 | 3,685 |
| AHU-11 | 465 | 3,000 |
| AHU-12 | 2,400 | 2,255 |
| AHU-13 | 5,105 | 10,725 |
| AHU-14 | 1,985 | 2,470 |
| AHU-15 | 3,950 | 5,890 |
| AHU-16 | 470 | 3,000 |
| Total | 49,480 | 91,710 |
| Difference | 42,230 | |

Air handler 4 was excluded from this analysis because it is used as an economizer and only supplies 100% outdoor air to the space. This was done so that the exhaust fans that are in the zone were properly sized. In order to ensure optimal air quality, the engineer adequately ventilated North Pocono High School. However, this forces the system to condition more outdoor air than recommended and therefore increases the energy used by the system.

# Existing Design Loads

An energy model was used to determine the buildings cooling load. The Trace *TRACE 700* Program was used. The school was broken down into the 11 zones listed in Table 7.

Table 7 – Zone Description

| Zone | Area ($ft^2$) | Occupancy (People) |
|---|---|---|
| Lower Level Classrooms | 35,685 | 425 |
| Middle Level Classrooms | 62,349 | 893 |
| Upper Level Classrooms | 51,375 | 945 |
| Administrative Offices | 10,000 | 121 |
| Gymnasium | 14,921 | 1500 |
| Auditorium | 10,720 | 890 |
| Large Group Instruction | 3,075 | 100 |
| Cafeteria | 15,362 | 480 |
| Food Court | 2,760 | 100 |
| Faculty Dining | 650 | 20 |
| Kitchen | 3,383 | 10 |
| Lobby | 2,245 | 0 |

After all the data was input into the program the results were generated. Tables 8 and 9 shows the results for North Pocono’s cooling and heating load calculated by *TRACE 700*.

Table 8 – Computed Cooling Load

| Zone | Computed Cooling Load ($ft^2$/ton) |
|---|---|
| Lower Level Classrooms | 388 |
| Middle Level Classrooms | 395 |
| Upper Level Classrooms | 357 |
| Administrative Area | 360 |
| Gymnasium | 244 |
| Auditorium | 324 |
| Large Group Instruction | 453 |
| Cafeteria | 374 |
| Food Court | 345 |
| Faculty Dining | 497 |
| Kitchen | 333 |
| Lobby | 509 |
| **Building Average** | **382** |
| **Total Tons** | **565** |

Table 9 – Computed Heating Load

| Zone | Computed Heating Load (MBH) |
|---|---|
| Lower Level Classrooms | 895 |
| Middle Level Classrooms | 1,041 |
| Upper Level Classrooms | 1,328 |
| Administrative Area | 343 |
| Gymnasium | 435 |
| Auditorium | 240 |
| Large Group Instruction | 59 |
| Cafeteria | 330 |
| Food Court | 63 |
| Faculty Dining | 12 |
| Kitchen | 318 |
| Lobby | 81 |
| **Building Average** | **429** |
| **Total Tons** | **5,145** |

# Lost Useable Space

North Pocono is not served by a central cooling plant and most of the equipment is on the roof. The amount of space lost to mechanical system is minimal. Table 10 is a comparison of the lost usable space due to the mechanical system.

Table 10 – Lost Useable Space

| | AREA ($ft^2$) | PERCENTAGE |
|---|---|---|
| Mechanical Space | 2,357 | 1% |
| Remaining Spaces | 234,075 | 99% |
| Total | 236,432 | 100% |

# Mechanical System Redesign

### *Redesign Objectives*

The objectives of the redesign were to lower the amount of energy the building needs to operate while meeting the computed design loads in tables 8 and 9, lower the emissions from the system, and gain knowledge in order to design a new system. The current system was restricted by the budget set by the school district; however, the new system will not be restrained by the budget.

### *Ground Source Heat Pumps with Dedicated Outdoor Air Systems*

The new design consisted of replacing the 16 DX AHU's with 15 Dedicated Outdoor Air Systems (DOAS) and using Ground Source Heat Pumps (GSHP) in the spaces. The reason for using 15 DOAS units is because two of the current AHUs, 11 and 16, serve one space therefore the ventilation air for that space will be brought in by one DOAS unit. The DOAS units were sized to bring in the amount of ventilation air set by ASHRAE Standard 62.1. Table 6 shows that approximately 42,000 less air is needed therefore less energy will be used on conditioning excess outdoor air.

The DOAS units were designed so that they can handle the latent load in the space during the cooling season. This is done by dehumidifying the air and driving the air temperature down to approximately 55 $^{o}$F. By bringing the temperature down the DOAS unit will also eliminate approximately 20% of the sensible load; the remaining 80% will be handled by the GSHP. When heat is called for, the units are designed with small electric resistance heaters to provide some heating while the majority of the load is handled by the GSHP. Figure 4 is a picture of Carrier's 62D model, which was used as the basis of design.

Figure 4 – DOAS unit

## *Sizing the Ground Loop*

The GSHP system used a vertical closed loop system. This means bore holes are drilled to a depth between 100 – 400 ft, and the piping is not open to the thermal sink, such as a body of water or a well. The process of a ground loop is similar to that of a traditional water source heat pump. Instead of using mechanical equipment to provide the heat exchange the system takes advantage of the constant ground temperature to transfer heat to the water.

The ground loop was sized using a computer program developed at the University of Alabama, called *GCHPCalc*. The program is equipped to size ground loops based off the heat gains and losses the building under goes during the design day. Table 11 shows the heat gains and losses North Pocono under goes.

Table 11 – Building Heat Gains and Losses

| Hours | Heat Losses (MBh) | Heat Gains (MBh) |
|---|---|---|
| 8 a.m. – Noon | 15186.2 | 11621.7 |
| Noon – 4 p.m. | 15779.0 | 11133.4 |
| 4 p.m. – 8 p.m. | 851.0 | 623.2 |
| 8 p.m. – 8 a.m. | 0 | 0 |

Next the program requested that all the ground data be entered into the program. Figures 5 and 6 shows the defaults the program uses, and since a thorough ground study was not done for the project the values provided by the program were used to size the ground loop. The ground temperature was however determined to be 50 $^{o}$F by the regional map provided in the program.

Figure 5 – Ground Properties

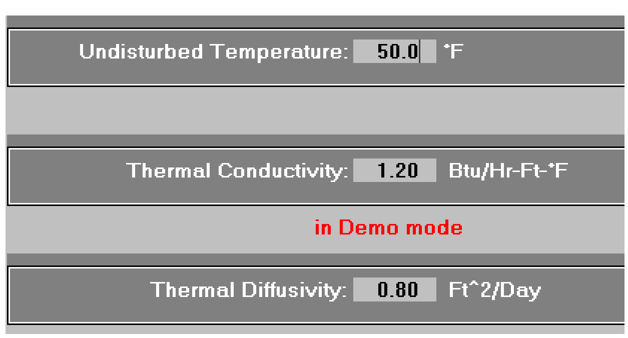
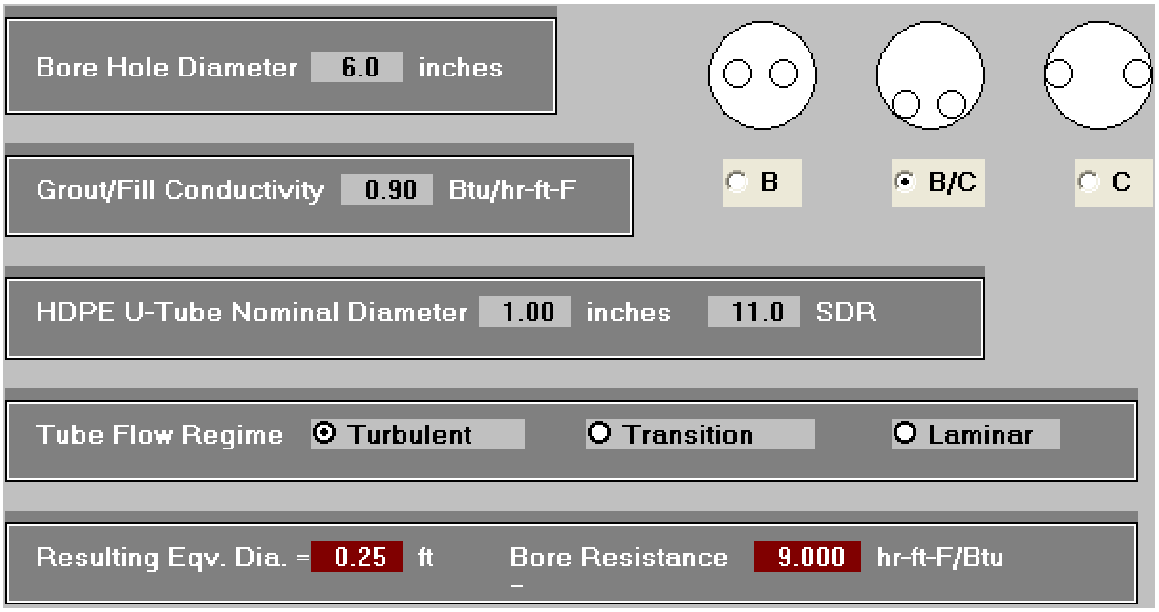
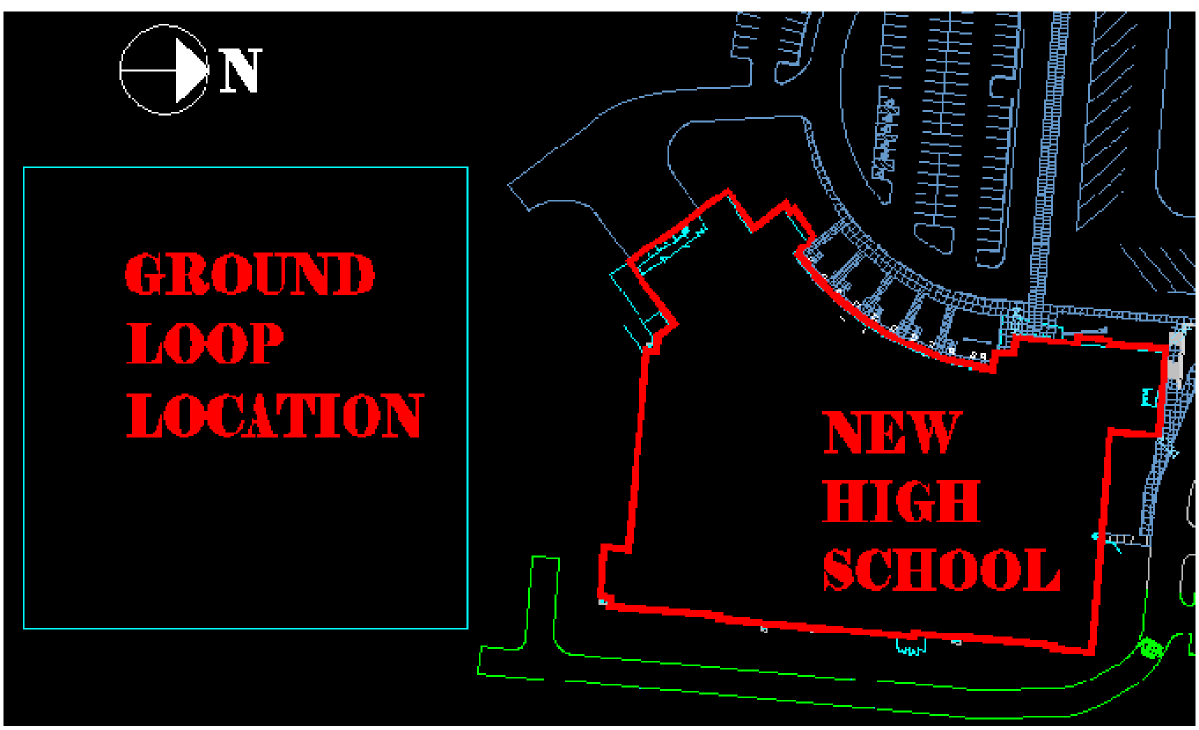


Figure 6 – Pipe Properties




Next the layout for the loop system was selected. The school is being built in a rural area with an abundance of land available. The configuration for the loop system is 35 rows by 30 rows with 8 bores per a parallel loop, and goes to depth of 390 ft. This turns out to be approximately 140,000 ft$^2$. Figure 7 shows the location of the loop system.

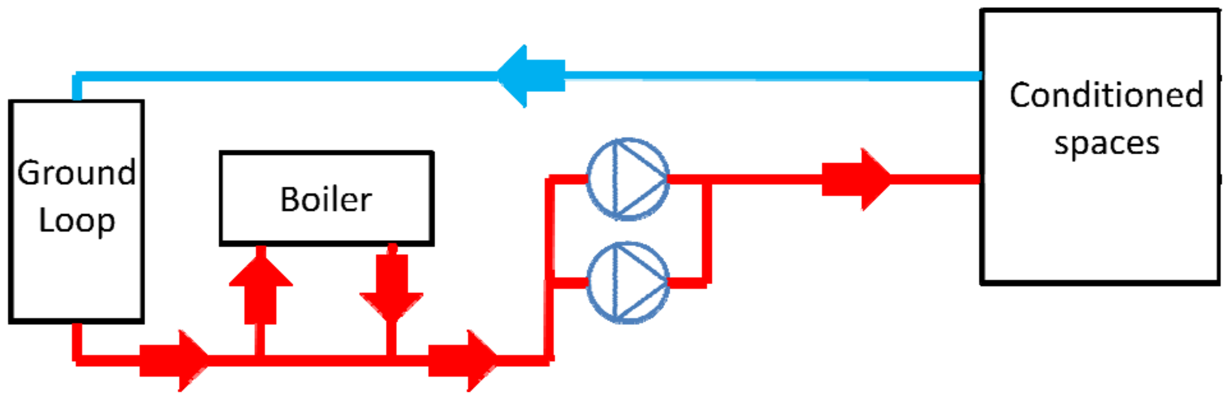
Figure 7 – Ground Loop Location in Relation to the School (not to scale)



The same program offered a cost estimation program. The program determined that it would be approximately $46.8 million dollars for materials and installation of the ground loop.

