Final Report

State College, PA

The Palmerton

Student Apartments

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Executive Summary

The Palmerton is a multi-use building created on the edge of the downtown area in State College, Pennsylvania, only 2 blocks away from Pennsylvania State University (Penn State). The Palmerton is a $15 Million, 7 story building containing: 3 levels of parking, 2 of which are below grade, a small commercial space for rent that can accommodate 2-3 small stores. The rest of the building, floors 2-7, are student apartments, 10 one bedroom and 55 two bedroom apartments.

Background

This section contains all the existing conditions for the building and is the way it is being built currently. The Palmerton was designed by HAAS Building Solutions and is being built by Poole Anderson Construction.

Analysis 1: Research

A survey was conducted to prove that college students want more out of their housing and want them to be more environmentally friendly. This survey will help determine the demand for green housing in State College.

Analysis 2: Green Roof

The implementation of an intensive green roof on this space can provide a positive architectural image and usable space that could bring money in for the owner if implemented correctly. There are three main things to make this possible, first, **Breadth 1**, analyze the existing structure and redesign it when necessary, due to the added weight of the saturated soil, plants, and the increased live load. Second, design the layout and the access to the roof. Third, look at ways to have this space make money for the owner to offset the cost.

Analysis 3: Mechanical Redesign

Running a water loop through the building and allowing smaller water to air heat pumps that exchange heat with this loop, can allow for energy savings. The temperature of the water loop would be maintained from a roof top boiler and condenser. Additionally, allowing the fresh air and the stale air to exchange heat before they leave or enter the building, will allow for a great deal of savings in operation costs.

BACKGROUND

Local Conditions

In State College there are two distinct types of buildings. One is a steel frame building with a curtain wall. These are primarily on Penn State's campus. Downtown state college tends to be a different type of building. They are for the most part made of precast concrete elements and cast in place concrete, which is what The Palmerton is. This building is built just like many buildings have been built before it in this area. One major difference is the underground parking garage. Not too many projects have gone two to three stories below grade for a parking garage.

The site is somewhat congested, leaving little room for laydown. The crane pulls items right off the delivery truck which requires shutting down one lane of traffic. The parking space for workers is also limited, maybe enough to park 15 cars, however many of the workers drive large trucks. Many of the workers squeeze their cars and trucks on W Highland Alley on the south side of the site.

Construction waste management was not a concern on this project. Despite recycling programs for on campus construction projects, there was not an opportunity to recycle on this job. Luckily for this job most of the structure is precast so there is smaller amount of waste. There are a lot of metal studs used in the project, whose waste could easily be recycled. The main waste will come about during finishes, with drywall, carpet, and tile.

Subsurface conditions were one of the more interesting aspects of this project due to a contaminant known as PCE, which seeped into the soil of the site. This chemical originates from an outdated dry cleaning process, which Balfurd Cleaners, located next door, used in the past. Before Balfurd Cleaners moved in, in the 1960's, there was another cleaning business that most likely used the same toxic chemical in their cleaning process. The chemical was required to be completely removed before the site could be used.

Client Information

Blue Mountain Harmony, LLC, wishes not to reveal any information.

Purely speculating, Blue Mountain Harmony is making a multi-use facility in order to delve into two different markets, student apartments as well as the commercial sector for some small shops or maybe a café. Due to the area this project should do well.

Project Delivery System

The Palmerton is a design-bid-build project, which was selected by the owner. The owner would prefer that most of the contracts be kept confidential. What can be said is that some of the contracts were GMP contracts and others were Cost plus a fee. As seen in the diagram below all the subcontractors work directly below Poole Anderson Construction, except for R&R Steel who is working under Altoona Pipe & Steel who is was contracted by Poole Anderson Construction.

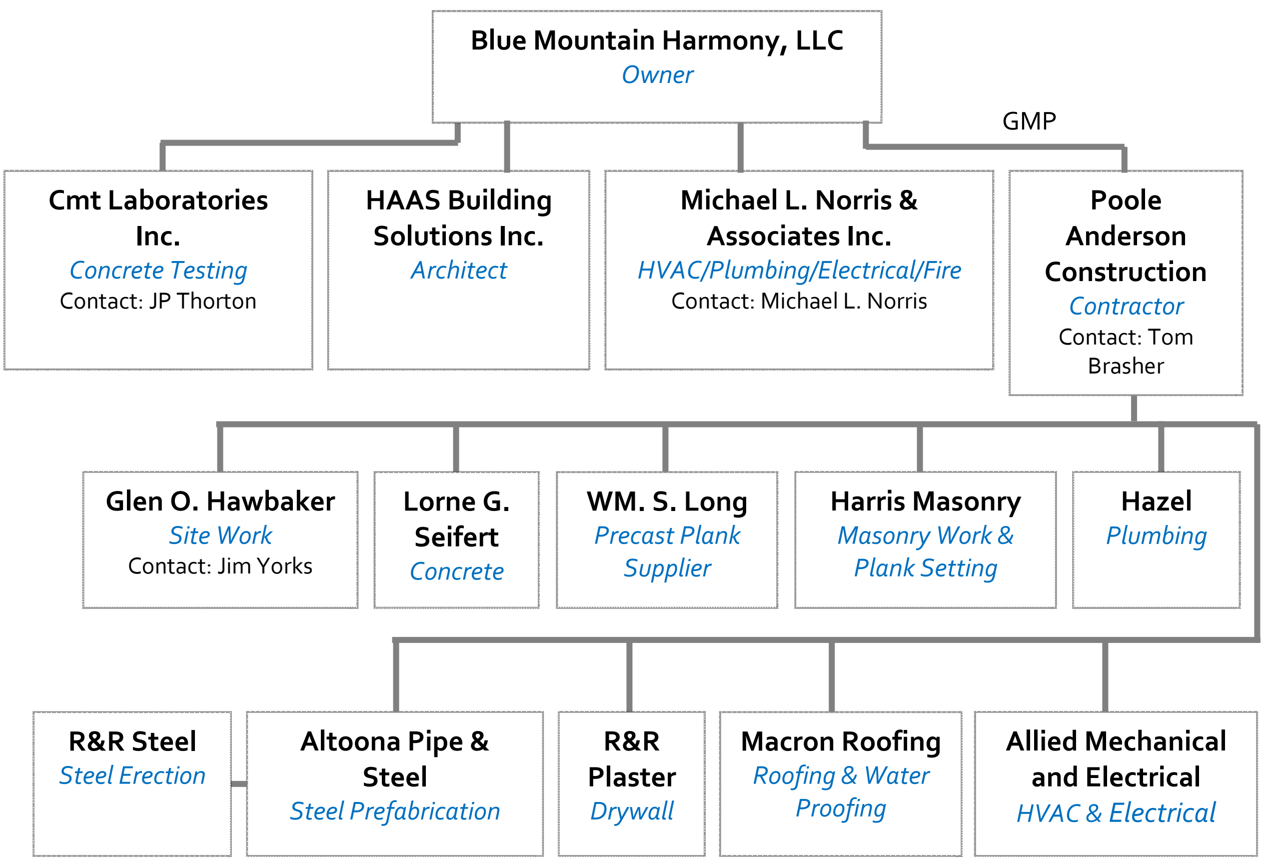

Figure 1: Project Delivery System

Staffing Plan

The Palmerton has 3 staff from Poole Anderson assigned to the project. Ben Shuff is the Project Manager and Tom Brasher, the Project Engineer both work underneath Dan Long, the Vice President of Operations, at Poole Anderson Construction. Ben Shuff and Tom Brasher coordinate the project mostly from the onsite office, located in the basement of the church next door and communicate the project with the outside world, through deliveries, other engineers, the architect, and the owner. Terry Getz, the Superintendent, organizes the construction on the site and works directly with the subcontractors on the site. He is the main communication between the subcontractors and Ben and Tom. This is all shown in Figure 2

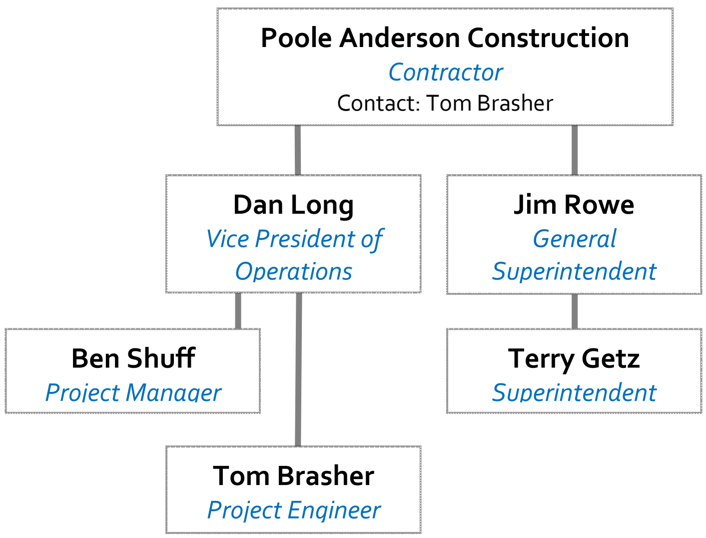

Figure 2: Staffing Plan

Building Systems Summary

Demolition

There were two existing buildings on the property. One, the old 320 W. West Beaver Ave., was located on the west end of the site and 310 -314 W. Beaver Ave., which was located at the east end of the site. Both of these buildings were demolished. There was also a small structure taken down behind the church to the north east of the building. All three building are shown clearly on the site plan In Appendix C.

Excavation

320 W. Beaver Ave. was excavated mostly two levels below grade, except for the northeastern part which went 3 levels below, due to the sloping of the parking garage and the slight slope of site. There were two major issues on this project dealing with the excavation; the first was the amount of rock. A great deal of drilling and blasting were required. The second, was contaminated soil, see Local Conditions on page 4 for more information.

In the process of excavation, shoring pipes were placed 8' o.c., down one level below grade. Next, pre split holes are drilled every 6" o.c., between the shoring pipes, to allow for the soil and rock to split along those holes when excavated. After these were drilled, explosives were used to blast the rock and soil to the inside of the site, for it to be removed. Once the excavation was down one story below grade, lagging was used to hold back the soil and rock. This process was repeated until the required depth was met, which was typically 19'. Dewatering was not needed during the entire process of excavation and construction. This is because of a natural sink hole located to the west of the site under South Atherton Street. This also made for some interesting foundations.