At the given ground conditions the GSHP provided enough cooling capacity but additional heating was needed. The heating performance of the GSHP at that temperature provides 3,187.8 MBH of heating while the total building load is 5058.3 MBH. To provide the remaining load a 2,000 MBH boiler was placed in the loop. Figure 8 is the flow diagram for the GSHP loop system.

Figure 8 – GSHP Flow Diagram




## *Heat Pump Selection*

The class room spaces will be served by a new console heat pump based on Carrier's 50PEC model. Figure 9 is picture of the unit.

Figure 9 – Carrier's 50PEC Console Heat Pump

The units were placed in the back of the classrooms and since they are only 12" deep they will take up minimal amount of space. This means that the outdoor air will be ducted directly into the space. This will ensure that each space gets the proper amount of ventilation. Figure 10 is a diagram of the air flow in a classroom.

Figure 10 – Typical Classroom Air Flow Diagram

The administrative offices and cafeteria area will use ceiling mounted heat pumps. The outdoor air will be ducted directly into these units so the space is properly ventilated. Figure 11 shows the units selected to condition these spaces. The unit is based off the Carrier 50YC, 50YD, and 50YE models.

Figure 11 – Ceiling Mounted Heat Pump

This model has a horizontal layout available which is the option that was selected for the school so that it can fit in the plenum space.

Due to the high loads and the absence of plenum space in the gym and auditorium rooftop water source heat pumps were selected to condition these areas. The gym will use 3 - 248 MBH cooling capacity units and the auditorium will use 2 - 175 MBH cooling capacity units. This equipment was based off Carrier's 50RTG unit pictured below.

Figure 12 – Rooftop Water Source Heat Pump

# Redesign –ASHRAE Standard 90.1

## *HVAC Equipment*

The new mechanical equipment performance values were reviewed to ensure that the system complied with ASHREA Standard 90.1-2007. Table 12 shows the 15 DOAS units compliance values. The fans horse power must be less than the airflow multiplied by 0.0015.

Table 12 – DOAS Compliancy

| Unit | Air Flow (cfm) | CFM*0.0015 | Fan HP | Compliant |
|---|---|---|---|---|
| DOAS-1 | 4,195 | 6.3 | 5 | Yes |
| DOAS-2 | 4,815 | 7.2 | 5 | Yes |
| DOAS-3 | 4,810 | 7.2 | 5 | Yes |
| DOAS-5 | 2,750 | 4.1 | 3 | Yes |
| DOAS-6 | 2,865 | 4.3 | 3 | Yes |
| DOAS-7 | 4,525 | 6.8 | 5 | Yes |
| DOAS-8 | 3,895 | 5.8 | 5 | Yes |
| DOAS-9 | 4,910 | 7.4 | 5 | Yes |
| DOAS-10 | 1,670 | 2.5 | 1.5 | Yes |
| DOAS-11 | 935 | 1.4 | 1 | Yes |

Table 12 – cont.

| | | | | |
|---|---|---|---|---|
| DOAS-12 | 2,115 | 3.2 | 3 | Yes |
| DOAS-13 | 5,105 | 7.7 | 5 | Yes |
| DOAS-14 | 1,985 | 3 | 2 | Yes |
| DOAS-15 | 3,950 | 5.9 | 5 | Yes |

Table 12 shows that each unit complies with Standard 90.1. The specifications of the other equipment selected for the redesign state they exceed the Standard requirements.

# System Comparison

After analyzing each system they both condition the school adequately. However, as stated before the current system was limited by the budget while the redesign had the luxury of not being constrained by the same budget. Table 13 compares the overall mechanical initial budget to the new systems equipment cost.

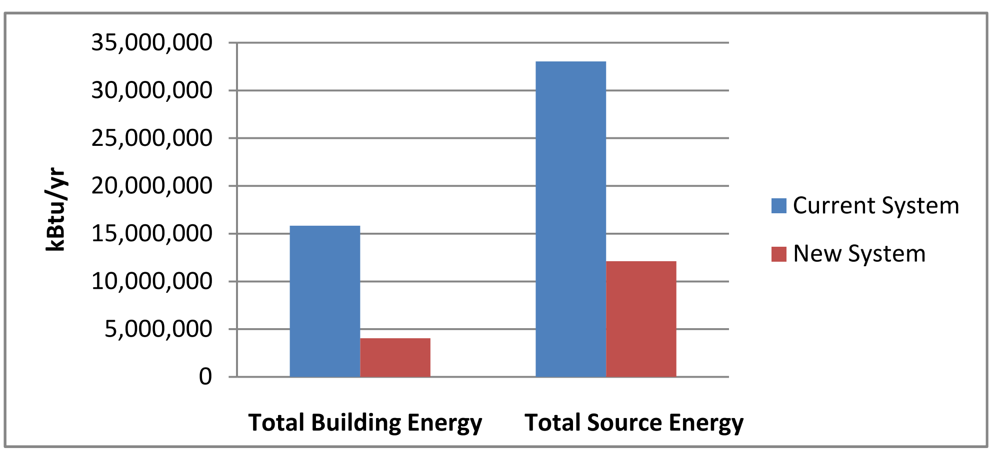
Table 13 –Initial Mechanical Cost vs. Redesigned Equipment Cost

| | Cost ($) |
|---|---|
| New Mechanical Cost | 50,291,756 |
| Mechanical Initial Cost | 4,300,000 |
| Difference | 45,991,756 |

There is a significant difference in first cost between the two systems, however when the systems energy use was calculated it showed significant savings in the redesigned system.

Chart 2 compares the energy consumed by each system over one year. Appendix B has a monthly energy chart for each system.

Chart 2 – Energy Consumption Comparison



This difference led to savings in energy costs. Table 14 shows the utility rates for each system. The redesign did not include oil since the two oil fired boilers were eliminated from the design; however, the new boiler used to provide extra heating capacity in the ground loop system uses natural gas.

Table 14 –Utility Rates

| Utility | Company | | Rate |
|---|---|---|---|
| Electricity | PP&L | Charge per KW | $7.306 |
| | | First 200 KWH | $12.11 |
| | | Next 200 KWH | $9.162 |
| | | Remaining KWH | $0.03948/KWH |
| Oil | - | Consumption | $0.80/therm |
| Natural Gas | UGI | Customer Fee | $10.62 |
| | | Consumption | $0.85/therm |

North Pocono is still looking for an oil provider therefore the rate that was used in the analysis was a sample that was in the TRACE 700 economic library. Chart 3 showed the yearly utility cost for North Pocono High School. Appendix C shows the monthly cost to operate each system.

Chart 3 – Yearly Utility Cost Comparison

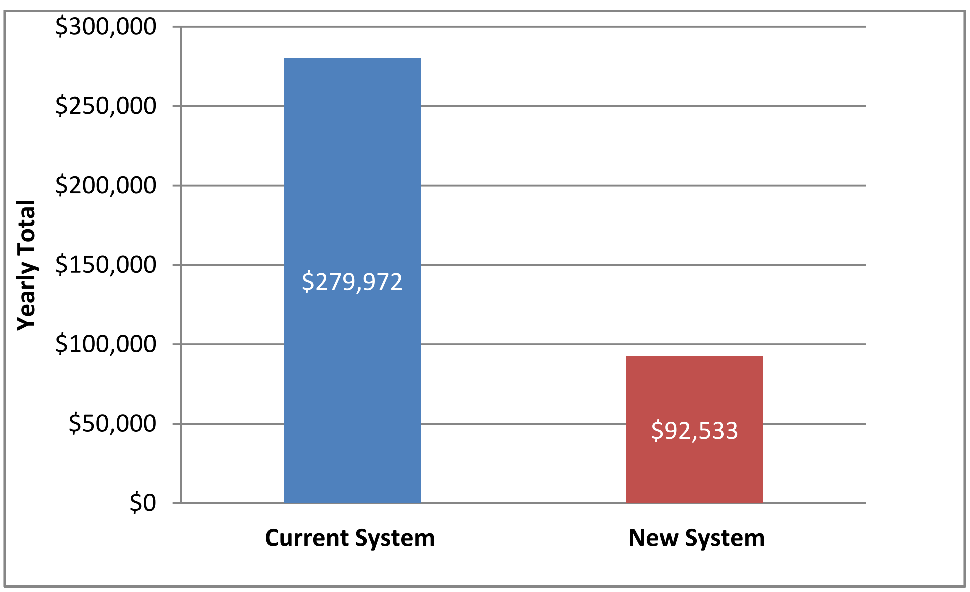


Chart 4 – Cost/ft$^2$-yr Comparison

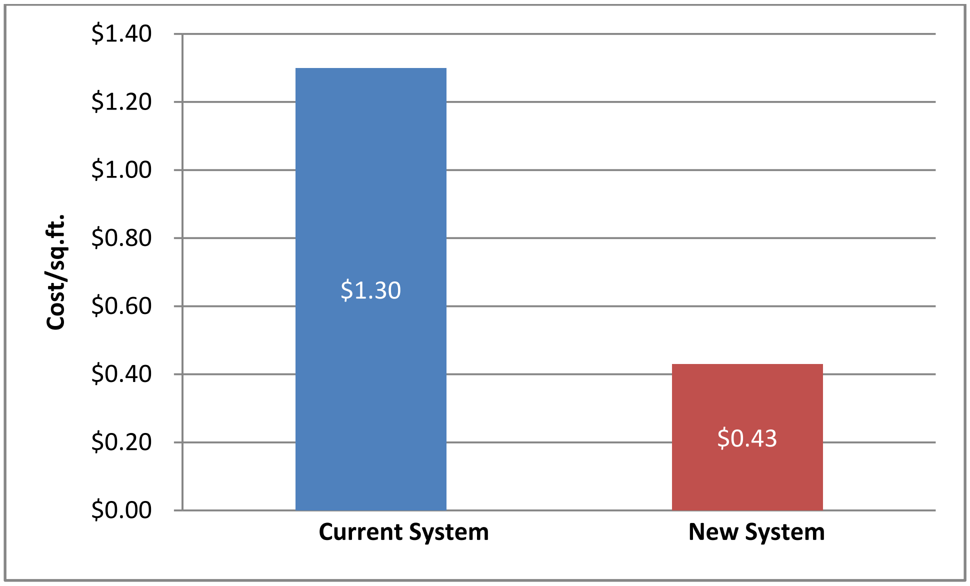



Table 12 showed that the new mechanical equipment cost is $46 million more than the original system. The new system saved North Pocono $187,439 a year in utility costs. This would result in a 245 year payback to change from the current system to the redesign.

The redesign also has an environmental advantage over the current system. Chart 5 and 6 compares the difference in emissions from each system.

Chart 5 – $CO_2$ Yearly Emissions

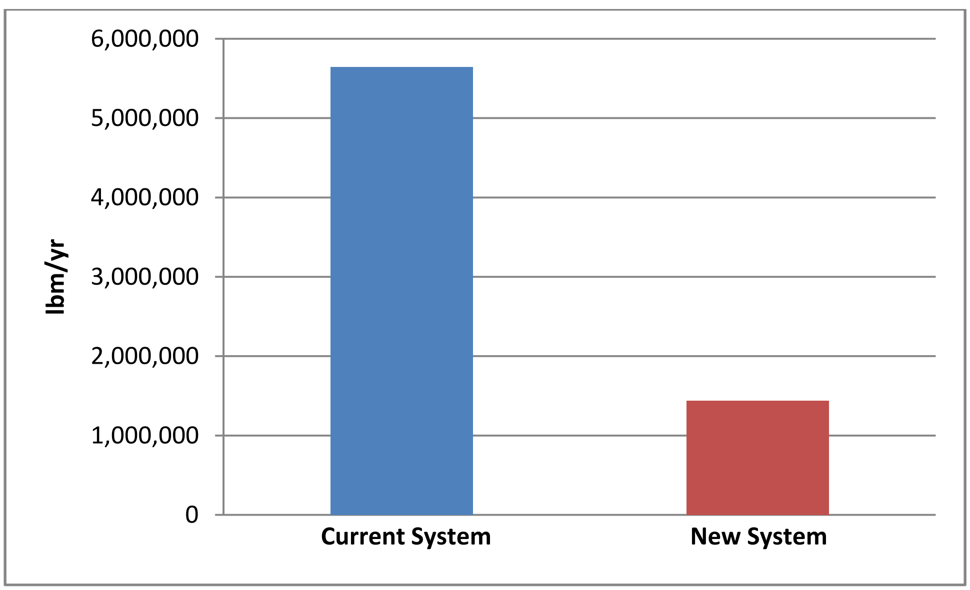
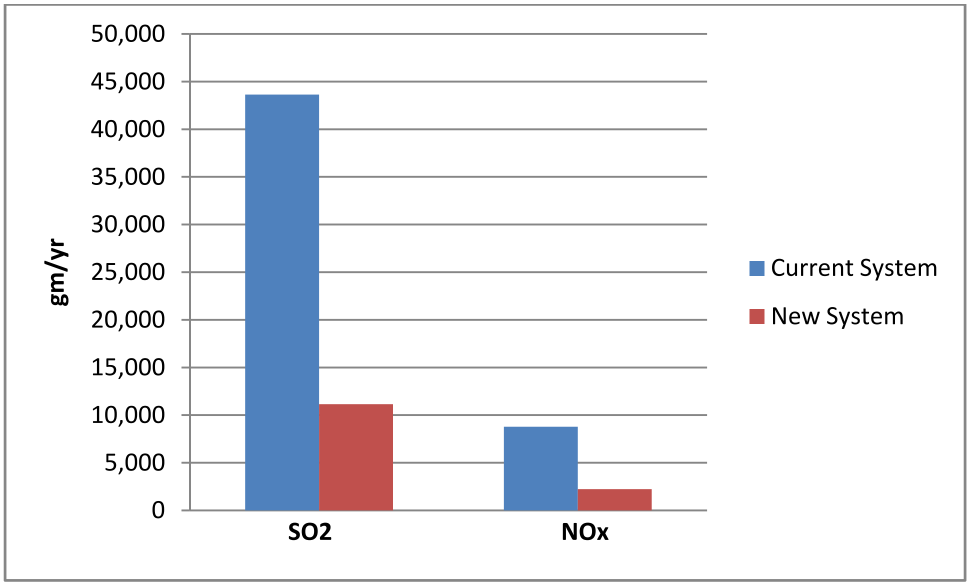


Chart 6 – $SO_2$ and $NO_x$ Yearly Emissions



# Structural Breadth

With the redesign of mechanical equipment that is placed on the roof, the structure was directly impacted by the new system. The roof is a non-composite 1.5" 20 gauge steel deck supported by steel joists that are bearing on 8" CMU walls. This breadth study kept the roof deck the same while analyzing the difference in the steel joists. The self weight of the deck is 7.0 psf with a controlling snow load of 39 psf. The equipment loads for the two systems are shown in Table 15.

Table 15 – Equipment Loads

| CURRENT ROOF LOADS | | | REDESIGNED ROOF LOADS | | |
|---|---|---|---|---|---|
| Unit | Weight (lbs) | Weight (lbs/ft$^2$) | Unit | Weight (lbs) | Weight (lbs/ft$^2$) |
| AHU-1 | 8,295 | 61.4 | DOAS-1 | 4,975 | 43.7 |
| AHU-2 | 9,360 | 32.8 | DOAS-2 | 4,975 | 43.7 |
| AHU-3 | 23,752 | 52.8 | DOAS-3 | 5,575 | 49.0 |
| AHU-4 | 2,816 | 33.4 | AHU-4 | 2,816 | 33.4 |
| AHU-5 | 4,903 | 45.5 | DOAS-5 | 3,280 | 38.2 |
| AHU-6 | 12,815 | 46.1 | DOAS-6 | 3,260 | 38.0 |
| AHU-7 | 6,602 | 43.2 | DOAS-7 | 4,975 | 43.7 |
| AHU-8 | 5,553 | 39.6 | DOAS-8 | 3,260 | 38.0 |
| AHU-9 | 8,364 | 41.2 | DOAS-9 | 4,975 | 43.7 |
| AHU-10 | 4,903 | 45.5 | DOAS-10 | 3,160 | 36.8 |
| AHU-11 | 4,891 | 55.7 | DOAS-11 | 2,720 | 31.7 |
| AHU-12 | 1,896 | 26.2 | DOAS-12 | 2,855 | 33.3 |
| AHU-13 | 9,965 | 32 | DOAS-13 | 5,075 | 44.4 |
| AHU-14 | 4,731 | 39.1 | DOAS-14 | 3,160 | 36.8 |
| AHU-15 | 8,364 | 41.2 | DOAS-15 | 3,260 | 38.0 |
| AHU-16 | 4,891 | 55.7 | RTG-1 (3) | 1,960 | 59.6 |
| CU-2a | 4,057 | 43.4 | RTG-2 (2) | 1,770 | 53.9 |
| CU-2b | 4,057 | 43.4 | x | x | x |
| CU-3 | 3,998 | 29.4 | x | x | x |
| CU-4 | 484 | 28.9 | x | x | x |
| CU-5 | 484 | 28.9 | x | x | x |
| CU-8 | 531 | 20.9 | x | x | x |
| **Total** | **135,712** | **886.3** | **Totals** | **62,051** | **705.9** |

As shown above the new system reduced the total weight by 73,661 lbs which is a 55% decrease from the original roof loads. The DOAS units were placed in the same locations to ensure that the roof penetrations are not affected, and the architecture of the building is not impacted. Figure 13 shows the location of the 16 DX units while Figure 14 displays the location of the DOAS units.

Figure 13 – Current Equipment Location

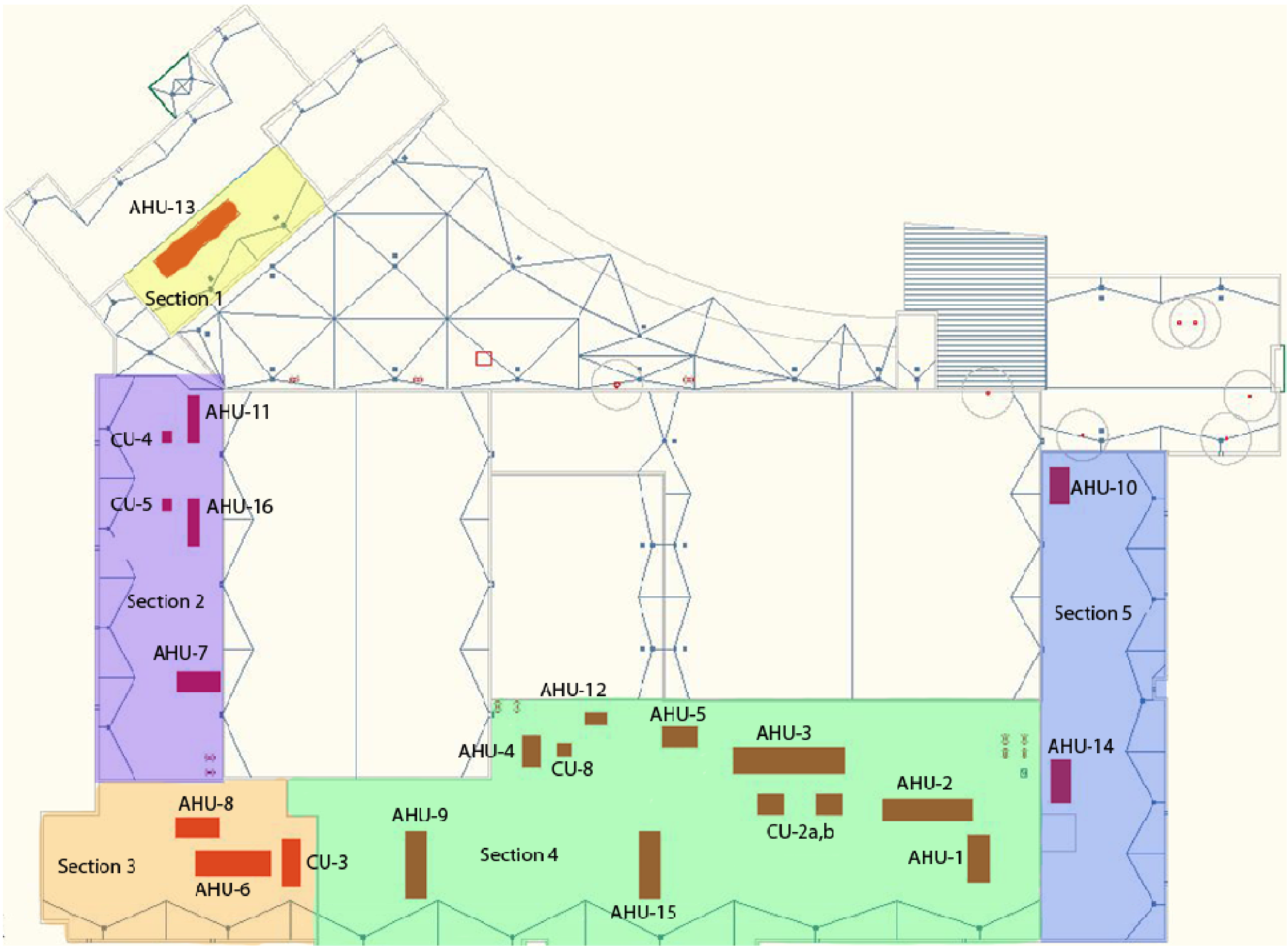
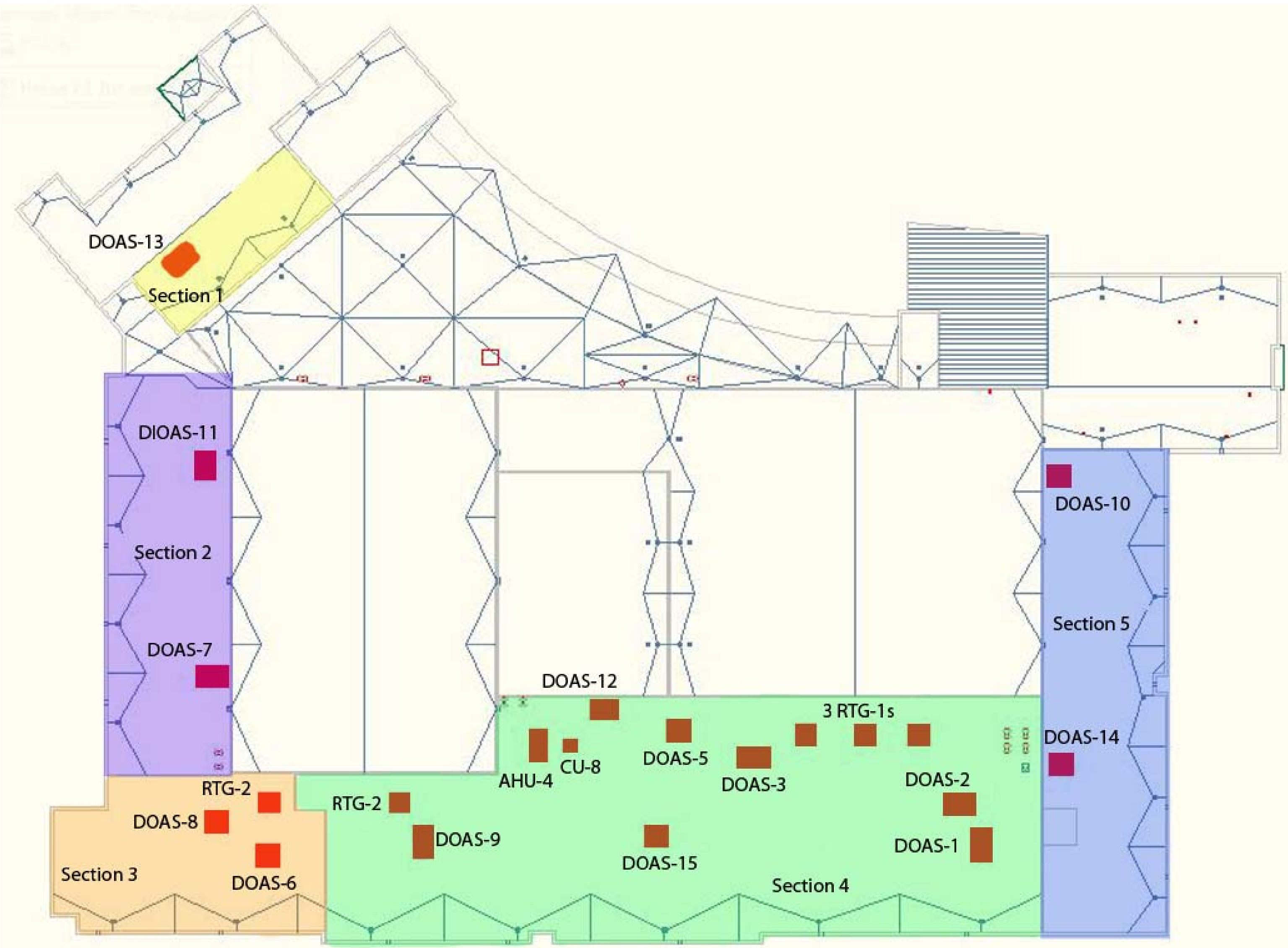


Figure 14 – New Equipment Locations




The information above was then entered into the RAM modeling program to determine the new sizes of the steel joists supporting the roof. Table 16 breaks down the 5 sections of the roof and the joists for each design scenario.