Structure

The foundation varied going from east to west. On the east side of the building, the footers were incased in rock. As you travel west along the site the bedrock drops off dramatically due to the sink hole under South Atherton Street. On the west side the footers had 70' long mini piles underneath them to transfer the loads to bedrock.

The parking garage contains cast in place concrete walls for the exterior walls, structural interior walls and columns. The formwork used was made by Ulma. There were two types used, one was Mega Forms, which are large metal wall forms put in place with a crane, the other is called Mega Light, which are much smaller that can be put in place by hand. The floors for the parking garage are slopped as ramps for the cars to get up and down the different levels. The bottom floor level is a slab on grade, at least 5" thick with welded wire mesh. The parking floors above consist of solid precast panels that are tied together with welding plates.

All precast panels for the building were poured and manufactured by Wm S Long Inc, in Callery, PA.

The first floor, at grade level, is mostly cast in place concrete walls; however, it contains a structural steel front for the commercial space. The commercial store front had a glass curtain wall system supported by a steel frame. The rest of the façade at the first floor is non load bearing brick requiring minimal scaffolding. At Floor 2, the structure is a combination of cast in place concrete and CMU walls. In floors 2-7, the structure consisted of CMU walls. All of the floors were hollow core planks with a 2" topping. These are attached with welded plates up to the 3rd Floor, and then switch to bent rebar, which is grouted into the CMU walls. Exterior and interior non load bearing walls consisted of metal stud framing.

The tower crane used on this project was a Peiner SK 315, which is located in the elevator shaft on the western side of the building that has an 8-16 ton capacity and an HUH of 237'.

Mechanical

The sprinkler system utilizes a dry pipe system for the parking garage, while for the rest of the building a wet pipe system was implemented. The fire pump is located in the basement.

The mechanical system is split into 4 areas, the parking garage, the commercial space, the corridors and the apartments. There is a main mechanical room in the basement that contains two combustion water heaters connected to a hot water storage tank, which will be used for the domestic hot water. The commercial floor does not have a mechanical system implemented at the moment, but the system will be electric and decided upon tenant fit out. The parking garage has continuously running fans that pull in fresh air. The corridors of the building are heated through two gas fired 3000 CFM air handling units that are housed on the roof. The roof also contains a 27.9 kW condensing unit that cools the corridors. The 2 bedroom apartments have individual 2 ½ ton heat pumps with an addition 5.4 kW of heating capacity. The one bedroom apartment has a 2 ton heat pump with the same addition electric resistance heat as the 2 bedroom apartment. Each heat pump is located in the exterior porch closet of its apartment. They are controlled from a thermostat. Each apartment's bathroom has an individual 0.75 kW wall heater and is directly vented to the outside.

Electrical

The power enters into the building into the main switchboard with a 2000 A main breaker, located in the basement and is then distributed up through the building via a 1600 A copper busway. There is a 125 kW backup diesel generator located in the basement. Each floor has a 400 A panel coming off of the busway that distributes the power to a 125 A panel for each apartment. There are 3 other panels that run off of the busway. The first Panel E1 is 400 A and distributes the power for the fire suppression system and safety systems, such as exit signs.

Panel MSB is another 400 A panel that distributes power for the heating systems for the corridors and the basement. Panel LSB is a 225 A panel for the lighting and receptacles in the parking garage as well as the first floor, containing the mail room and the commercial spaces.

CATV cable and phone lines are distributed throughout the building. Each apartment has a cable jack and telephone jack located in the living room and each bedroom, there is also an additional telephone jack in the kitchen.

Project Schedule

There are two main items in this schedule that caused delays. The first occurred during the design process. This plot of land was originally designed for another building, Nicholas Tower, which was moved to another site; therefore the design had to essentially start over. Many of the same aspects of Nicholas Tower carried over to 320 W. Beaver Ave, which allowed HAAS Building Solutions to base the design off of something. During this period the lead Architect on the project left HAAS Building Solutions, which extended the design process even further. The other main item that delayed the project was the excavation phase. This was due to the amount of drilling and blasting to create a large hole, two floors below grade. During this process contaminated soils were found, which required special removal, delaying the project further. For further information about the soil conditions refer to local conditions on page 8. Besides these two main factors, the schedule flows smoothly. After the foundation and parking garage are constructed, the rest of the building is a flow of trades one after another. The hollow core planks are placed, the block walls are erected, and then the different trades can move up through the building following one floor behind the structural erection.

The schedule for The Palmerton is made of several major sections throughout construction. The first is the design phase which a great deal of time. The second major part was excavation, which was one of the most intensive parts of the project, due to an average depth of 19' below grade and soil conditions being mostly rock. The third section we get to construction of the parking garage, which consists of cast in place footers, an exterior wall, interior walls and columns and a slab on grade for the lowest level. The levels above that have a floor structure of prefabricated floor planks. After the completion of the parking garage below grade the commercial space is constructed at the same time as the on grade part of the parking garage. After these areas are complete, the apartment floors get built. These floors use a flow of trades that go through the building on a weekly schedule. This sequence is shown in Appendix B: SIPS Schedule.

Refer to Appendix A: Detailed Project Schedule for the overall schedule.

Project Cost Evaluation

Square Foot Cost Analysis Table 1

Exterior wall construction		Concrete Block and Precast Panels	
Ground Floor Area	13,427 SF		
Gross Floor Area	80,102 SF		
Number of Stories	7		RS Means 2002
Story Height	9'		
Perimeter	640 LF		
Basement Area	56,533 SF		

Specify Source	Page	104	Model #	140	Area	85,000 SF	
	Frame	Steel Frame With Concrete Block					
Size Adjustment	65000	80102	85000				$111.97
	$114.05	$111.97	$111.30				
Height Adjustment	65000	80102	85000		$0.99	per foot	$2.96
	$1.25	$0.99	$0.90		3	foot difference	
Perimeter	65000	80102	85000		$2.97	per 100 LF	$4.48
	$3.65	$2.97	$2.75		150.69	LF Difference	
Total Adjustment				Cost per SF			**$113.49**
Building Cost	$113.49		80102	SF			**$9,090,972**
Basement Cost	$21.40		56533	SF			**$1,209,806**

Additives

Type	#	Cost					
Elevator	1	$105,400.00	Adjustment	5	$5,675.00	$28,375.00	$133,775
Cook top	65	$400.00	Assumed 400 because of range of 340-1475				$26,000
Fridge	65	$600.00	Assumed 600 because of range of 555-950				$39,000
Total							**$198,775**

Total Building Cost						**$10,499,553**
Location Modifier	City	State College PA	Date	May-07	0.96	**$10,079,571**
Final Cost	Time Factor	2002	2007	1.32		**$13,267,500**

D4 Cost Estimate					
Table 2					
Code	Division Name		%	SF Cost	Projected
1	General Requirements		4.53	$7.90	$632,805
3	Concrete		10.82	$18.88	$1,512,325
4	Masonry		17.31	$30.21	$2,419,881
5	Metal		2.49	$4.35	$348,443
6	Wood & Plastics		1.82	$3.18	$254,724
7	Thermal & Moisture Protection		3.06	$5.35	$428,545
8	Doors & Windows		7.06	$12.31	$986,055
9	Finishes		10.22	$17.84	$1,429,019
10	Specialties		0.8	$1.40	$112,142
11	Equipment	Appliances	0.05	$0.08	$6,408
12	Furnishings	Window Treatments	0.08	$0.13	$10,413
14	Conveying Systems	Elevators	2.6	$4.53	$362,862
15	Mechanical		24.8	$43.28	$3,466,814
16	Electrical		14.36	$25.05	$2,006,555
	Total		100	$174.49	**$13,977,000**

Actual Cost		
Table 3		
Type of Cost	SF Cost	Projected
Construction Cost	$83.00	$11,000,000
Excavation Cost	$30.00	$4,000,000
Mechanical Cost	$8.00	$1,000,000
Electrical Cost	$6.00	$800,000
Structural Cost	$34.00	$4,500,000
Total Cost	$113.00	**$15,000,000**

The actual costs were not allowed to be disclosed but rough numbers were given.

There is some variation in the costs due to several factors. The RS Means estimate shown in Table 1 and the D4 estimate shown in Table 2, are low because there were not any multiuse facilities to compare to 320 W. Beaver in the references used. These estimates assume that there is a three story basement not a parking garage and does not have a commercial space on the front of the first floor. When looking at two estimates using a parking garage and a building then combining them, the cost was extremely high giving a false representation of the project. The actual cost was given by Pole Anderson Construction. One reason the actual cost is higher is due to the excavation costs.

Structural Estimate

The structural Estimate was split into floors. The two levels below grade were lumped together. The commercial section was done separately from the parking behind it. Then the 2nd floor was calculated, the 3rd – 6th floors were lumped together, then last the 7th floor.

Table 4: Structural Estimate	
Parking Garage	$1,165,469.26
Commercial	$151,962.43
2nd Floor	$287,756.23
3rd - 6th Floors	$713,187.78
7th Floor	$217,006.19
Total	**$2,535,381.89**

This number is almost 2 million less than a ballpark number received from the project engineer. The exact estimate was confidential. This could be due to the estimate assumptions and not as much of a clarification between all the beams above the cast in place concrete. The complexity of the below grade parking could have a major impact on this number. The last large difference is that every piece needs to be pulled off of the delivery truck which can slow production, increasing the labor costs.

For further breakdown of each section of the building, refer to Appendix E: Detailed Structural Estimate.

Listed below are assumptions made during the estimate.

> Parking Garage, assumed all walls at angles were 11'-4" which would be the same volume, but would definitely cost more to construct at an angle which could increase the cost of labor. Assumed both underground parking levels were identical except the floor structure and the mechanical room. For the exterior walls, a 14' high grade wall was assumed, which is incorrect, but the cost should be relatively similar. For the cast in place estimates, numbers were used that included rebar, concrete, and formwork. The formwork had an estimated use of 4 times, which is not the case on the project. Strip Footings that were 5' X 1'8" were assumed to be 5' X 1'4" which is a big difference, however the calculation is done is cubic yards, so the only effect this would have is on the

Mechanical Estimate

This estimate focuses on the heating and cooling systems only. The major part that was looked into in detail was the systems for each apartment. This estimate is split into sections depending on the different spaces and type of equipment. The one and two bedroom apartments were the two spaces chosen to be done as a system. This helped simplify the process due to the apartments being identical when looking at the mechanical systems. The rest of the mechanical estimate was arranged by type of material, due to the fact that they were scattered all around the building.

Listed below are assumptions made during the estimate.

> Interpolation was used for the following, bathroom exhaust fan, 14" flex ductwork, the one bedroom heat pump, rooftop air conditioning unit, condensing unit, make up air handling unit. Wall heating were estimated off of the smaller unit and an oil based wall heater from RSMeans. The cost was adjusted, by comparing the difference between other oil and oil units that preformed the same function.

General Conditions Estimate

The numbers used for the general conditions estimate, were drawn from numbers used in previous classes were general estimates were used. Some of the numbers were given by the Project Engineer, from Poole Anderson Construction.

Table 5: General Conditions Estimate	
Staff	$314,850.00
General Site Work	$19,515.00
Temporary Utilities	$55,820.00
Temporary Facilities	$5,154.00
Total	**$395,339.00**

The numbers used for the general conditions estimate, were drawn from numbers used in previous classes were general estimates were used. Some of the numbers were given by the Project Engineer, from Poole Anderson Construction.

One major cost that was not needed for The Palmerton was the cost of a job trailer. This was not, thanks to the church next door letting Poole Anderson Construction using their basement. The major cost was then the staff wages, which shows how important time and productivity are in the workforce of today.

Refer to Appendix F: General Conditions Estimate, for a more detailed cost break down.

Site Layout Planning

Throughout the construction process there are three phases that require site plan19ning. Due to the limited amount of space on site, planning becomes extremely important. Most of this needs to be done through deliveries, since there is not much storage space, especially in the beginning of the project. Later into construction items can be stored in the parking garage and on site. The items that are stored on site are crammed into the south side of the site.

Throughout the entire construction process the temporary offices are located in the basement of the church next door. It is accessed on the south west corner of the building. The parking for the workers and managers is right at the back of the church which can hold approximately 15 cars when they are squeezed together, however many of the workers drive trucks, so less than 15 vehicles can fit. The bathroom facilities are located right next to the parking, along with the dumpster.

Excavation

During this phase the most notable things to consider is the depth of the excavation. The excavation started at the ramp area and then worked its way down. Trucks drove through the back of the site at this point in the project.

Superstructure

The major issues to be considered during this phase of construction are the deliveries and the crane. The deliveries will shut down one lane of traffic, using cones and road signs. These signs and cones are moved after construction hours and on the weekends. The area shut down can hold about two large trucks, which means that the crane has to pick the materials directly from the truck into place, this process must flow smoothly or things can be delayed significantly.

The crane seems to be very large when first seeing it on site, due to the amount it sticks out into the street and over the neighboring buildings. The operator has to be extremely careful of pedestrians and traffic around the site.

Finishes

During this stage, there will be many workers on site and a great deal of coordination will need to take place. Due to the flow of trades throughout the building material storage for each trade can be stored in the parking garage until the materials are needed. At this point they can be taken to the floor where they are needed. At this stage parking should not be an issue; workers could potentially park in a section of the parking garage saving outdoor storage space.

ANALYSIS 1: RESEARCH

Introduction

Problem Statement

Student apartment buildings are made to be inexpensive for many reasons. One, students do not care as much about their living conditions. Two, students cannot afford any more expense. Therefore green student apartment buildings are not feasible, because students will not pay for the increased cost the buildings and its systems.

Goal

Is any of this true? The goal of this research is to disprove this problem statement and show that students not only want green buildings but are willing to pay more for them.

Expected Outcomes

It is expected that most students will be willing to pay more to live in a green building and want a higher quality of life.

How Can Owners Benefit

Existing

When apartment buildings are designed and constructed, the owner decides to reduce costs upfront as much as possible, such that the initial investment is lower. This course of action leads to cheap, high energy consuming buildings. The owner only focuses on the financial bottom line and does not care about their intense energy consumptive building, for two reasons. The first explanation is that if the building is inexpensively created then it will be even less cost incurred to fix. Since, college students break things whether it is roughhousing or a party, things will be damaged. Therefore, from an investor's standpoint, why spend the money on nicer materials and better quality construction, when it is too much of a financial risk.

Secondly, why would the owner pay upfront for energy efficient appliances and systems, if they can deflect the cost of the inefficiencies onto the students? The owners' lack of energy concerns is a major issue when approaching current construction methodology. The owners of apartments are not responsible, nor do they worry, about how the residents use their energy. Some students leave the blinds closed during the day and will have the lights on even when they are not there. Other students' tendencies are to leave their computers on all the time and sometimes even their television, even when they are not there. Unfortunately, this excessive use of energy may sound crazy but these types of practices occur all the time. A simple reason for this energy consumptive attitude could be that some students, just like the owners, do not understand the long-term repercussions and/or care.

The thoughts of college students tend to leave them paying for large energy bills, which they already struggle paying. Throughout campuses, a selection of the student population would rather live without heating and air-conditioning to avoid bills. Yet, if the initial cost incurred for more energy efficient systems proved to be less expensive, this current state of approaching high energy consuming buildings might be altered. But, as of right now, none of this allows for any progression in the technologies implemented into student apartment buildings, unless it was cheap.

Proposed

Owners are passing up an enormous potential to make money. If owners include the energy bills in rent, then the owners would be paying the energy bills. This has the potential to be profitable if the owner invests in more efficient technology upfront, allowing them to reap the benefits and the cost savings. The owner could still charge the same amount for energy as what they have been paying before the switch. Not only could this make a student's life easier but could create a larger profit margin for the owner.

One potential problem with this system is that there will most likely be some students who do not care and will leave their lights, television, computer, etc, on all the time. This can destroy the goal of reducing the energy consumption for the owner. A possible solution to tackle this issue is to put a limit on the resident's energy consumption and if they go over that limit they will be charged.

How to Determine the Demand

To determine how much students would pay for a green building and what kind of demand exists for green student apartment buildings, a survey was written up and given out to Penn State students. This survey was structured in such a way that it was able to be filled out quickly and easily understood. The actual survey is on the page 19.

Forming the Survey

This survey was made to first determine what the student's current condition was, in terms of student housing and how the bills are allocated. The second half of the survey consists of questions that attempt to assess what kind of demand for different aspects of a green building and then to quantify personal value by willingness to defray costs. The goal was to split the rest of the survey into 5 questions based off of the LEED rating system, Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, and Indoor Environment Quality. The final questions reflect these different topics, but are not directly out of them.

Each question was difficult to write, because a sincere response is necessary. Also many aspects of the LEED rating system and green design are integration, which can have the questions influence each other. The goal was to avoid integration to determine whether the student truly cares about living in a green building, as a whole or in particular aspects.

The first set of questions, within the second section of the survey, deals with Sustainable sites. This question was an attempt at understanding what a green outdoor space means to the student. Then following up by asking them to place a dollar value on how much they desire one. A concern with this section of questions is if it distinguishes between the student caring about the space's environmental impact and just wanting a nice place to hang out. Obviously both aspects are positive features of a green space and are most likely desirable, but there is no indication of their motive behind their assessment of the space. Specifically in this survey it is a possible source of error, however to correct it the survey would become increasingly longer and less likely for people to actually participate.

It was determined that trying to asses water usage would be difficult for the students taking the survey to understand. Creating a question that deals with water, while proving there is a demand for student apartment buildings, may be difficult. Thus, the second question deals with energy and assesses how the student feels about where the energy comes from. The follow up question was to quantify how much more they are willing pay for clean energy.

The third sets of questions touches on indoor environment and energy together. It deals with adequate light levels within the students have in their apartment. They were asked, if during the day, do they feel there is enough daylight coming into their space. Then, once again, it was asked how much they would pay for the correct amount of daylight. These questions became tricky to formulate because it touches on two different areas, while potentially expanding to a third. Having too much glass could increase the heat transferring through the wall of the building, but achieves the most daylight. To avoid undesired complexity, these questions were worded carefully. The reason this section on day lighting was included, was because students can easily relate to it and is often an area not done correctly in student apartment buildings.

The fourth group of questions was an attempt to understand students' opinions on materials, how they are manufactured, and what kind of elements go into them like whether they are organic or potentially toxic. This does not address the main focus of LEED with respect to Materials & Resources which is where the material comes from, how much was recycled, how much is thrown out. It does make an effort to get the students to begin to grasp these complex notions of hazardous materials that exist throughout our daily lives. To reduce confusion an example of these types of materials and conditions were added. Once again, the students were asked to place a monetary value on the improvement of their environment.

Subsequently, last question set deals with Indoor Environmental Quality, with respect to fresh air and health. This section is such an important area to ask about, especially for students with asthma or allergies or other health concerns. However everyone should relate to these questions, since respiratory function is vital to human survival. Because the value on quality life plays a distinct role, financially quantifying costs are requested.

Expected Outcomes

It is expected that around 75% care about the different topics that the questions address, yet only 50% would be willing to pay more for them. Some possible costs incurred to the students are expected to be higher than others, for instance it is expected that air quality is the highest, then continuing to, green outdoor space, daylight, energy, materials. The reason behind this projection it might be in order of how each directly affects the student, only limited to his or her own knowledge.

Architectural Engineering - Senior Thesis Research Survey | Kyle Macht

Please either circle or fill in the blank, for your most correct answer.