Table 16 – Roof Joist Comparison

| Section | Joist Span | Joist Spacing | Current Joist | Redesigned Joist |
|---|---|---|---|---|
| **Section 1** | 29'- 4" | 5'-2" | 22K9 | 16K2 |
| **Section 2** | 34'-8" | 5'-8" | 24K9 | 18K3 |
| | 13'-1" | 5'-6" | 16KCS3 | 10K1 |
| **Section3** | 13'-0" | 5'-10 1/8" | 12K3 | 10K1 |
| | 34'-8" | 5'-7 1/2" | 24k9 | 26k6 |
| | 13'-4" | 5'-0" | 16KCS3 | 10K1 |
| **Section 4** | 38'-0" | 5'-7 1/2" | 24K9 | 28k6 |
| | 13'-0" | 5'-10 1/8" | 12K3 | 10K1 |
| | 13'-0" | 5'-4" | 16KCS3 | 10K1 |
| | 11'-4" | 4'-9" | 16KCS3 | 10K1 |
| | 10'-0" | 4-9" | 12K5 | 10K1 |
| | 43'-8" | 5'-6 1/2" | 28K12 | 30K9 |
| | 10'-8" | 6'-2" | 12K3 | 10K1 |
| | 25'-8" | 5'-7 1/2" | 20K6 | 24K4 |
| **Section 5** | 13'-0" | 5'-10 3/4" | 12K3 | 10K1 |
| | 34'-4" | 5'-9" | 24K9 | 22K4 |

Table 17 is a breakdown of the roof girders that are located in those sections of the roof.

Table 17 – Girder Comparison

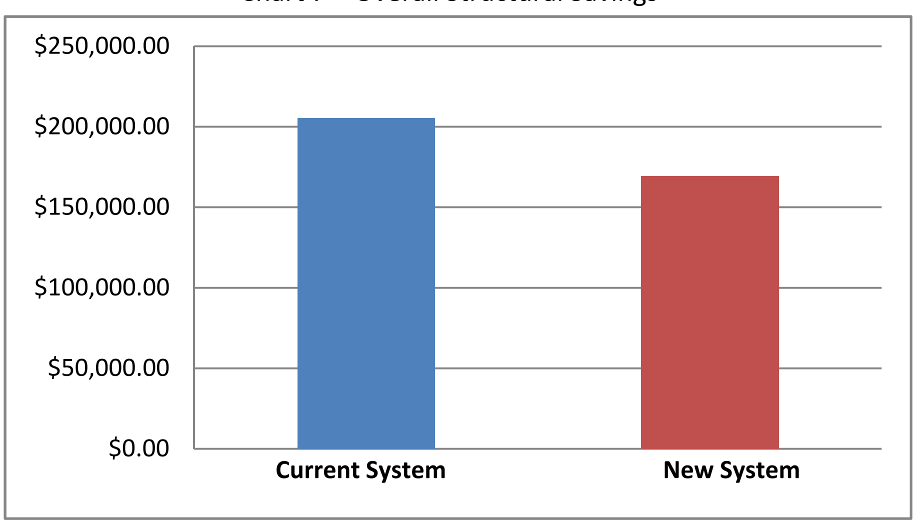
| Section | Span | Current Girder | Redisgned Girder |
|---|---|---|---|
| **Section1** | 27'-4" | W18x35 | W16x26 |
| | 23'-8" | W18x35 | W16x26 |
| | 29'-6" | W18x35 | W16x31 |
| | 20'-4" | W16x31 | W16x26 |
| | 26'-0" | W18x40 | W18x35 |
| | 29'-4" | W14x22 | W8x10 |
| **Section 2** | 23'-8" | W16x36 | W8x10 |
| **Section 3** | 11'-4" | W12x19 | W8x10 |
| | 34'-2" | W21x62 | W21x19 |
| | 33'-6" | W14x22 | W10x12 |
| | 12'-4" | W12x16 | W8x10 |
| | 12'-0" | W12x16 | W8x10 |
| **Section 4** | 33'-4" | W14x22 | W12x14 |
| | 19'-0" | W12x19 | W8x10 |

Table 17 – Cont.

| | | | |
|---|---|---|---|
| | **37'-0"** | **W16x31** | **W16x26** |
| | 20'-0" | W16x36 | W14x22 |
| | 21'-4" | W16x36 | W14X22 |
| | 10'-0" | W12x19 | W8x10 |
| | 28'-0" | W16x26 | W12x19 |
| | 15'-4" | W14x22 | W8x10 |
| | 14'-8" | W14x22 | W8x10 |
| | 30'-0" | W21x44 | W14x22 |
| | 17'-3" | W16x36 | W8x10 |
| | 29'-8" | W21x44 | W21x44 |
| | 27'-8" | W21x44 | W18x35 |
| | 39'-0" | W24x68 | W21x44 |
| **Section 5** | 29'-3" | W21x44 | W16x31 |
| | 28'-7" | W24x55 | W24x55 |
| | 23'-3" | W18x35 | W10x12 |
| | 34'-0" | W18x40 | W14x22 |
| | 32'-6" | W18x40 | W16x26 |
| | 13'-8" | W8x24 | W8x10 |
| | 33'-4" | W16x31 | W8x10 |

The new system showed a reduction in the majority of the structural roof frame. The new system results in a cheaper material and construction cost. Chart 7 shows the overall savings in the reduced system while Appendix D has a breakdown of savings for the joists and girders.

Chart 7 – Overall Structural Savings



# Electrical Breadth

Another building system affected by the mechanical system redesign is the electrical system. This breadth compared the electrical panels that serve the rooftop equipment as well as the major mechanical equipment in the mechanical room. There are 4- 480/277V panels that serve this equipment. Table 18 lists the current equipment that will be either changed out or eliminated because of the system redesign.

Table 18 – Current Equipment Electrical Data

| Equipment | Amps | KVA |
|---|---|---|
| AHU-1 | 230.56 | 110.67 |
| AHU-2 | 226.25 | 108.60 |
| AHU-3 | 66.51 | 138.56 |
| AHU-5 | 134.40 | 64.53 |
| AHU-6 | 71.00 | 34.08 |
| AHU-7 | 180.10 | 86.46 |
| AHU-8 | 166.25 | 79.80 |
| AHU-9 | 230.00 | 110.40 |
| AHU-10 | 135.94 | 65.25 |
| AHU-11 | 17.19 | 8.25 |
| AHU-12 | 49.6 | 23.82 |
| AHU-13 | 135.69 | 282.69 |
| AHU-14 | 109.12 | 52.38 |
| AHU-15 | 103.02 | 214.63 |
| AHU-16 | 17.19 | 8.25 |
| Pump-1 | 46.75 | 22.44 |
| Pump-2 | 46.75 | 22.44 |
| Pump-3 | 46.75 | 22.44 |
| Boiler -1 | 6.33 | 13.19 |
| Boiler -2 | 6.33 | 13.19 |
| CU-2a | 230 | 110.4 |
| CU-2b | 230 | 110.4 |
| CU-3 | 75.81 | 157.93 |
| CU-4 | 43.38 | 20.82 |
| CU-5 | 43.38 | 20.82 |
| **Total** | **2648.3** | **1902.44** |

The redesign replaced all 16 air-handling units with 15 DOAS units. The condensing units, CU-Xs, were eliminated and one of the pumps was eliminated. The boilers were replaced by one smaller unit that will be served by a smaller sized panel board because it only requires 120V to run. Table 19 is list of the new equipment with their loads.

Table 19 – Redesigned Equipment Electrical Data

| Equipment | Amps | KVA |
|---|---|---|
| DOAS-1 | 95.62 | 45.90 |
| DOAS-2 | 105.63 | 50.70 |
| DOAS-3 | 103.75 | 49.80 |
| DOAS-5 | 67.50 | 32.40 |
| DOAS-6 | 72.50 | 34.80 |
| DOAS-7 | 88.12 | 42.30 |
| DOAS-8 | 80.00 | 38.40 |
| DOAS-9 | 175.00 | 84.00 |
| DOAS-10 | 59.37 | 28.50 |
| DOAS-11 | 49.37 | 23.70 |
| DOAS-12 | 62.50 | 30.00 |
| DOAS-13 | 292.50 | 140.40 |
| DOAS-14 | 59.37 | 28.50 |
| DOAS-15 | 80 | 38.4 |
| Pump-1 | 46.75 | 22.44 |
| Pump-2 | 46.75 | 22.44 |
| RTG-1a | 67.36 | 32.34 |
| RTG-1b | 67.36 | 32.34 |
| RTG-1c | 67.36 | 32.34 |
| RTG-2a | 40.31 | 19.35 |
| RTG-2b | 40.31 | 19.35 |
| **Total** | **1767.43** | **848.4** |

The new system showed a reduction in both KVA and amps. Charts 7 and 8 shows how the two systems electrical data compares to one another.

Chart 7 – Amp Comparison

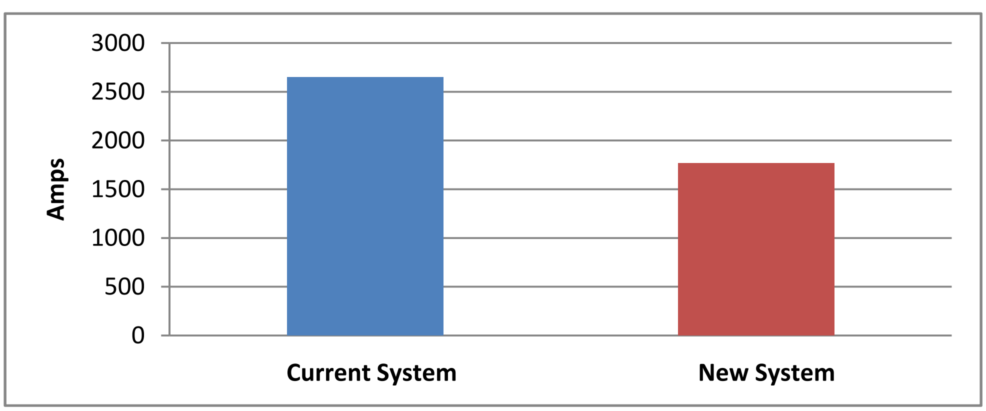
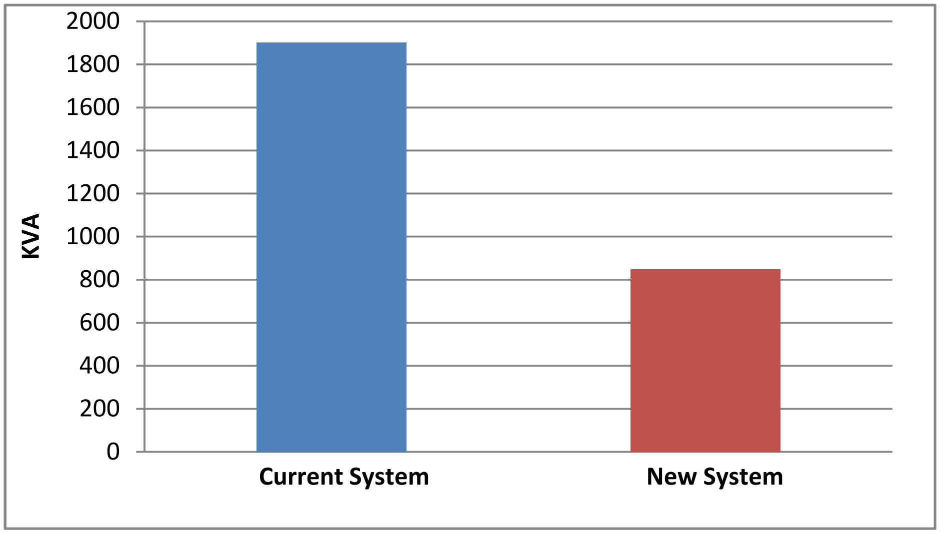


Chart 8 – KVA Comparison




When the numbers from the two systems were compared it is a 33% reduction in Amps and a 55% reduction in the KVA's needed to run the new system. Appendix E has the 4 panel boards and the current frame and feeder sizes. Appendix F has the replacement panel boards.

# Conclusions

The integrated redesign of North Pocono High School met all of the goals set prior to the start of the project. The redesign lowered the yearly energy consumption by 75%; the electrical consumption was cut by 55% a year. These reductions led to a saving of $187.4 thousand a year in utility costs. However, the savings from the new system would not be seen until 245 years because the redesign was $46 million more up front than the original design. The higher initial cost was due to the size of the ground loop. The ground loop could be reduced by adding a cooling tower and chiller to assist during the cooling season, and increasing the size of the boiler to provide more than auxiliary heating. The addition of this equipment would decrease the ground loop and thus decrease the cost of installing it. In an ever-growing environmentally conscious society it is important to see how building systems are affecting the environment. The new system emits 75% less pollutants a year than the current design. The smaller roof frame saved 17% of the initial cost. Overall, the redesign has numerous advantageous over the current system, however in today's world the financial benefits still drives the majority of the industry. From a financial standpoint it would be recommended that North Pocono keep the current system.

# References

ASHRAE, 2007, ANSI/ASHRAE, Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta, GA. 2007.

ASHRAE, 2007, ANSI/ASHRAE, Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta, GA. 2007.

Carrier Console Heat Pump Literature. http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/50pec-2pd.pdf

Carrier Dedicated Outdoor Air System Literature. http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/62d-1apd.pdf

Carrier Heat Pump Literature. http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/ca161.pdf

Carrier Rooftop Water Source Heat Pump. http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/50rtg-2pd.pdf

GPI Inc., 2007. Mechanical Specifications. GPI Inc., Scranton, PA. 2008.

Geokiss. GCHPCalc. Northport, AL.

Mumma, Stanley, Overview of Integrating Dedicated Outdoor Air Systems with Parallel Terminal Systems. American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Atlanta, GA. 2003.

PP&L Electric Utilities Corporation, Rates Schedule LP-4. 2008. http://www.pplelectric.com/NR/rdonlyres/C17294DC-59A1-4ADC-B566-29CA965528AA/0/rate_lp4_r.pdf

Trane, Trace 700. Trane Inc. Piscataway, New Jersey.