Age: ______________ Male or Female
Major: ______________________________

Do you live in a student apartment building or a dorm? Y N

Do you personally pay your own rent? Y N
If so, how much do you pay per month? $ ______________

Do you pay your own electric and heating bill? Y N
If so, how much do you pay on average per month? $ ______________

1 Do you have a green outdoor space nearby your current apt. building? Y N
2 How much would you be willing to pay a month to have a usable, exterior green space? $ ______________

1 Do you care where your energy is currently coming from? Y N
2 How much would you be willing to pay a month to have environmentally friendly energy, such as solar and wind? $ ______________

1 Do you feel that you have enough daylight in your current apt. such that you don't need to turn on the lights during the day? Y N
2 How much would you be willing to pay a month for sufficient daylight in your apartment such that you wouldn't need other lighting during the day? $ ______________

1 Do you care about the environmental impacts of the materials in your apt.? For instance, was the wood sustainably havested or from an old growth forest. Were your materials made from recyled content. Y N
2 How much would you pay to minimize the overall environmental impacts, with respect to materials? $ ______________

1 Are you concerned about the contents of the air you breath in your current apt.? For example, the air having high CO_2 levels, mold, potential harmfull chemicals that can get trapped in fabrics and carpet. Y N
2 How much would you be willing to pay for cleaner air ? $ ______________

1 Did you answer 4 out of the 5 questions labeled #2, with a number greater than 0? Y N
a If no, would you want to live in a green building if it cost the same? Y N

b If yes, you want to live in a green student apartment building! This type of building is healthier for you and the environment, adn uses less energy the typical building. You said that you would be willing to pay more for this building, however you do not have too! When designed correctly, green buildings can potentially cost less.

Thank You!

Survey Results

Before analyzing the data received, let's discuss things the reactions occurred while the survey was being taken. The main locations of the survey were at the HUB during dinner time, all on the same day, and in an Industrial Engineering class. The differences in locations on campus were to collect a representative sample, so that where the survey was taken did not impact the results. This was able to be an unbiased survey due to the amount of different ages, majors, and ethnicities.

It was interesting how students responded when being asked to take the survey. Some said "Sure" and were more than happy to help. Some were very skeptical and they had to think about it before they said yes. Some wanted to know what it was about beforehand. Some were silent through the survey, while others talked a lot and asked a lot of questions. Overall only 7 people declined. One student was eventually convinced by a friend to take it and the others had only said no because they had a test in 30 minutes.

There were a total of 99 surveys filled out and only 1 was not used in the results due to a lack of useful answers on the survey. There were 10 determined to be unreasonable and were separated from the rest of the results, due to the extremely high amounts the students were willing to pay.

It was interesting to observe the students taking the survey. Some flew right through, either because they did not care about the survey or they said no to all the answers meaning. If they said no to all the questions, it was obvious they do not care about green buildings. It was interest to observe that many groups of students would answer similarly to one another. In most cases, this type of response pattern was consistent.

$ Rent	Landscape	Energy	Daylight	Materials	IAQ	Total x/5	$	%	Green	Green With no $
				Survey Results Pay Their Own Rent						
420	$ 7.50	$ 35.00	$ 15.00	$ 15.00	$ 15.00	5	$ 87.50	21%	Yes	Yes
388	$ -	$ 20.00	$ 20.00	$ 20.00	$ 20.00	4	$ 80.00	21%	Yes	Yes
500	$ -	$ 30.00	$ 10.00	$ 50.00	$ 10.00	4	$ 100.00	20%	Yes	Yes
620	$ 20.00	$ 10.00	$ 10.00	$ 5.00	$ 20.00	5	$ 65.00	10%	Yes	Yes
350	$ 5.00	$ 10.00	$ 10.00	$ -	$ -	4	$ 25.00	7%	Yes	Yes
372	$ -	$ 50.00	$ -	$ 20.00	$ 20.00	3	$ 90.00	24%	No	Yes
525	$ -	$ 50.00	$ 40.00	$ 15.00	$ 5.00	4	$ 110.00	21%	Yes	Yes
352	$ -	$ 25.00	$ 20.00	$ 20.00	$ 5.00	4	$ 70.00	20%	Yes	Yes
375	$ 15.00	$ 30.00	$ 15.00	$ 20.00	$ 20.00	5	$ 100.00	27%	Yes	Yes
800	$ -	$ -	$ -	$ 20.00	$ 50.00	2	$ 70.00	9%	No	Yes
525	$ -	$ -	$ -	$ -	$ -	0	$ -	0%	No	Yes
300	$ 50.00	$ 150.00	$ -	$ -	$ 50.00	3	$ 250.00	83%	No	Yes
395	$ -	$ -	$ -	$ -	$ -	0	$ -	0%	No	Either
380	$ 20.00	$ 10.00	$ 10.00	$ -	$ -	3	$ 40.00	11%	No	Yes
770	$ -	$ 30.00	$ -	$ 30.00	$ 50.00	3	$ 110.00	14%	No	Yes
605	$ -	$ 30.00	$ -	$ 10.00	$ 10.00	3	$ 50.00	8%	No	Yes
620	$ -	$ -	$ 20.00	$ 10.00	$ 5.00	3	$ 35.00	6%	No	Yes
392	$ 20.00	$ -	$ 5.00	$ -	$ 10.00	3	$ 35.00	9%	No	Yes
430	$ -	$ 50.00	$ -	$ 10.00	$ 10.00	3	$ 70.00	16%	No	Yes
418	$ -	$ -	$ -	$ -	$ -	0	$ -	0%	No	Yes
500	$ 15.00	$ 10.00	$ 20.00	$ 30.00	$ 10.00	5	$ 85.00	17%	Yes	Yes
335	$ 10.00	$ 20.00	$ 5.00	$ 5.00	$ 10.00	5	$ 50.00	15%	Yes	Yes
450	$ 150.00	$ 50.00	$ -	$ -	$ -	2	$ 200.00	44%	No	Yes
400	$ -	$ -	$ -	$ -	$ 100.00	1	$ 100.00	25%	No	Yes
445	$ 10.00	$ -	$ -	$ -	$ 10.00	2	$ 20.00	4%	No	Yes
425	$ -	$ -	$ -	$ 25.00	$ 55.00	2	$ 80.00	19%	No	Yes
550	$ -	$ 50.00	$ 20.00	$ 20.00	$ 20.00	4	$ 110.00	20%	Yes	Yes
300	$ 5.00	$ 30.00	$ 30.00	$ 50.00	$ 10.00	5	$ 125.00	42%	Yes	Yes
345	$ 5.00	$ 13.50	$ 5.00	$ 5.00	$ 15.00	5	$ 43.50	13%	Yes	Yes
460	$ 20.00	$ 10.00	$ 15.00	$ 10.00	$ -	4	$ 55.00	12%	Yes	Yes
400	$ -	$ -	$ -	$ 10.00	$ -	1	$ 10.00	3%	No	Yes
325	$ -	$ -	$ 10.00	$ -	$ 20.00	2	$ 30.00	9%	No	Yes
360	$ -	$ -	$ -	$ 20.00	$ -	1	$ 20.00	6%	No	Yes
560	$ -	$ 60.00	$ -	$ -	$ 50.00	2	$ 110.00	20%	No	Yes
350	$ 15.00	$ 75.00	$ 25.00	$ 15.00	$ 10.00	5	$ 140.00	40%	Yes	Yes
345	$ -	$ -	$ -	$ -	$ 10.00	1	$ 10.00	3%	No	Yes
300	$ -	$ -	$ -	$ -	$ -	0	$ -	0%	No	Yes
324	$ -	$ -	$ -	$ -	$ 50.00	1	$ 50.00	15%	No	Yes
500	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	5	$ 50.00	10%	Yes	Yes
346	$ -	$ 10.00	$ 50.00	$ 10.00	$ 50.00	4	$ 120.00	35%	Yes	Yes
424	$ 20.00	$ 30.00	$ 20.00	$ 30.00	$ 50.00	5	$ 150.00	35%	Yes	Yes
380	$ -	$ -	$ -	$ 6.00	$ 30.00	2	$ 36.00	9%	No	Yes
400	$ 10.00	$ 3.00	$ 3.00	$ 3.00	$ 3.00	5	$ 22.00	6%	Yes	Yes
400	$ 20.00	$ 15.00	$ 5.00	$ 20.00	$ 20.00	5	$ 80.00	20%	Yes	Yes
500	$ 20.00	$ 10.00	$ -	$ -	$ 15.00	3	$ 45.00	9%	No	Yes
285	$ 15.00	$ 10.00	$ 5.00	$ 5.00	$ 5.00	5	$ 40.00	14%	Yes	Yes
290	$ 10.00	$ 10.00	$ -	$ -	$ -	2	$ 20.00	7%	No	No
AVG	$ 10.05	$ 20.14	$ 8.47	$ 11.04	$ 18.15	3.09	$ 67.85	17%		

Survey Results Do Not Pay Their Own Rent									
Don't Pay rent	Landscape	Energy	Daylight	Materials	IAQ	Total x/5	Total More	Green	Green With no $
	$ -	$ 20.00	$ -	$ 10.00	$ 10.00	3	$ 40.00	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ -	$ 50.00	$ 25.00	$ 50.00	3	$ 125.00	No	Yes
	$ -	$ -	$ 20.00	$ -	$ -	1	$ 20.00	No	Yes
	$ -	$ -	$ 20.00	$ 10.00	$ 10.00	3	$ 40.00	No	Yes
	$ 20.00	$ 20.00	$ 20.00	$ 10.00	$ 30.00	5	$ 100.00	Yes	Yes
	$ -	$ -	$ 10.00	$ 10.00	$ 5.00	3	$ 25.00	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ 1.00	$ -	$ 1.00	$ 5.00	3	$ 7.00	No	Yes
	$ -	$ -	$ -	$ 20.00	$ 10.00	2	$ 30.00	No	Yes
	$ -	$ 20.00	$ 5.00	$ 5.00	$ 5.00	4	$ 35.00	Yes	Yes
	$ 15.00	$ 20.00	$ 10.00	$ 15.00	$ 10.00	5	$ 70.00	Yes	Yes
	$ -	$ -	$ 25.00	$ -	$ 50.00	2	$ 75.00	No	Yes
	$ 20.00	$ 10.00	$ -	$ 20.00	$ -	3	$ 50.00	No	Yes
	$ 10.00	$ 20.00	$ 10.00	$ 15.00	$ 5.00	5	$ 60.00	Yes	Yes
	$ 5.00	$ 5.00	$ 5.00	$ 25.00	$ 10.00	5	$ 50.00	Yes	Yes
	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	5	$ 100.00	Yes	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ 50.00	$ -	$ -	$ -	$ 50.00	2	$ 100.00	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ 20.00	$ 40.00	$ 40.00	$ 40.00	$ 20.00	5	$ 160.00	Yes	Yes
	$ -	$ 50.00	$ 40.00	$ 20.00	$ 20.00	4	$ 130.00	Yes	Yes
	$ -	$ -	$ 30.00	$ -	$ 40.00	2	$ 70.00	No	Yes
	$ 50.00	$ -	$ 10.00	$ -	$ 20.00	3	$ 80.00	No	Yes
	$ 20.00	$ 10.00	$ 10.00	$ -	$ 25.00	4	$ 65.00	Yes	Yes
	$ -	$ 20.00	$ -	$ 20.00	$ 20.00	3	$ 60.00	No	Yes
	$ -	$ 20.00	$ 20.00	$ 20.00	$ 20.00	4	$ 80.00	Yes	Yes
	$ 7.50	$ 7.50	$ 15.00	$ 10.00	$ 25.00	5	$ 65.00	Yes	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ -	$ -	$ -	$ -	$ 50.00	1	$ 50.00	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ 20.00	$ 50.00	$ 10.00	$ -	$ -	3	$ 80.00	No	Yes
	$ -	$ 10.00	$ -	$ -	$ 20.00	2	$ 30.00	No	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
	$ 12.50	$ -	$ 25.00	$ 50.00	$ -	3	$ 87.50	No	Yes
	$ 50.00	$ 50.00	$ 20.00	$ 20.00	$ 50.00	5	$ 190.00	Yes	Yes
	$ -	$ 7.50	$ 10.00	$ 30.00	$ 12.50	4	$ 60.00	Yes	Yes
	$ -	$ -	$ -	$ -	$ -	0	$ -	No	Yes
AVG	$ 7.80	$ 9.78	$ 10.37	$ 9.66	$ 14.45	2.49	$ 52.06		

Total								
AVG	$ 9.01	$ 15.31	$ 9.35	$ 10.40	$ 16.43	2.81	$ 60.49	No BIG Numbers

Survey Results Off the Charts									
Don't Pay rent	Landscape	Energy	Daylight	Materials	IAQ	Total x/5	Total More	Green	Green With no $
	$ -	$ 30.00	$ 100.00	$ -	$ 1,000.00	3	$ 1,130.00	No	Yes
	$ 450.00	$ 50.00	$ 50.00	$ -	$ 25.00	3	$ 575.00	No	Yes
	$ -	$ 70.00	$ 50.00	$ 100.00	$ 70.00	4	$ 290.00	Yes	Yes
	$ 250.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	5	$ 330.00	Yes	Yes
	$ 60.00	$ 60.00	$ 40.00	$ 50.00	$ 75.00	5	$ 285.00	Yes	Yes
	$ -	$ 100.00	$ 25.00	$ 100.00	$ 50.00	4	$ 275.00	Yes	Yes
	$ -	$ -	$ 20.00	$ 70.00	$ 70.00	3	$ 160.00	No	Yes
	$ 200.00	$ 100.00	$ 50.00	$ 50.00	$ 200.00	5	$ 600.00	Yes	Yes
510	$ 100.00	$ 100.00	$ 50.00	$ 50.00	$ 500.00	5	$ 800.00	Yes	Yes
3500	As Much As Needed					5	A Lot	Yes	Yes
AVG	$ 117.78	$ 58.89	$ 45.00	$ 48.89	$ 223.33	4.2	$ 60.52		

Results

The general layout of these surveys first show the rent, that the students pay, in the left most column. Then the next five are how much they would pay more in the respective areas. To the right of that is the total number of areas that the student would be willing to pay more for. The next column shows the total that students would pay for these different areas. Out of the two columns to the right, the first answers yes if there is at least four areas that the student would be willing to pay more for and on the right whether the student would prefer a green student apartment building if it cost the same as a typical apartment building. In the table *Survey Results Pay Their Own Rent* includes the students rent, it also shows how much of a percentage are the students willing to pay over what they do.

It is clear that from the right most column in all tables, that all but two students do prefer a green student apartment building if they were the same cost as a typical building. As for the two who dismissed the idea of a green building, the one student made a note on the survey stating that he did not care and the other might have been a mistake or a misunderstanding of the question. The results show that 99% of students want green student apartment buildings; there is an evident demand. 41% of students are willing to pay more within four different areas. 85% of students are willing to pay some amount more for a green student apartment building. Once again it is clear that students want a green apartment building.

As expected students are willing to pay the most for cleaner air, however, a green outdoor space and day lighting, which were predicted as second and third were fifth and fourth respectively. Students said they would defray quite a bit more, putting energy in second. Third goes to materials, which was expected to be ranked last.

There are differences between all the questions, however the most significant difference is whether the students answer is for a better world or just a personal benefit. The questions pertaining to energy and materials have the most global of an impact, where the other three could be looked at as just a personnel benefit. Meaning that choosing to pay more for greener power does not change things on the resident's side, it just helps combat global warming and an energy crisis. Similar aspect with the materials, the major difference with those is the energy of creating the product and its impact on the environment throughout the materials life. Where, having better ventilation helps the resident more than the environment.

Keeping this in mind, let's look at the analysis again. Starting at the first question moving to the last question, these are the amount of people willing to pay more, 43%, 59%, 57%, 59%, 72%. All are similar except for two extreme parts of the range. Air quality, which was expected to be the maximum, was at 72% and an exterior green space proved to be the minimum value at 43%. The exterior green space was not predicted to be the last value. Thus a potential form of error is in flawed wording. Many people might have referred to exterior spaces as in the fields and campus that are free. So why would a student pay for one at their apartment, hence the least percentage.

These numbers also show that the overall people who will pay more are willing to pay the most for green energy compared to all the other areas.

Summary

This data clearly shows that students want to live in green apartment, 98% said they did. However, not everyone was willing to pay for it, 85% said they would. 41% of students are willing to pay more in 4 different areas. These numbers clearly show that there is a demand for green housing. That almost half of the students want more out of their housing, whether that is health, energy independency, or environmental sensitivity.

A way for owners to help make this transition and actually make some money off of being energy efficient is to include everything in rent. This allows an owner to make an investment up front and charge as if the same amount of energy was being used for a typical building.

ANALYSIS 2: GREEN ROOF

Introduction

Problem Statement

Above the commercial space in the Palmerton, is a large standard flat roof with three air handling units on it. This is a potential eye sore to buildings in close proximity that would look down onto it, along with the students in the above apartments. This roof can also be seen by pedestrians walking up the street. This area, as it is now, will be looked over as if it was negative space, the hope is that people will focus more on the apartments above then the roof below them.

This roof has the potential to be something more. It could be one of the defining characteristic of the building. This roof might cost more, but, hopefully it will add enough value to the building to be able to pay for itself over time.

Goal

The implementation of an intensive green roof on this space can provide a positive architectural image and usable space that could bring money in for the owner if implemented correctly. There are three main things to make this possible, first, **Breadth 1**, analyze the existing structure and redesign it when necessary, due to the added weight of the saturated soil, plants, and the increased live load. Second, design the layout and the access to the roof. Third, look at ways to have this space make money for the owner to offset the cost.

Expected Outcomes

The addition of this intensive green roof should allow The Palmerton to grow in popularity and makes this building a hot spot to live, which can potentially allow the owner increase rent.

Background

What is a Green Roof

A green roof is a roof that utilizes vegetation and a growing media as the outmost layer of the roof. This acts as the protective component of the roof. There are two different types of green roofs. The first is an extensive green roof which is a simpler lighter version, consisting of typically 3"-6" of growing media weighing 16-35 psf when it is fully saturated. The second type is an intensive green roof, which requires a deeper growing media, usually 8" or more. This requires a more complicated drainage system and sometimes an irrigation system. These spaces are typically used for public access and can vary greatly in weight.

Advantages

Typical roofs take all the rain that hits them, adds pollutants, and then transports the water directly to a drain toward a sewer. These sewers dump this polluted water directly to our streams which is then used for drinking water where we take out the pollutants through a fairly expensive and energy intensive procedure. Before we, as humans, disrupted this system, rain would hit soil and plants. As the water traveled through the soil the plants pulled out the impurities and fed off of them. This naturally filtered water then seeps down to underground streams which then emerge as spring water. Green roofs can help restore this process by retaining this water to grow plants providing oxygen and potential habitat. If there is an excess of rain, the water would still be able to run off through a drainage system.

Figure 3: Water Runoff

Green roofs also can help save energy by keeping the roof cooler in the summer. As the sun hits the plants, the plants go through photosynthesis and help keep the building cool. This process helps maintain the roof temperature. See Figure 4. Typically 40% of cities impervious area is roofs; this can cause a great deal of heat island effect.

Green roofs also have a much longer life span then typical roofs. Typical roofs have a life span of and green roofs have a life span of. Green roofs also have the potential to reduce some upfront costs of drains, HVAC, and water management.