# Appendix A – Air Handler Ventilation

| Air Handler 1 | SA cfm = 15,850 | Min OA cfm = 4,335 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor-D001 | Corridor | 55 | 210 |
| FCS Lab-D014 | Classroom | 460 | 405 |
| Storage-D016 | Storage | 50 | 40 |
| Classroom-D017 | Classroom | 350 | 350 |
| Classroom-D018 | Classroom | 350 | 350 |
| Electrical-D025 | Electrical | 15 | 10 |
| Business Room-D113 | Classroom | 350 | 345 |
| Business Lab-D114 | Computer Lab | 480 | 345 |
| Classroom-D117 | Classroom | 350 | 345 |
| Corridor-D118 | Corridor | 85 | 90 |
| Room-D120 | | 170 | 135 |
| Classroom-D121 | Classroom | 350 | 345 |
| Classroom-D122 | Classroom | 350 | 345 |
| Classroom-D123 | Classroom | 350 | 345 |
| Electrical-D133 | Electrical | 15 | 10 |
| Corridor-A101 | Corridor | 75 | 60 |
| Training-A105 | Classroom | 70 | 90 |
| Office-A106 | Office | 40 | 30 |
| Classroom-A107 | Classroom | 390 | 345 |
| **Total** | | **4,355** | **4,195** |

| Air Handler 2 | SA cfm = 16,415 | Min OA cfm = 7,675 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Faculty Room-D027 | Office | 375 | 310 |
| Classroom-D010 | Classroom | 550 | 345 |
| Classroom-D011 | Classroom | 570 | 360 |
| Faculty Room-D135 | Office | 375 | 310 |
| SGI-D136 | Classroom | 205 | 105 |
| Classroom-D137 | Classroom | 560 | 350 |
| Classroom-D138 | Classroom | 560 | 350 |
| SGI-D139 | Classroom | 205 | 105 |
| Aerobics-D140 | Aerobics | 810 | 670 |
| Corridor-D001 | Corridor | 50 | 210 |
| General Science-D106 | Classroom | 625 | 405 |
| Storage-D107 | Storage | 20 | 15 |
| Classroom-D109 | Classroom | 625 | 405 |
| Classroom-D110 | Classroom | 550 | 345 |
| Business Lab-D111 | Computer Lab | 550 | 345 |
| Electrical Room-D250 | Storage | 180 | 50 |
| Classroom-D206 | Classroom | 550 | 345 |
| **Total** | | **7,360** | **5,025** |

| Air Handler 3 | SA cfm = 36,000 | Min OA cfm = 10,270 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Tickets-D226 | Office | 100 | 20 |
| Gymnasium-D125 | Gymnasium | 9,005 | 4,475 |
| Lobby - A202 | Lobby | 1,165 | 315 |
| **Total** | | **10,270** | **4,810** |

| Air Handler 4 | SA cfm = 3,700 | Min OA cfm = 3,700 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Women's Team Room-D143 | Conference | 260 | 105 |
| Coaches' Office-D144 | Office | 270 | 25 |
| Women's Locker-D148 | Conference | 410 | 145 |
| Instructor's Office-D149 | Office | 270 | 35 |
| Men's Locker-D151 | Conference | 410 | 145 |
| Instructor's Office-D152 | Office | 270 | 35 |
| Men's Team Room-D156 | Conference | 260 | 105 |
| Coaches' Office-D157 | Office | 270 | 25 |
| Weight Room-D158 | Weights | 1,090 | 510 |
| Corridor | Corridor | 150 | 130 |
| Corridor | Corridor | 150 | 130 |
| **Total** | | **3,810** | **1,390** |

| Air Handler 5 | SA cfm = 6,800 | Min OA cfm = 3,945 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Control Room-D232 | Media Center | 85 | 35 |
| Studio-D233 | Office | 80 | 30 |
| Corridor-D237 | Corridor | 80 | 95 |
| Choral Room-D238 | Music | 1,225 | 1,100 |
| Health-D240 | Classroom | 550 | 350 |
| Music Classroom-D242 | Music | 375 | 255 |
| Practice-D243 | Music | 100 | 60 |
| Practice-D244 | Music | 100 | 60 |
| Practice-D245 | Music | 100 | 60 |
| Music Classroom-D246 | Music | 340 | 255 |
| Music Office-D247 | Office | 275 | 65 |
| Musice Lab-D248 | Music | 550 | 385 |
| **Total** | | **3,860** | **2,750** |

| Air Handler 6 | SA cfm = 19,500 | Min OA cfm = 19,500 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Auditorium -C209 | ıditorium Seati | 17,760 | 2,645 |
| Stage-C231 | Stage | 1,780 | 220 |
| Total | | 19,540 | 2865 |

| Air Handler 7 | SA cfm = 13,500 | Min OA cfm = 4,355 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor-C201 | Corridor | 175 | 135 |
| Corridor-C202 | Corridor | 90 | 95 |
| Corridor-C203 | Corridor | 90 | 70 |
| Classroom-C210 | Classroom | 350 | 350 |
| Classroom-C211 | Classroom | 350 | 345 |
| Classroom-C212 | Classroom | 350 | 345 |
| Classroom-C213 | Classroom | 350 | 345 |
| Classroom-C214 | Classroom | 350 | 345 |
| Classroom-C215 | Classroom | 350 | 345 |
| Classroom-C216 | Classroom | 350 | 345 |
| Classroom-C217 | Classroom | 390 | 345 |
| Classroom-C218 | Classroom | 390 | 345 |
| Classroom-C219 | Classroom | 390 | 345 |
| Classroom-C220 | Classroom | 390 | 345 |
| Classroom-C221 | Classroom | 390 | 345 |
| Dressing Room-C225 | Office | 20 | 40 |
| Dressing Room-C230 | Office | 25 | 40 |
| Total | | 4,800 | 4,525 |

| Air Handler 8 | SA cfm = 13,500 | Min OA cfm = 4,355 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor-C101 | Corridor | 70 | 85 |
| Classroom-C103 | Classroom | 410 | 345 |
| Classroom-C104 | Classroom | 410 | 345 |
| Classroom-C105 | Classroom | 410 | 345 |
| Classroom-C106 | Classroom | 410 | 345 |
| Electrical-C115 | Electrical | 15 | 10 |
| Classroom-C118 | Classroom | 370 | 350 |
| Classroom-C119 | Classroom | 370 | 345 |
| Classroom-C120 | Classroom | 370 | 345 |
| Classroom-C121 | Classroom | 370 | 345 |
| Classroom-C122 | Classroom | 370 | 345 |
| Classroom-C123 | Classroom | 370 | 345 |
| Classroom-C124 | Classroom | 370 | 345 |
| Total | | 4,315 | 3,895 |

| Air Handler 9 | SA cfm = 14,195 | Min OA cfm = 6,245 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Chemistry-C222 | Science Lab | 500 | 710 |
| Science Prep-C223 | Classroom | 135 | 65 |
| Chemistry-C224 | Science Lab | 550 | 480 |
| Earth Science-C107 | Science Lab | 500 | 710 |
| Science Prep-C108 | Science Lab | 80 | 80 |
| Earth Science-C109 | Science Lab | 605 | 480 |
| Corridor-C001 | Corridor | 85 | 85 |
| Classroom-C003 | Clasroom | 560 | 345 |
| Classroom-C004 | Clasroom | 560 | 345 |
| Art Classroom-C005 | Art Class | 840 | 595 |
| Storage-C006 | Storage | 100 | 40 |
| Art Classroom-C008 | Art Class | 750 | 600 |
| Corridor-C011 | Corridor | 60 | 60 |
| Corridor-C018 | Corridor | 30 | 30 |
| Classroom-C020 | Clasroom | 435 | 350 |
| Classroom-C021 | Clasroom | 435 | 345 |
| Total | | 6,225 | 5,320 |

| Air Handler 10 | SA cfm = 8,565 | Min OA cfm = 3,770 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor - A203 | Corridor | 45 | 45 |
| Police - A205 | Office | 75 | 30 |
| Waiting - A206 | Reception | 220 | 70 |
| Adminstrative Area - A207 | Reception | 215 | 65 |
| Work/Break Room - A208 | Break | 210 | 55 |
| Storage - A209 | Storage | 75 | 15 |
| Corridor - A210 | Corridor | 240 | 25 |
| Adminstrative Area - A211 | Reception | 255 | 45 |
| Vice Priniciple -A214 | Office | 95 | 40 |
| Office - A215 | Office | 150 | 40 |
| Principal's Office- A216 | Office | 190 | 65 |
| Conference Room-A217 | Conference | 380 | 115 |
| Waiting - A218 | Reception | 65 | 65 |
| Nurses Office-A219 | Office | 165 | 65 |
| Cot-A220 | Classroom | 65 | 65 |
| Exam Room - A222 | Office | 95 | 25 |
| Storage - A224 | Storage | 20 | 20 |
| Hearing-A225 | Office | 100 | 45 |
| Cot-A226 | Classroom | 65 | 50 |
| Corridor-D211 | Corridor | 60 | 150 |
| Corridor-D216 | Corridor | 25 | 25 |
| Conference Room-D217 | Conference | 220 | 65 |
| Office-D218 | Office | 75 | 40 |
| Office-D219 | Office | 70 | 30 |
| Office-D220 | Office | 75 | 40 |
| Conference Room-D221 | Conference | 120 | 120 |
| File Room-D222 | Storage | 25 | 25 |
| Office-D223 | Office | 70 | 40 |
| Office-D224 | Office | 70 | 40 |
| Adminstrative Wating-D225 | Reception | 105 | 105 |
| Kitchenette-D271 | Coffee Station | 45 | 45 |
| Total | | **3,685** | **1,670** |

| Air Handler 11 | SA cfm = 3,000 | Min OA cfm = 3,000 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| LGI-C208 | Multi-Use | 2,750 | 470 |

| Air Handler 12 | SA cfm = 3,800 | Min OA cfm = 2,250 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor-D249 | Corridor | 230 | 200 |
| Band Room-D254 | Music | 2,000 | 1,890 |
| Corridor-D274 | Corridor | 25 | 25 |
| Total | | **2,255** | **2400** |

| Air Handler 13 | SA cfm = 18,200 | Min OA cfm = 10,800 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Corridor-B202 | Corridor | 160 | 40 |
| Cafeteria-B203 | Cafeteria | 8,640 | 4,375 |
| Faculty Dining | Cafeteria | 540 | 270 |
| Food Court-B208 | Cafeteria | 1,250 | 360 |
| Office-B214 | Office | 25 | 20 |
| School Store | Store | 110 | 40 |
| Total | | **10,725** | **5,105** |

| Air Handler 14 | SA cfm = 10,300 | Min OA cfm = 2,575 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Storage-D207 | Storage | 105 | 50 |
| Computer Lab-D208 | Computer Lab | 720 | 440 |
| Library-D209 | Library | 1,120 | 965 |
| Office-D210 | Office | 130 | 55 |
| Corridor-D211 | Corridor | 60 | 120 |
| Classroom-D212 | Classroom | 285 | 345 |
| Electrical Room-D235 | Electrical | 50 | 10 |
| Total | | **2,470** | **1,985** |

| Air Handler 15 | SA cfm = 15,300 | Min OA cfm = 6,120 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| Physics-D203 | Classroom | 630 | 405 |
| Science Prep-D204 | Classroom | 145 | 65 |
| Physics-D205 | Classroom | 585 | 405 |
| Corridor-D101 | Corridor | 270 | 215 |
| Biology Classroom-D103 | Classroom | 630 | 405 |
| Science Prep-D104 | Classroom | 245 | 65 |
| Biology Classroom-D105 | Classroom | 585 | 405 |
| Electrical-C016 | Electrical | 90 | 10 |
| Corridor-D001 | Corridor | 80 | 210 |
| Communication Lab-D003 | Computer | 705 | 520 |
| Press Room-D004 | Office | 330 | 50 |
| Dark Room-D005 | Classroom | 75 | 75 |
| CADD Lab-D007 | Computer | 570 | 395 |
| Wood Shop-D008 | Wood Shop | 750 | 670 |
| Custodial BreakRoom | BreakRoom | 200 | 55 |
| Total | | **5,890** | **3,950** |

| Air Handler 16 | SA cfm = 3,000 | Min OA cfm = 3,000 | |
|---|---|---|---|
| Space | Use | $OA_{sup}$ (cfm) | ASHRAE Value |
| LGI-C208 | Multi-Use | 2,750 | 465 |

# Appendix B – Monthly Energy Consumption

Table B1 – Current System

| Utility | | Jan. | Feb. | Mar. | Apr. | May | June |
|---|---|---|---|---|---|---|---|
| Electricity | On-Pk Cons. (kWh) | 305,564 | 281,327 | 307,909 | 132,569 | 185,980 | 244,396 |
| | On-Pk Dem. (kW) | 718 | 631 | 874 | 1,068 | 1,732 | 1,961 |
| Oil | Cons. (therms) | 15,666 | 18,995 | 9,814 | 4,268 | 1,153 | 618 |

| Utility | | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|
| Electricity | On-Pk Cons. (kWh) | 196,354 | 10,715 | 184,177 | 144,000 | 165,781 | 2,461,314 |
| | On-Pk Dem. (kW) | 2,191 | 326 | 1,932 | 1,228 | 1,086 | 2,191 |
| Oil | Cons. (therms) | 217 | 0 | 1,096 | 4,422 | 6,071 | 12,094 |