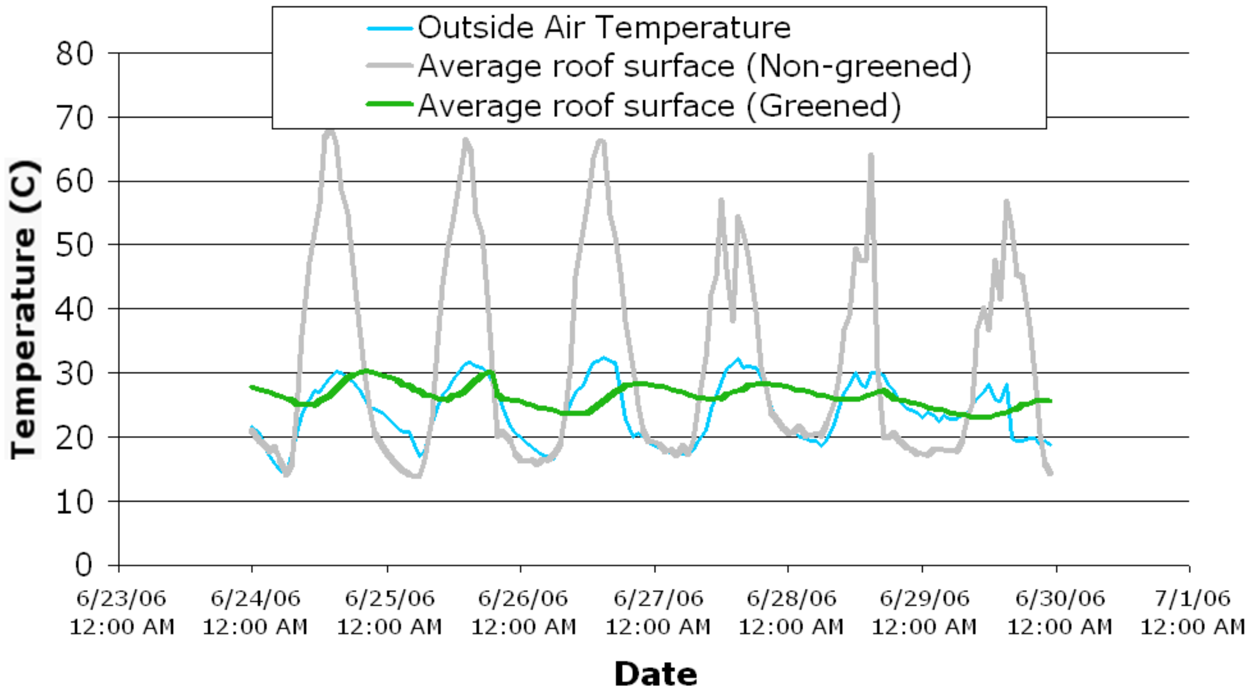

Figure 4: Average Roof Temperature

Green Roof Composition

Green Roofs have several different components in them. Starting from the bottom is the structure. After this is the insulation and then the water proof membrane. From this point the roof is pretty standard; the roof would normally have some kind of gravel above this. With a green roof there are a couple additional layers, a root barrier, so the roots can't grow into the building, a drainage layer, for irrigation and runoff for downpours, filter fabric, growing media, and the vegetation.

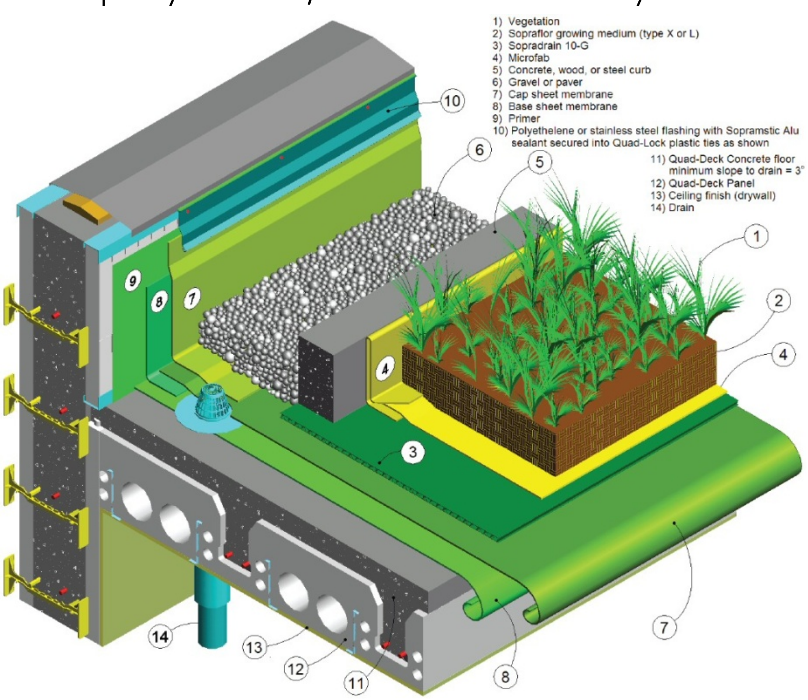

Figure 5: Green Roof Composition

Green Roof Uses

There is approximately 6,500 SF of roof above the commercial space. This is split into 2 different areas. The northern part and the southern part which drops down about 12" in areas were the building steps back. As of now there are 3 air handling units and some other small equipment on this roof. In order for this roof to work as a potential occupied space these would need to be moved. There is space under the commercial area and behind it where a unit could fit. This will go further in depth in Analysis 3: Mechanical Redesign.

This space could be a great area for relaxation in a hectic stressful college lifestyle. If residents were granted private access to this space they could use it as a place to study and relax. It could be a place to sun tan or just a place to hang out with friends, maybe have a picnic.

This space could also be used as a seating area for a café or restaurant that is renting in the space below. If the seating area was surrounded by greenery, this could turn into a major hot spot to eat and draw a lot of attraction.

This space could be a valuable asset to the owner of the building. This space adds valuable space and increases the value of the building. The owner could charge more money for rent for the residents to use this space. More detail can be found in the **Green Roof Survey** section. The owner could also charge the tenant in the commercial space for utilizing the roof as a sitting area. Typically in State College, rates for indoor space are typically $16 - $18 per square foot per month. Typically for outdoor seating on sidewalk, realtors let their tenants use it for free. For a green space on the roof, the rates would be in the vicinity of $2 - $4 per square foot per month. This works out to be $5,000 - $10,000 a month for approximately 2,500 SF, that's $60,000 - $120,000 a year. This will help pay off the initial investment of the green roof.

Green Roof Design

This space wants to be private while still making it beautiful from the street and from the roof. The best way to do this esthetically is to use tall plants. This becomes a problem because the depth of the soil would have to increase to support the taller plants. This adds weight, meaning more material, more cost, more time to construct. The building would also need some major design changes. The challenge was to create the same amount of privacy without impacting the structure significantly.

It was important that the schedule of residential part of the building was not impacted much by addition of the green roof and that it would continue on as originally scheduled. In order to do this effectively while using conservative structural numbers the depth of the soil was decreased to 4". This means that many taller plants could not grow in this soil. Therefore 12" of soil, contained in a planter box, was used around the edge of the green roof directly above the columns below. This way the hollow planks could be kept light otherwise some other kind of structure would ne to be used such as double t beams.

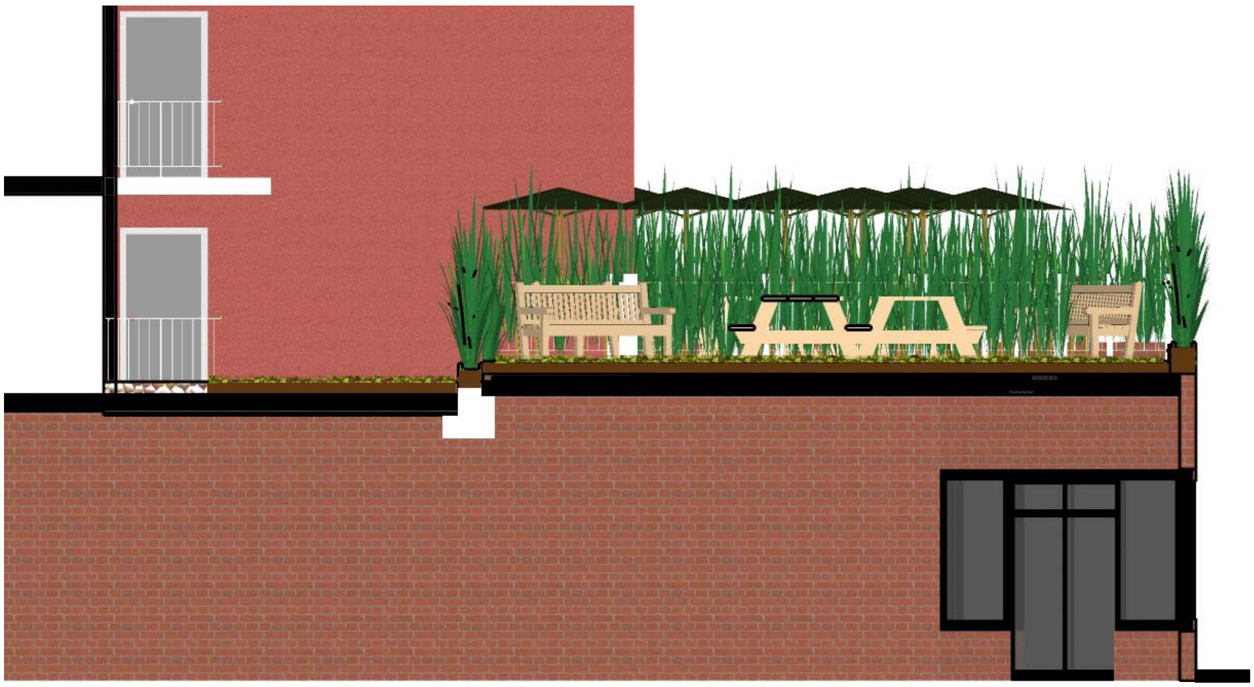

Figure 6: Green Roof Section

Plant Selection

Vegetation needs to be chosen carefully. The plants need to withstand the harsh winter, people walking on them, as well as surviving in the shade. The coral carpet is extremely durable and can withstand people walking on it. The big bluestem can be used as the barrier and be the planting on the edge of the roof. The others can be dispersed throughout.

Figure 7: Big Bluestem, Little Bluestem, Ostrich Fern, Coral Carpet

Green Roof Survey

A survey was performed in an attempt to quantify what Penn State students would pay for a green roof that was accessible to them. The survey was presented as follows. "You are a student at Penn State, living in downtown State College. There are 2 buildings that you are looking at living in." They were shown the pictures below on an 11X17 sheet of paper. "The picture on the bottom middle is the one building; the other is shown in the center. The other views show what the building and roof would look like from different spaces. The building with the proposed green roof would be accessible to you, as a resident, for studying, hanging out, parties, whatever you would like. How much more would you be willing to pay a month to live in the building with the green roof?" Some asked how much would they already be paying and they were told $550 a month per person and everything except parking is included in this rate.