Table B2 – Redesigned System

| Utility | | Jan. | Feb. | Mar. | Apr. | May | June |
|---|---|---|---|---|---|---|---|
| Electricity | On-Pk Cons. (kWh) | 111,134 | 109,432 | 88,717 | 71,274 | 93,038 | 117,034 |
| | On-Pk Dem. (kW) | 549 | 594 | 500 | 454 | 696 | 789 |
| Gas | Cons. (therms) | 16 | 15 | 14 | 8 | 9 | 0 |

| Utility | | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|
| Electricity | On-Pk Cons. (kWh) | 101,469 | 10,519 | 93,781 | 77,860 | 77,306 | 96,078 |
| | On-Pk Dem. (kW) | 832 | 325 | 758 | 501 | 463 | 504 |
| Gas | Cons. (therms) | 0 | 0 | 8 | 9 | 12 | 16 |

# Appendix C – Monthly Energy Cost

Table C1 – Current System

| Utility | | Jan. | Feb. | Mar. | Apr. | May | June |
|---|---|---|---|---|---|---|---|
| Electricity | Total ($) | 17,315 | 16,676 | 18,442 | 19,860 | 24,711 | 26,384 |
| Oil | Cons. ($) | 6,266 | 7,598 | 3,926 | 1,707 | 247 | 87 |

| Utility | | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|
| Electricity | Total ($) | 28,064 | 14,438 | 26,172 | 21,028 | 19,991 | 17,500 | **250,581** |
| Oil | Cons. ($) | 87 | 0 | 439 | 1,769 | 2,428 | 4,837 | **29,391** |

Table C2 – Redesigned System

| Utility | | Jan. | Feb. | Mar. | Apr. | May | June |
|---|---|---|---|---|---|---|---|
| Electricity | Total ($) | 8,404 | 8,665 | 7,161 | 6,136 | 8,764 | 10,390 |
| Gas | Cons. ($) | 25 | 24 | 23 | 18 | 18 | 11 |

| Utility | | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
|---|---|---|---|---|---|---|---|---|
| Electricity | Total ($) | 10,090 | 2,795 | 9,246 | 6,740 | 6,440 | 7,481 | **92,312** |
| Gas | Cons. ($) | 11 | 11 | 18 | 18 | 20 | 24 | **221** |

# Appendix D – Structural Cost Analysis

Table D1 – Current Joist Estimate

| Joist | Total Liner Feet | Cost/L.F. | Total Cost ($) |
|---|---|---|---|
| 12K3 | 1349.99 | 10.04 | 13,553.90 |
| 12K5 | 60 | 10.28 | 616.80 |
| 16KCS3 | 1247.25 | 9.67 | 12,060.91 |
| 20K6 | 102.666 | 10.68 | 1,096.47 |
| 22K9 | 439.995 | 13.18 | 5,799.13 |

| | | | |
|---|---|---|---|
| 24K9 | 4745.967 | 14.32 | 67,962.25 |
| 28K12 | 1091.665 | 17.26 | 18,842.14 |
| **Total** | | | **119,931.60** |

Table D2 – Redesigned Joist System

| Joist | Total Liner Feet | Cost/L.F. | Total Cost ($) |
|---|---|---|---|
| 10K1 | 2706.239 | 10.78 | 29,173.26 |
| 16K2 | 439.995 | 9.67 | 4,254.75 |
| 18K3 | 1039.98 | 10.38 | 10,794.99 |
| 22K4 | 1132.989 | 11.18 | 12,666.82 |
| 24K4 | 102.666 | 11.52 | 1,182.71 |
| 26K6 | 623.999 | 12.27 | 7,656.47 |
| 28K6 | 1900 | 13.66 | 25,954.00 |
| 30K9 | 1091.665 | 14.06 | 15,348.81 |
| **Total** | | | **107,031.81** |

Table D3 – Current Girder Estimate

| Girder | Total $ft^2$ | Cost/$ft^2$ | Total Cost ($) |
|---|---|---|---|
| W8x24 | 9.11 | 54.50 | 496.50 |
| W12x16 | 24.333 | 36.00 | 875.99 |
| W12x19 | 40.333 | 41.50 | 1,673.82 |
| W14x22 | 108.304 | 53.00 | 5,740.11 |
| W16x26 | 37.33 | 53.00 | 1,978.49 |
| W16x31 | 120.888 | 63.50 | 7,676.39 |
| W16x36 | 109.665 | 72.00 | 7,895.88 |
| W18x35 | 155.623 | 72.00 | 11,204.86 |
| W18x40 | 138.75 | 81.00 | 11,238.75 |
| W21x44 | 151.519 | 87.50 | 13,257.91 |
| W21x62 | 59.792 | 121.00 | 7,234.83 |
| W24x55 | 57.167 | 107.00 | 6,116.87 |
| W24x68 | 78 | 130.00 | 10,140.00 |
| Total | | | 85,530.39 |

Table D4 – Redesigned Girder Estimate

| Girder | Total $ft^2$ | Cost/$ft^2$ | Total Cost ($) |
|---|---|---|---|
| W8x10 | 141.054 | 28.50 | 4,020.04 |
| W10x12 | 47.292 | 32.00 | 1,513.34 |
| W12x14 | 33.333 | 35.00 | 1,166.66 |
| W12x19 | 228 | 41.50 | 9,462.00 |
| W14x22 | 122.889 | 53.00 | 6,513.12 |
| W16x26 | 187.776 | 53.00 | 9,952.13 |
| W16x31 | 78.333 | 63.50 | 4,974.15 |
| W18x35 | 80.499 | 72.00 | 5,795.93 |
| W21x19 | 59.792 | 41.50 | 2,481.37 |
| W21x44 | 120.167 | 87.50 | 10,514.61 |
| W24x55 | 57.167 | 107.00 | 6,116.87 |
| Total | | | 62,510.21 |

# Appendix E – Current Panel Boards

## *Panel M4U1*

| | | | |
|---|---|---|---|
| DESIGNATION: **M4U1** | VOLTAGE: 480/277V-3PH-4W | LOCATION: ELEC. RM. | |
| | MAINS: 1200A | FED BY: MDP | |
| | TYPE: MOTORS | FEEDER SIZE: 4 SETS OF 4#500,1#4/0G, IN 3"C (AL) | |
| | O.C. DEVICE: MLO (1200A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 25.27 | 36.80 | | | | | | | 2 | |
| CONDSNER CU-3 | 3 | 150 | 3 | | | 25.27 | 36.80 | | | 3 | 200 | 4 | AIR HAND AHU-9 |
| | 5 | | | | | | | 25.27 | 36.80 | | | 6 | |
| | 7 | | | 21.51 | 34.34 | | | | | | | 8 | |
| AIR HAND AHU-5 | 9 | 110 | 3 | | | 21.51 | 34.34 | | | 3 | 200 | 10 | AIR HAND AHU-15 |
| | 11 | | | | | | | 21.51 | 34.34 | | | 12 | |
| | 13 | | | 28.82 | 26.60 | | | | | | | 14 | |
| AIR HAND AHU-7 | 15 | 150 | 3 | | | 28.82 | 26.60 | | | 3 | 125 | 16 | AIR HAND AHU-8 |
| | 17 | | | | | | | 28.82 | 26.60 | | | 18 | |
| | 19 | | | 23.17 | 11.36 | | | | | | | 20 | |
| EX. FAN EF-2 | 21 | 125 | 3 | | | 23.17 | 11.36 | | | 3 | 70 | 22 | AIR HAND AHU-6 |
| | 23 | | | | | | | 23.17 | 11.36 | | | 24 | |
| | 25 | | | 0.83 | 0.83 | | | | | | | 26 | |
| EXHAUST FAN EF-5 | 27 | 20 | 3 | | | 0.83 | 0.83 | | | 3 | 20 | 28 | EXHAUST FAN EF-17 |
| | 29 | | | | | | | 0.83 | 0.83 | | | 30 | |
| | 31 | | | 7.94 | 0.55 | | | | | 1 | 20 | 32 | EXHAUST FAN EF-1 |
| AIR HAND AHU-12 | 33 | 40 | 3 | | | 7.94 | 0.83 | | | | | 34 | |
| | 35 | | | | | | | 7.94 | 0.83 | 3 | 20 | 36 | EXHAUST FAN EF-17 |
| | 37 | | | | 0.83 | | | | | | | 38 | |
| SPARE BREAKER | 39 | 20 | 3 | | | | | | | 1 | 20 | 40 | SPACE |
| | 41 | | | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 218.86 | | 218.30 | | 218.30 | | | TOTAL KVA | | 655.47 |
| | | | | | | | | | | | TOTAL AMP | | 788.41 |

| DESIGNATION: | VOLTAGE: | 480/277V-3PH-4W | LOCATION: ELEC. RM. | |
|---|---|---|---|---|
| **M4U1** | MAINS: | 1200A | FED BY: | MDP |
| | TYPE: | MOTORS | FEEDER SIZE: | 4 SETS OF 4#500,1#4/0G, IN 3"C (AL) |
| | O.C. DEVICE: | MLO (1200A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: | SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | | | 2.11 | 10.58 | | | | | | | 46 | |
| AHU-4 | 45 | 30 | 3 | | | 2.11 | 10.58 | | | 3 | 30 | 48 | CU-8 |
| | 47 | | | | | | | 2.11 | 10.58 | | | 50 | |
| | 49 | | | | | | | | | | | 52 | |
| SPACE | 51 | 80 | 3 | | | | | | | 3 | 125 | 54 | SPARE BREAKER |
| | 53 | | | | | | | | | | | 56 | |
| | 55 | | | | | | | | | | | 58 | |
| SPACE | 57 | 110 | 3 | | | | | | | 3 | 100 | 60 | SPACE |
| | 59 | | | | | | | | | | | 62 | |
| | TOTAL KVA/PHASE | | | 12.68 | | 12.68 | | 12.68 | | | TOTAL KVA | | 38.05 |
| | | | | | | | | | | | TOTAL AMP | | 45.77 |
| | | | | | | | | | | | TOTAL PANEL KVA | | 693.52 |
| | | | | | | | | | | | TOTAL PANEL AMP | | 834.17 |

## Panel M4U2

| | MAINS: | 1200A | FED BY: | MDP |
|---|---|---|---|---|
| **M4U2** | TYPE: | MOTORS | FEEDER SIZE: | 4 SETS OF 4#500,1#4/0G, IN 3"C (AL) |
| | O.C. DEVICE: | MLO (1200A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: | SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 36.80 | 22.17 | | | | | | | 2 | |
| CU-2A | 3 | 225 | 3 | | | 36.80 | 22.17 | | | 3 | 100 | 4 | AHU-3 |
| | 5 | | | | | | | 36.80 | 22.17 | | | 6 | |
| | 7 | | | 36.20 | 36.89 | | | | | | | 8 | |
| AHU-2 | 9 | 200 | 3 | | | 36.20 | 36.89 | | | 3 | 200 | 10 | AHU-1 |
| | 11 | | | | | | | 36.20 | 36.89 | | | 12 | |
| | 13 | | | 21.75 | 17.46 | | | | | | | 14 | |
| AHU-10 | 15 | 110 | 3 | | | 21.75 | 17.46 | | | 3 | 90 | 16 | AHU-14 |
| | 17 | | | | | | | 21.75 | 17.46 | | | 18 | |
| | 19 | | | 5.83 | 2.11 | | | | | | | 20 | |
| WOOD SHOP BUS | 21 | 60 | 3 | | | 5.83 | 2.11 | | | 3 | 20 | 22 | LIFT STATION |
| | 23 | | | | | | | 5.83 | 2.11 | | | 24 | |
| | 25 | | | 17.21 | 3.88 | | | | | | | 26 | |
| PANEL M2L1 | 27 | 225 | 3 | | | 14.06 | 3.88 | | | 3 | 100 | 28 | AC-1 |
| | 29 | | | | | | | 13.13 | 3.88 | | | 30 | |
| | 31 | | | 7.20 | | | | | | | | 32 | |
| DC-1 | 33 | 50 | 3 | | | 7.20 | | | | 3 | 80 | 34 | SPARE BREAKER |
| | 35 | | | | | | | 7.20 | | | | 36 | |
| SPACE | 37 | 20 | 1 | | | | | | | 1 | 20 | 38 | SPACE |
| SPACE | 39 | 20 | 1 | | | | | | | 1 | 20 | 40 | SPACE |
| SPACE | 41 | 20 | 1 | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 207.52 | | 204.36 | | 203.44 | | | TOTAL KVA | | 615.31 |
| | | | | | | | | | | | TOTAL AMP | | 740.10 |

| DESIGNATION: | VOLTAGE: 480/277V-3PH-4W | LOCATION: MID LEVEL |
|---|---|---|
| **M4U2** | MAINS: 1200A | FED BY: MDP |
| | TYPE: MOTORS | FEEDER SIZE: 4 SETS OF 4#500,1#4/0G, IN 3"C (AL) |
| | O.C. DEVICE: MLO (1200A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 36.80 | 22.05 | | | | | | | 2 | |
| CU-2B | 3 | 225 | 3 | | | 36.80 | 22.05 | | | 3 | 200 | 4 | PANEL M2L1 XFMR |
| | 5 | | | | | | | 36.80 | 22.05 | | | 6 | |
| | 7 | | | | | | | | | | | 8 | |
| SPARE BREAKER | 9 | 225 | 3 | | | | | | | 3 | 100 | 10 | SPARE BREAKER |
| | 11 | | | | | | | | | | | 12 | |
| | 13 | | | | | | | | | | | 14 | |
| SPACE | 15 | 100 | 3 | | | | | | | 3 | 100 | 16 | SPACE |
| | 17 | | | | | | | | | | | 18 | |
| TOTAL KVA/PHASE | | | | 58.85 | | 58.85 | | 58.85 | | | | TOTAL KVA | 176.56 |

| | |
|---|---|
| TOTAL AMP | 212.37 |
| TOTAL PANEL KVA | 791.87 |
| TOTAL PANEL AMP | 952.47 |
| DIVERSITY | 0.85 |

## *Panel M4U3*

| DESIGNATION: | VOLTAGE: | 480/277V-3PH-4W | LOCATION: MAIN ELECTRIC ROOM | |
|---|---|---|---|---|
| **M4U3** | MAINS: | 600A | FED BY: | MDP |
| | TYPE: | MOTORS | FEEDER SIZE: | 2 SETS OF 4#350,1#1/0G, IN 3"C (AL) |
| | O.C. DEVICE: | MLO (500A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: | SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7.48 | 7.48 | | | | | | | 2 | |
| PUMP P-2 | 3 | 50 | 3 | | | 7.48 | 7.48 | | | 3 | 50 | 4 | PUMP P-3 |
| | | | | | | | | 7.48 | 7.48 | | | 6 | |
| | 7 | | | 2.11 | **45.23** | | | | | | | 8 | |
| BOILER B-1 | 9 | 20 | 3 | | | 2.11 | **45.23** | | | 3 | **250** | 10 | AIR HAND AHU-13 |
| | 11 | | | | | | | 2 | **45.23** | | | 12 | |
| | 13 | | | 3.88 | **6.94** | | | | | | | 14 | |
| KITCHEN AIR MAU-1 | 15 | 30 | 3 | | | 3.88 | **6.94** | | | 3 | **40** | 16 | CONDENSER CU-4 |
| | 17 | | | | | | | 3.88 | **6.94** | | | 18 | |
| | 19 | | | **2.75** | **6.94** | | | | | | | 20 | |
| AIR HAND AHU-11 | 21 | 40 | 3 | | | **2.75** | **6.94** | | | 3 | **40** | 22 | CONDENSER CU-5 |
| | 23 | | | | | | | **2.75** | **6.94** | | | 24 | |
| | 25 | | | **2.75** | 1.33 | | | | | | | 26 | |
| AIR HAND AHU-16 | 27 | 40 | 3 | | | **2.75** | 1.33 | | | 3 | 20 | 28 | EX. FAN EF-21 |
| | 29 | | | | | | | **2.75** | 1.33 | | | 30 | |
| | 31 | | | 1.33 | 1.33 | | | | | | | 32 | |
| EX. FAN EF-20 | 33 | 20 | 3 | | | 1.33 | 1.33 | | | 3 | 20 | 34 | EX. FAN EF-21 |
| | 35 | | | | | | | 1.33 | 1.33 | | | 36 | |
| SPACE | 37 | 20 | 1 | | | | | | | 1 | 20 | 38 | SPACE |
| SPACE | 39 | 20 | 1 | | | | | | | 1 | 20 | 40 | SPACE |
| SPACE | 41 | 20 | 1 | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 89.55 | | 89.55 | | 89.55 | | | TOTAL KVA | | 268.64 |
| | | | | | | | | | | | TOTAL AMP | | 323.12 |

| DESIGNATION: | VOLTAGE: | 480/277V-3PH-4W | LOCATION: MAIN ELECTRIC ROOM | |
|---|---|---|---|---|
| **M4U3** | MAINS: | 600A | FED BY: | MDP |
| | TYPE: | MOTORS | FEEDER SIZE: | 2 SETS OF 4#350,1#1/0G, IN 3"C (AL) |
| | O.C. DEVICE: | MLO (500A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: | SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | | | 3.33 | 0.83 | | | | | 1 | 20 | 44 | EX. FAN EF-12 |
| CONDSER CU-6 | 45 | 20 | 3 | | | 3.33 | 0.28 | | | | | 46 | |
| | 47 | | | | | | | 3.33 | 0.28 | 3 | 20 | 48 | EX. FAN EF-27 |
| | 49 | | | 2.13 | 0.28 | | | | | | | 50 | |
| PANEL M2U1 | 51 | **60** | 3 | | | 2.14 | 1.18 | | | | | 52 | |
| | 53 | | | | | | | 1.89 | | 3 | 20 | 54 | AIR COMPRESSOR |
| | 55 | | | | | | | | | | | 56 | |
| SPARE BREAKER | 57 | 20 | 3 | | | | | | | 1 | 20 | 58 | |
| | 59 | | | | | | | | | 1 | 20 | 60 | SPACE |
| | TOTAL KVA/PHASE | | | 6.57 | | 6.92 | | 5.49 | | | TOTAL KVA | | 18.97 |
| | | | | | | | | | | | TOTAL AMP | | 22.82 |
| | | | | | | | | | | | TOTAL PANEL KVA | | 287.61 |
| | | | | | | | | | | | | | 0.83 |
| | | | | | | | | | | | TOTAL PANEL AMP | | 345.94 |
| | | | | | | | | | | | DIVERSITY | | 0.85 |

### *Panel EQ4U1*

| | | | |
|---|---|---|---|
| DESIGNATION: | VOLTAGE: 480/277V-3PH-4W | LOCATION: MAIN ELEC. ROOM | |
| **EQ4U1** | MAINS: 225A | FED BY: MDP | |
| | TYPE: EMERGENCY | FEEDER SIZE: 4#300,1#2G, IN 2.5"C (AL) | |
| | O.C. DEVICE: MLO (225 AMP BREAKER IN ED4U1) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 5.82 | 7.48 | | | | | | | 2 | |
| WELL PUMP | 3 | 40 | 3 | | | 5.82 | 7.48 | | | 3 | 50 | 4 | PUMP P-1 |
| | 5 | | | | | | | 5.82 | 7.48 | | | 6 | |
| | 7 | | | 0.28 | 3.33 | | | | | | | 8 | |
| FUEL PUMP FOP-1 | 9 | 20 | 3 | | | 0.28 | 3.33 | | | 3 | 20 | 10 | CU-7 |
| | 11 | | | | | | | 0.28 | 3.33 | | | 12 | |
| | 13 | | | 2.11 | 0.44 | | | | | | | 14 | |
| B-2 | 15 | 20 | 3 | | | 2.11 | 0.44 | | | 3 | 20 | 16 | BC-2 |
| | 17 | | | | | | | 2.11 | 0.44 | | | 18 | |
| | 19 | | | 11.70 | 9.37 | | | | | | | 20 | |
| BP-1 | 21 | **60** | 3 | | | 11.70 | 10.28 | | | **3** | **80** | 22 | PANEL EQ2U3 |
| | 23 | | | | | | | 11.70 | 10.77 | | | 24 | |
| | 25 | | | | | | | | | 1 | 20 | 26 | SPACE |
| SPARE BREAKER | 27 | 20 | 3 | | | | | | | 1 | 20 | 28 | SPACE |
| | 29 | | | | | | | | | 1 | 20 | 30 | SPACE |
| | TOTAL KVA/PHASE | | | 40.52 | | 41.43 | | 41.92 | | TOTAL KVA | | 123.88 | |
| | | | | | | | | | | TOTAL AMP | | 149.00 | |
| | | | | | | | | | | DIVERSITY | | 0.85 | |

## *Main Switch Board*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MAIN | | MAIN SWITCHBOARD MSB41 SCHEDULE | | | | (NORMAL) | |
| ELECTRIC RM | | | | | | | |
| VOLTAGE: | 277/480 | 3 PHASE | | 4 WIRE | | 65,000 | AIC |
| MAIN BUS SIZE: | 4000A | NEUTRAL: | | FULL | GROUND BUS: | FULL | |
| MAIN DEVICE: | "4000A MCB | MOUTING: | | SURFACE | | | |
| CIRCUIT NUMBER | LOAD ITEM | OVERCURRENT DEVICE FRAME | TRIP | POLE | FEEDER SIZE | REMARKS | |
| 1 | FIRE PUMP TAP | --- | --- | 3 | SEE RISER DIAGRAM | | |
| 2 | M4U1 | **1200** | **1200** | 3 | SEE PANEL SCHEDULE | | |
| 3 | M4U2 | **1200** | **1200** | 3 | SEE PANEL SCHEDULE | | |
| 4 | M4U3 | **600** | **500** | 3 | SEE PANEL SCHEDULE | | |
| 5 | ED4U1 | 600 | 600 | 3 | SEE PANEL SCHEDULE | | |
| 6 | K4U1 | **600** | **600** | 3 | SEE PANEL SCHEDULE | | |
| 7 | **L4U1/L4M1/L4L1** | 600 | 600 | 3 | SEE PANEL SCHEDULE | | |
| 8 | **L4U2/L4M2/L4L2** | 600 | **400** | 3 | SEE PANEL SCHEDULE | | |
| 9 | L4U3 | **100** | **100** | 3 | SEE PANEL SCHEDULE | | |
| 10 | **L4U4** | **100** | **100** | 3 | SEE PANEL SCHEDULE | | |
| 11 | **EQ4U1** | **225** | **225** | 3 | SEE PANEL SCHEDULE | | |
| 12 | **E4U1** | **225** | **125** | 3 | SEE PANEL SCHEDULE | | |
| 13 | **R2U4 XFMER** | **100** | **60** | 3 | SEE RISER DIAGRAM | | |
| 14 | SPARE | 400 | 400 | 3 | | | |
| 15 | SPACE | 600 | 600 | 3 | | | |
| 16 | SPACE | 400 | 400 | 3 | | | |

# Appendix F – New Panels

## Panel M4U1

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U1** | VOLTAGE: 480/277V-3PH-4W | LOCATION: ELEC. RM. | |
| | MAINS: 800A | FED BY: MDP | |
| | TYPE: MOTORS | FEEDER SIZE: 4 SETS OF 4#2/0, 1#0G, IN 2.5" C (CU) | |
| | O.C. DEVICE: MLO (800A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 10.00 | 28.00 | | | | | | | 2 | |
| DOAS-12 | 3 | 70 | 3 | | | 10.00 | 28.00 | | | 3 | 200 | 4 | DOAS-9 |
| | 5 | | | | | | | 10.00 | 28.00 | | | 6 | |
| | 7 | | | 10.80 | 12.80 | | | | | | | 8 | |
| DOAS-5 | 9 | 70 | 3 | | | 10.80 | 12.70 | | | 3 | 200 | 10 | DOAS-15 |
| | 11 | | | | | | | 10.80 | 12.80 | | | 12 | |
| | 13 | | | 14.10 | 12.80 | | | | | | | 14 | |
| DOAS-7 | 15 | 90 | 3 | | | 14.10 | 12.80 | | | 3 | 80 | 16 | DOAS-8 |
| | 17 | | | | | | | 14.10 | 12.80 | | | 18 | |
| | 19 | | | 23.17 | 11.60 | | | | | | | 20 | |
| EX. FAN EF-2 | 21 | 125 | 3 | | | 23.17 | 11.60 | | | 3 | 80 | 22 | DOAS-6 |
| | 23 | | | | | | | 23.17 | 11.60 | | | 24 | |
| | 25 | | | 0.83 | 0.83 | | | | | | | 26 | |
| EXHAUST FAN EF-5 | 27 | 20 | 3 | | | 0.83 | 0.83 | | | 3 | 20 | 28 | EXHAUST FAN EF-17 |
| | 29 | | | | | | | 0.83 | 0.83 | | | 30 | |
| | 31 | | | | 0.55 | | | | | 1 | 20 | 32 | EXHAUST FAN EF-1 |
| SPARE BREAKER | 33 | 40 | 3 | | | | 0.83 | | | | | 34 | |
| | 35 | | | | | | | | 0.83 | 3 | 20 | 36 | EXHAUST FAN EF-17 |
| | 37 | | | | 0.83 | | | | | | | 38 | |
| SPARE BREAKER | 39 | 20 | 3 | | | | | | | 1 | 20 | 40 | SPACE |
| | 41 | | | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 126.32 | | 125.66 | | 125.76 | | | TOTAL KVA | | 377.74 |
| | | | | | | | | | | | TOTAL AMP | | 454.35 |

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U1** | VOLTAGE: 480/277V-3PH-4W | LOCATION: ELEC. RM. | |
| | MAINS: 800A | FED BY: MDP | |
| | TYPE: MOTORS | FEEDER SIZE: 4 SETS OF 4#2/0, 1#0G, IN 2.5" C (CU) | |
| | O.C. DEVICE: MLO (800A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | | | 2.11 | 10.58 | | | | | | | 46 | |
| AHU-4 | 45 | 30 | 3 | | | 2.11 | 10.58 | | | 3 | 30 | 48 | CU-8 |
| | 47 | | | | | | | 2.11 | 10.58 | | | 50 | |
| | 49 | | | | | | | | | | | 52 | |
| SPACE | 51 | 80 | 3 | | | | | | | 3 | 125 | 54 | SPARE BREAKER |
| | 53 | | | | | | | | | | | 56 | |
| | 55 | | | | | | | | | | | 58 | |
| SPACE | 57 | 110 | 3 | | | | | | | 3 | 100 | 60 | SPACE |
| | 59 | | | | | | | | | | | 62 | |
| | TOTAL KVA/PHASE | | | 12.68 | | 12.68 | | 12.68 | | | TOTAL KVA | | 38.05 |
| | | | | | | | | | | | TOTAL AMP | | 45.77 |
| | | | | | | | | | | | TOTAL PANEL KVA | | 415.79 |
| | | | | | | | | | | | TOTAL PANEL AMP | | 500.12 |
| | | | | | | | | | | | DIVERSITY | | 0.85 |