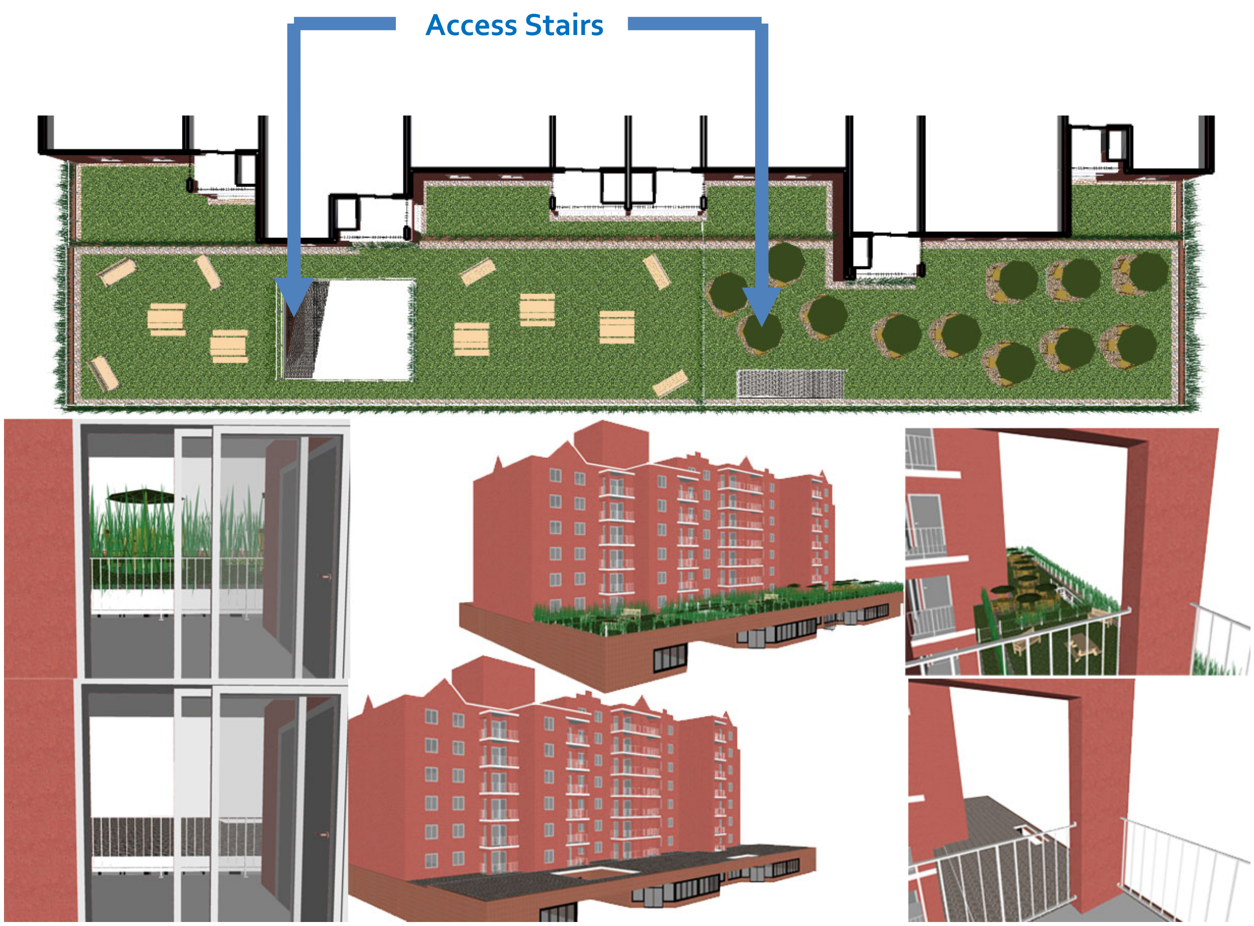

Figure 8: Existing Roof Compared to the Proposed Green Roof

Table 4: Survey Analysis

	Rate Per Month
1	$ 20.00
2	$ 75.00
3	$ -
4	$ 15.00
5	$ 50.00
6	$ 50.00
7	$ 25.00
8	$ 50.00
9	$ 50.00
10	$ 50.00
11	$ 20.00
12	$ 20.00
13	$ 20.00
14	$ 100.00
15	$ 110.00
16	$ 25.00
17	$ 50.00
18	$ 100.00
19	$ 75.00
20	$ 100.00
21	$ 50.00
22	$ 50.00
23	$ 10.00
24	$ -
25	$ 20.00
26	$ 50.00
27	$ 25.00
28	$ 50.00
29	$ 10.00
30	$ 50.00
31	$ 30.00
32	$ 25.00
33	$ 50.00
34	$ 50.00
Avg.	$ 43.38
Mean	$ 50.00
Min	$ -
Max	$ 110.00

Survey Results

Once the cost of rent was revealed, most students were overwhelmed with the number. Knowing this many said that they would never live here. This altered to survey somewhat, but at the same time could have made it realistic, because now they know they have something to base their answer off of. Even though the students said they would not pay for the apartment. Due to the fact that The Palmerton has been booked for quite some time, some students are willing to pay this and would probably pay a little more anyways just because of the high demand for nice housing downtown.

The most common response was $50 a month, with the lowest being $0 a month and the highest at $110 a month.

This data may be a little skewed due to the student base being a great deal of architectural engineers. However, the ones that were not gave similar numbers and sometimes a little higher. Therefore if this data was skewed it may even be a little low. This may be due the architectural engineers knowing about green roofs and are more familiar with them. This means that students that do not know a lot about green roofs may be more intrigued and think of them as more rare; in turn they are likely to pay a little more.

Another factor that may decrease the numbers in the survey is that only half of the students would be living on the green roof side. This fact was not known to the students who took part in the survey.

Even with this smaller data base this data shows that students are willing to pay more a great deal more for an accessible green roof and most had similar numbers. Assuming the owner charges $40, this green roof will make$9,600 a month, that’s $115,200 a year from the residents alone.

This survey got different results then the Student Apartment Survey, the main reason is probably due to seeing the space. Most students from the first survey might not be able to picture what a large difference a green space can make.

Green Roof Structural Redesign, Breadth 1

Refer to the Structural Calculations in Appendix G: Strucutural Calculations.

Green Roof Schedule

This roof was designed completely with schedule in mind. There are minimal changes in the residential side of the building with relatively no impact on schedule. The only major change is the roof and planting. This can be done while the majority of the work is going on inside. There is no major equipment needed at this point. A telescoping boom fork lift can take care of all the lifting required to the 1 story roof. Refer to Appendix A1: Proposed Project Schedule.

The beams on the south side of the roof, where the roof lowers, are 1617% faster to erect then the existing design, due to them being precast. The cast in place takes 219.144 hours to form and pour, where the precast beams take 18 hours to erect. This will allow that part of the building to speed up by a week, which allows the rest of the structure, which may take a little while longer, to finish on schedule.

Green Roof Estimate

Table 5: Green Roof Comparison shows the difference in cost of the existing system compared to the first system. The proposed green roof costs about twice as much. However, the additional income from the green roof is substantial. Renting the space out to a café or resturant below can bring in $5,000 - $10,000 a month. According the green roof survey will bring in $9,600 a month if residents pay $40 additionaly a month. Assuming the lower value of commercial rent and a 1 year payback. The owner would charge the residents $21.00 a month, half the amount students said they would pay.

Item	Size	Type	Unit	Mat	Lab	total	#	Total
Table 5: Green Roof Comparison								
Existing								
Spread Footer	8"	3000 PSI	SF	$ 241.00	$ 297.00	$ 538.00	8	$ 4,304.00
Steel Column	8x8	HSS8x8	EA	$ 555.00	$ 43.50	$ 598.50	8	$ 4,788.00
Steel Beam	12x8	HSS12x8x5/8	LF	$ 37.30	$ 13.80	$ 51.10	190	$ 9,709.00
	12x35	W12x35	LF	$ 36.39	$ 2.66	$ 39.05	24	$ 937.20
Concrete Beam	32	Cast in Place	CY	$ 298.00	$ 385.00	$ 683.00	27	$ 18,441.00
Screens for AHU	60"	Ruskin Screen	LF	$ 20.00	$ 20.00	$ 40.00	68	$ 2,720.00
Hollow Core	8"	15 strand	SF	$ 8.15	$ 4.61	$ 12.76	6487	$ 82,774.12
Roof		4 plies & gravel	SF	$ 1.49	$ 1.62	$ 3.11	6487	$ 20,174.57
Total								$ 143,847.89
Proposed With Green Roof								
Spread Footer	8"	3000 PSI	LF	$ 460.00	$ 500.00	$ 960.00	8	$ 7,680.00
Steel Column	10x5	HSS10x5x3/8	EA	$ 555.00	$ 43.50	$ 598.50	8	$ 4,788.00
Steel Beam	14x10	HSS14x10x5/8	LF	$ 45.62	$ 14.80	$ 60.42	190	$ 11,479.61
	12x72	W12x72	LF	$ 75.00	$ 3.40	$ 78.40	24	$ 1,881.60
Concrete Beam	24'	Precast T 12x32	EA	$ 193.00	$ 12.88	$ 205.88	9	$ 1,852.92
Planter Box	1'	Brick with 2x4	SF	$ 6.65	$ 12.65	$ 19.30	840	$ 16,212.00
		Soil and Plants		$ 25.00	$ 1.51	$ 26.51	840	$ 22,268.40
Railing	4'	Simple Metal	LF	$ 11.30	$ 6.10	$ 17.40	280	$ 4,872.00
Hollow Core	10"	15 strand	SF	$ 8.80	$ 4.28	$ 13.08	6287	$ 82,233.96
Stairs	10'	Metal 16 Risers	EA	$ 7,775.00	$ 1,825.00	$ 9,600.00	2	$ 19,200.00
Roof		4 plies	SF	$ 1.02	$ 1.70	$ 2.72	6287	$ 17,100.64
Green Roof	4"		SF	$ 20.00	$ 1.51	$ 21.51	6287	$ 135,233.37
Total								$ 324,802.50

Assumptions

The beams on the south side in each estimate are assumed to be the same all the across the building. In each design this beam would be the most significant in cost, schedule and bearing capacity. The screens to hide the 3 AHUs were estimated based on a couple different types of fences.

Green Roof Summary

The addition of this green roof can add major interest to the building. Pedestrians, whether they are students or not will be able to see this roof and know right away what it is and if they do not, they will probably want to find out. This can provide a great image for the owner and more importantly for the building itself. Imagine students asking, "Where do you live?" "I live the building with the green roof." It could become what defines the building instead of just the name or the location. Because of this, the roof could become an invaluable investment.

This asside, the addition of this green roof will cost about $180,000 more then the existing, due to a small increase in structure and the cost of the green roof itself. Renting this space to a café or a resturant would bring in $5,000 - $10,000 a month. This alone makes the payback period 1.5 to 3.0 years. With the commercial paying for this alone, the roof is definetely a worth while investment. Including the residents paying, it can cut the pay back time practically in half. Assuming residents will pay as much as they said they would the payback is in 9 months. Even if they pay half or a quarter of that, the green roof is a no brainer.