## Panel M4U2

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U2** | VOLTAGE: 480/277V-3PH-4W | LOCATION: MID LEVEL | |
| | MAINS: 800A | FED BY: MDP | |
| | TYPE: MOTORS | FEEDER SIZE: 2 SETS 4#500,1#0G, IN 3" C (AL) | |
| | O.C. DEVICE: MLO (800A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 6.45 | 16.60 | | | | | | | 2 | |
| RTG-2 | 3 | 50 | 3 | | | 6.45 | 16.60 | | | 3 | 125 | 4 | DOAS-3 |
| | 5 | | | | | | | 6.45 | 16.60 | | | 6 | |
| | 7 | | | 16.90 | 15.30 | | | | | | | 8 | |
| DOAS-2 | 9 | 125 | 3 | | | 16.90 | 15.30 | | | 3 | 100 | 10 | DOAS-1 |
| | 11 | | | | | | | 16.90 | 15.30 | | | 12 | |
| | 13 | | | 9.50 | 9.50 | | | | | | | 14 | |
| DOAS-10 | 15 | 60 | 3 | | | 9.50 | 9.50 | | | 3 | 60 | 16 | DOAS-14 |
| | 17 | | | | | | | 9.50 | 9.50 | | | 18 | |
| | 19 | | | 5.83 | 2.11 | | | | | | | 20 | |
| WOOD SHOP BUS | 21 | 60 | 3 | | | 5.83 | 2.11 | | | 3 | 20 | 22 | LIFT STATION |
| | 23 | | | | | | | 5.83 | 2.11 | | | 24 | |
| | 25 | | | 17.21 | 3.88 | | | | | | | 26 | |
| PANEL M2L1 | 27 | 225 | 3 | | | 14.06 | 3.88 | | | 3 | 100 | 28 | AC-1 |
| | 29 | | | | | | | 13.13 | 3.88 | | | 30 | |
| | 31 | | | 7.20 | 6.45 | | | | | | | 32 | |
| DC-1 | 33 | 50 | 3 | | | 7.20 | 6.45 | | | 3 | 50 | 34 | RTG-2 |
| | 35 | | | | | | | 7.20 | 6.45 | | | 36 | |
| SPACE | 37 | 20 | 1 | | | | | | | 1 | 20 | 38 | SPACE |
| SPACE | 39 | 20 | 1 | | | | | | | 1 | 20 | 40 | SPACE |
| SPACE | 41 | 20 | 1 | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 116.93 | | 113.78 | | 112.85 | | | TOTAL KVA | | 343.57 |
| | | | | | | | | | | | TOTAL AMP | | 413.25 |

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U2** | VOLTAGE: 480/277V-3PH-4W | LOCATION: MID LEVEL | |
| | MAINS: 800A | FED BY: MDP | |
| | TYPE: MOTORS | FEEDER SIZE: 2 SETS 4#500,1#0G, IN 3" C (AL) | |
| | O.C. DEVICE: MLO (800A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | 22.05 | | | | | | | 2 | |
| SPARE BREAKER | 3 | 225 | 3 | | | | 22.05 | | | 3 | 200 | 4 | PANEL M2L1 XFMR |
| | 5 | | | | | | | | 22.05 | | | 6 | |
| | 7 | | | | | | | | | | | 8 | |
| SPARE BREAKER | 9 | 225 | 3 | | | | | | | 3 | 100 | 10 | SPARE BREAKER |
| | 11 | | | | | | | | | | | 12 | |
| | 13 | | | | | | | | | | | 14 | |
| SPACE | 15 | 100 | 3 | | | | | | | 3 | 100 | 16 | SPACE |
| | 17 | | | | | | | | | | | 18 | |
| | TOTAL KVA/PHASE | | | 22.05 | | 22.05 | | 22.05 | | | TOTAL KVA | | 66.15 |
| | | | | | | | | | | | TOTAL AMP | | 79.57 |
| | | | | | | | | | | | TOTAL PANEL KVA | | 409.72 |
| | | | | | | | | | | | TOTAL PANEL AMP | | 492.81 |
| | | | | | | | | | | | DIVERSITY | | 0.85 |

## Panel M4U3

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U3** | VOLTAGE: 480/277V-3PH-4W | LOCATION: MAIN ELECTRIC ROOM | |
| | MAINS: 600A | FED BY: | MDP |
| | TYPE: MOTORS | FEEDER SIZE: | 2 SETS OF 4#300,1#1G, IN 2.5" C (CU) |
| | O.C. DEVICE: MLO (600A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7.48 | 7.48 | | | | | | | 2 | |
| PUMP P-1 | 3 | 50 | 3 | | | 7.48 | 7.48 | | | 3 | 50 | 4 | PUMP P-2 |
| | | | | | | | | 7.48 | 7.48 | | | 6 | |
| | 7 | | | | 46.80 | | | | | | | 8 | |
| | 9 | 20 | 3 | | | | 46.80 | | | 3 | 300 | 10 | DOAS-13 |
| | 11 | | | | | | | | 46.80 | | | 12 | |
| | 13 | | | 3.88 | 10.78 | | | | | | | 14 | |
| KITCHEN AIR MAU-1 | 15 | 30 | 3 | | | 3.88 | 10.78 | | | 3 | 70 | 16 | RTG-1 |
| | 17 | | | | | | | 3.88 | 10.78 | | | 18 | |
| | 19 | | | 7.90 | 10.78 | | | | | | | 20 | |
| DOAS-11 | 21 | 40 | 3 | | | 7.90 | 10.78 | | | 3 | 70 | 22 | RTG-1 |
| | 23 | | | | | | | 7.90 | 10.78 | | | 24 | |
| | 25 | | | 10.78 | 1.33 | | | | | | | 26 | |
| RTG-1 | 27 | 70 | 3 | | | 10.78 | 1.33 | | | 3 | 20 | 28 | EX. FAN EF-21 |
| | 29 | | | | | | | 10.78 | 1.33 | | | 30 | |
| | 31 | | | 1.33 | 1.33 | | | | | | | 32 | |
| EX. FAN EF-20 | 33 | 20 | 3 | | | 1.33 | 1.33 | | | 3 | 20 | 34 | EX. FAN EF-21 |
| | 35 | | | | | | | 1.33 | 1.33 | | | 36 | |
| SPACE | 37 | 20 | 1 | | | | | | | 1 | 20 | 38 | SPACE |
| SPACE | 39 | 20 | 1 | | | | | | | 1 | 20 | 40 | SPACE |
| SPACE | 41 | 20 | 1 | | | | | | | 1 | 20 | 42 | SPACE |
| | TOTAL KVA/PHASE | | | 109.88 | | 109.88 | | 109.88 | | TOTAL KVA | | | 329.63 |
| | | | | | | | | | | TOTAL AMP | | | 396.48 |

| DESIGNATION: | | | |
|---|---|---|---|
| **M4U3** | VOLTAGE: 480/277V-3PH-4W | LOCATION: MAIN ELECTRIC ROOM | |
| | MAINS: 600A | FED BY: | MDP |
| | TYPE: MOTORS | FEEDER SIZE: | 2 SETS OF 4#300,1#1G, IN 2.5" C (CU) |
| | O.C. DEVICE: MLO (600A CB IN MAIN SWBD) | MINIMUM O.C. DEVICE | |
| | MOUNTING: SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 43 | | | | 0.83 | | | | | 1 | 20 | 44 | EX. FAN EF-12 |
| | 45 | 20 | 3 | | | | 0.28 | | | | | 46 | |
| | 47 | | | | | | | | 0.28 | 3 | 20 | 48 | EX. FAN EF-27 |
| | 49 | | | 2.13 | 0.28 | | | | | | | 50 | |
| PANEL M2U1 | 51 | 60 | 3 | | | 2.14 | 1.18 | | | | | 52 | |
| | 53 | | | | | | | 1.89 | | 3 | 20 | 54 | AIR COMPRESSOR |
| | 55 | | | | | | | | | | | 56 | |
| SPARE BREAKER | 57 | 20 | 3 | | | | | | | 1 | 20 | 58 | |
| | 59 | | | | | | | | | 1 | 20 | 60 | SPACE |
| | TOTAL KVA/PHASE | | | 3.24 | | 3.59 | | 2.16 | | TOTAL KVA | | | 9.00 |
| | | | | | | | | | | TOTAL AMP | | | 10.82 |
| | | | | | | | | | | TOTAL PANEL KVA | | | 338.62 |
| | | | | | | | | | | | | | 0.83 |
| | | | | | | | | | | TOTAL PANEL AMP | | | 407.30 |
| | | | | | | | | | | DIVERSITY | | | 0.85 |

## Panel EQ4U1

| DESIGNATION: | VOLTAGE: | 480/277V-3PH-4W | LOCATION: MAIN ELEC. ROOM | |
|---|---|---|---|---|
| **EQ4U1** | MAINS: | 225A | FED BY: | MDP |
| | TYPE: | EMERGENCY | FEEDER SIZE: | 4#300,1#2G, IN 2.5"C (AL) |
| | O.C. DEVICE: | MLO (225 AMP BREAKER IN ED4U1) | MINIMUM O.C. DEVICE | |
| | MOUNTING: | SURFACE | INTERRUPTING RATING: 65,000 | |

| Description | CKT | O.C. AMP | P | KVA A | | KVA B | | KVA C | | P | O.C. AMP | CKT | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | 5.82 | | | | | | | | 2 | |
| WELL PUMP | 3 | 40 | 3 | | | 5.82 | | | | 3 | | 4 | |
| | 5 | | | | | | | 5.82 | | | | 6 | |
| | 7 | | | 0.28 | 3.33 | | | | | | | 8 | |
| FUEL PUMP FOP-1 | 9 | 20 | 3 | | | 0.28 | 3.33 | | | 3 | 20 | 10 | CU-7 |
| | 11 | | | | | | | 0.28 | 3.33 | | | 12 | |
| | 13 | | | | 0.44 | | | | | | | 14 | |
| | 15 | | 3 | | | | 0.44 | | | 3 | 20 | 16 | BC-2 |
| | 17 | | | | | | | | 0.44 | | | 18 | |
| | 19 | | | 11.70 | 9.37 | | | | | | | 20 | |
| BP-1 | 21 | 60 | 3 | | | 11.70 | 10.28 | | | 3 | 80 | 22 | PANEL EQ2U3 |
| | 23 | | | | | | | 11.70 | 10.77 | | | 24 | |
| | 25 | | | | | | | | | 1 | 20 | 26 | SPACE |
| SPARE BREAKER | 27 | 20 | 3 | | | | | | | 1 | 20 | 28 | SPACE |
| | 29 | | | | | | | | | 1 | 20 | 30 | SPACE |
| | TOTAL KVA/PHASE | | | 30.94 | | 31.84 | | 32.33 | | TOTAL KVA | | 95.11 | |
| | | | | | | | | | | TOTAL AMP | | 114.40 | |
| | | | | | | | | | | DIVERSITY | | 0.85 | |

## Main Switchboard

| MAIN BUS SIZE: | 4000A | NEUTRAL: | FULL | | GROUND BUS: | FULL |
|---|---|---|---|---|---|---|
| MAIN DEVICE: | "4000A MCB | MOUTING: | SURFACE | | | |

| CIRCUIT NUMBER | LOAD ITEM | OVERCURRENT DEVICE FRAME | TRIP | POLE | FEEDER SIZE | REMARKS |
|---|---|---|---|---|---|---|
| 1 | FIRE PUMP TAP | --- | --- | 3 | SEE RISER DIAGRAM | |
| 2 | M4U1 | **800** | **800** | 3 | SEE PANEL SCHEDULE | |
| 3 | M4U2 | **800** | **800** | 3 | SEE PANEL SCHEDULE | |
| 4 | M4U3 | **600** | **600** | 3 | SEE PANEL SCHEDULE | |
| 5 | ED4U1 | 600 | 600 | 3 | SEE PANEL SCHEDULE | |
| 6 | K4U1 | **600** | **600** | 3 | SEE PANEL SCHEDULE | |
| 7 | **L4U1/L4M1/L4L1** | 600 | 600 | 3 | SEE PANEL SCHEDULE | |
| 8 | **L4U2/L4M2/L4L2** | 600 | **400** | 3 | SEE PANEL SCHEDULE | |
| 9 | L4U3 | **100** | **100** | 3 | SEE PANEL SCHEDULE | |
| 10 | **L4U4** | **100** | **100** | 3 | SEE PANEL SCHEDULE | |
| 11 | **EQ4U1** | **225** | **225** | 3 | SEE PANEL SCHEDULE | |
| 12 | **E4U1** | **225** | **125** | 3 | SEE PANEL SCHEDULE | |
| 13 | **R2U4 XFMER** | **100** | **60** | 3 | SEE RISER DIAGRAM | |
| 14 | SPARE | 400 | 400 | 3 | | |
| 15 | SPACE | 600 | 600 | 3 | | |
| 16 | SPACE | 400 | 400 | 3 | | |