ANALYSIS 3: MECHANICAL REDESIGN

Introduction

Problem Statement

The Palmerton has many different mechanical systems throughout the building. The commercial spaces each have their own air handling unit that provides the heating and cooling. Each apartment has its own heat pump for heating and cooling; additionally each bathroom has an additional electric wall heater for comfort. The corridors will also have their own cooling and heating system and the same is true with areas of the parking garage.

Operation costs have a greater potential to be reduced if some of these systems were combined and utilized energy recovery. This would allow for one larger piece of equipment rather than many smaller units. This could also decrease the time of installation, as long as the distribution does not have many further challenges.

In the current system all the fresh air comes directly from the outside and is heated or cooled then thrown into the space. This is then dumped back outside through the bathroom exhaust. This is a great deal of heat that may have the potential to be recovered.

Goal

Running a water loop through the building and allowing smaller water to air heat pumps that exchange heat with this loop, can allow for energy savings. The temperature of the water loop would be maintained from a roof top boiler and condenser. Additionally, allowing the fresh air and the stale air to exchange heat before they leave or enter the building, will allow for a great deal of savings in operation costs.

Expected Outcomes

This system will cost more upfront, but will provide significant energy savings, that will save the owner a great deal of money over time.

Mechanical Design

The existing mechanical system is energy intensive, has a large upfront cost, and does not allow for energy recovery. It does allow for each apartment to have complete control of their system and it also is easy to fix. If one breaks it does not hinder the whole building and can be fixed separately.

Design Goals

There were 3 main areas of improvement that were looked into. The first was controlling the temperature that the heat pumps are exchanging with, which will increase efficiency of the heat pump and potentially allow for a downsizing of the system. This also allows the absence of electric resistance heat, which would typically be on a great deal of the winter. In turn this has the potential for energy savings, such that a payback period could be in 5 – 10 years.

Secondly, the consolidation of heating and cooling can allow for the system to be downsized and be more cost effective by using a couple larger pieces of equipment instead of small equipment for each apartment.

Thirdly the consolidation of air is a big area to achieve energy savings. Allowing the fresh air to exchange heat and humidity with the exhaust air will allow the heat pumps to do less work and will only require running a fan which would be on anyways. This is a potential way to save a lot of energy without using much.

While thinking about potential ways to tackle these design goals, the budget, schedule, and how it fits with the building, meaning that the building would not have to be altered significantly in order to implement the new system. These 3 items are the controlling factors when deciding on a mechanical design.

Design Process

During construction there was a point where there was just a large hole in the ground and there was a break in excavation to remove contaminated soil. This would be a perfect opportunity to implement a ground source heat pump, which would allow the mechanical system to have a constant temperature heat dump that does not require energy to keep the temperature constant. This sounds like a great option and it is, however payback periods for ground source heat pumps tend to be longer then 10years in many cases. The size of this building would require a large amount of piping in order to transfer heat with the ground properly.

Taking the idea of a ground source heat pump, there was a thought that maybe exchanging heat with the bottom slab of the parking garage could be an option. This slab does not have any insulation below it allowing heat to transfer with the ground through the slab. After further investigation, the volume of concrete and the heat transfer between the slab and the ground was not even close to large enough for this to. The slab would end up holding too much of the heat being transferred into or out of it.

Design

After this, it was decided to simulate a ground source heat pump by using a condenser and boiler to maintain a water loop at a somewhat constant temperature. Then water to air heat pumps could then exchange heat with this loop instead of the outside air. This also has the advantage of apartments exchanging heat with each other. If one heat pump is cooling and one is heating they would essentially be transferring heat between each other through the water loop. This situation is likely to happen because of solar gain and potentially personal preference of room temperature.

Consolidating the air in the building to allow for heat exchange was the next challenge. It was recommended by several mechanical designers that it would be better to consolidate all the air to one location, the roof. This would require running large vertical shafts for fresh air and exhaust through the building. These may get to large to fit somewhere in the building. The easiest way to consolidate the ductwork would be to run it in the corridors. The problem with this is that it would lower the ceiling height to below 8' which is not acceptable. Running these on the inside of the apartments on the hallway side would be a pain because they run through a lot of walls and through many rooms. This is not ideal for construction, it would be better to keep it simple.

Therefore it would be better to run them similar to the way they are run currently and let each unit have its own energy recovery ventilator. Although this is not consolidating as much, as the original goal, it does allow for air to exchange heat. This allows for only minor changes when talking about construction. The exhaust ductwork from the existing design was tweaked to accommodate the new system. The supply ductwork is exactly the same, only the mechanical closet ductwork changes slightly. This allows the installation to be more flexible when looking at the schedule. The next trade could be working on the inside of the apartment while a mechanical contractor can finish up the closet, install the ERV, and run the necessary plumbing for the water loop.

An ERV will be added that will exchange the heat and humidity with the outside air and the exhaust. The other bonus about adding this system is that, if this is run continuously it can constantly pull air out of the bathrooms and supply fresh air to the living spaces, the fan from the ERV can replace the exhaust fans in the bathroom, which are $200 a piece. This will also allow the air temperature to remain above F, completely eliminating the need for electric resistance heat. This will also help reduce the load required by the heat pumps, in turn helping reduce the boiler and the condenser.

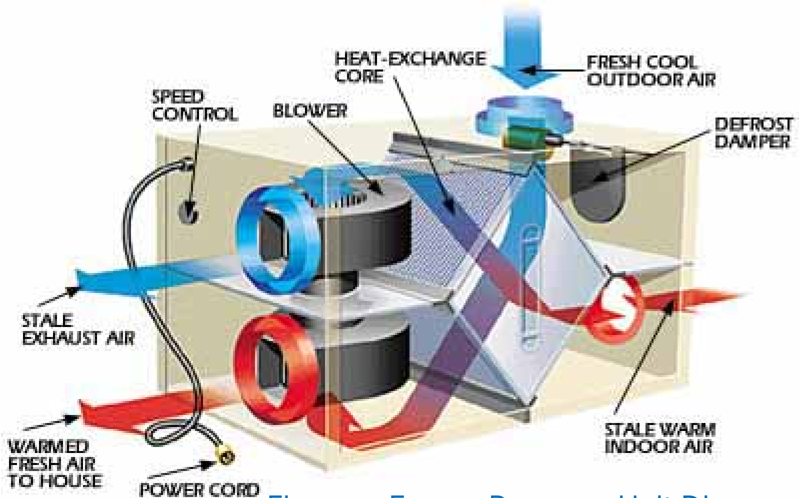

Figure 9: Energy Recovery Unit Diagram

Design Green Roof

Due to the addition of the green roof, the three rooftop air handling units would need to be moved. Luckily there is some room to hide them in the parking garage. There is a space below and south of the commercial space that they could be put. The space shown in Figure 10 is tight but would be perfect place for distributing air throughout the commercial space. This can be constructed when trades are in the floors above. During this phase the parking garage will be used primarily for storage, leaving a great deal of it open to be get work done. The schedule will not be impacted what so ever. This is also ideal to run the water loop to them since they are right next to the mechanical closets.

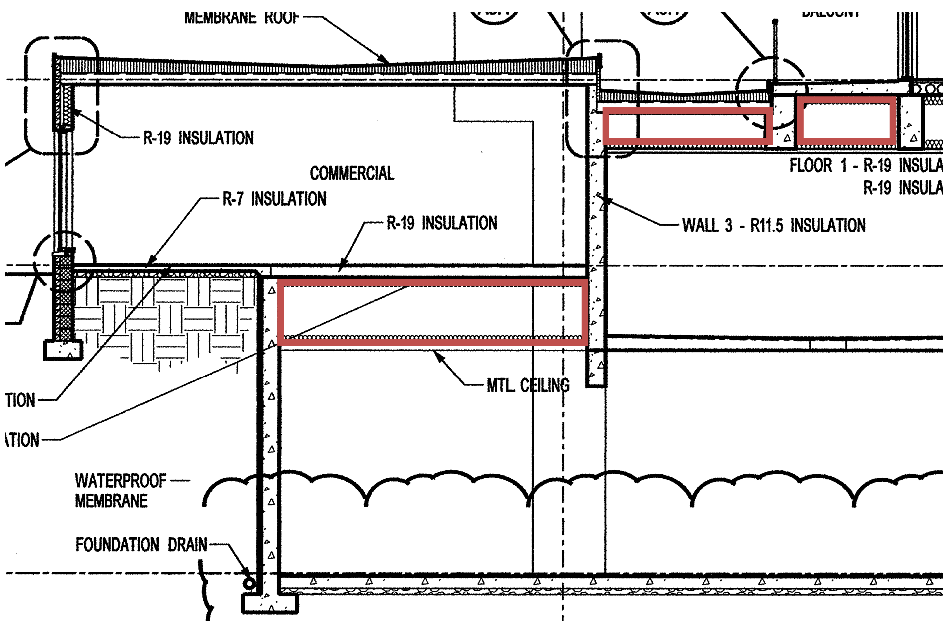

Figure 10: Commercial Mechanical Placement

Mechanical Redesign, Breadth 2

First the loads for the apartments were analyzed. See Appendix J: Mechanical Calculations, looking at the numbers boxed out this shows the heating and cooling demands by the space during peak months. Due to the implantation of the ERV while sizing this system the system does not need to be oversized to try to get those couple days that are too cold or warm. Also the heat pumps will always have a similar heat to exchange from due to water loop, which will be kept at 60°F and in the summer at 90°F. This allows the heat pump to be designed specifically for a max heat of 90°F not anything higher.

For the 2 bedroom apartment there is a heat loss of 14,405 Btu/hr and a heat gain of 17,288 Btu/hr. This means that the 2 bedroom heat pump can be downsized from a capacity of 24 MBH heating and 27 MBH cooling down to 14 MBH cooling and 18 MBH heating. This equates to a 2 ton unit instead of a 2.5 ton unit.

For a 1 bedroom apartment a heat loss of 11,159 Btu/hr and a heat gain of 11,006 Btu/hr. The existing heat pump was designed for 12,800 Btu/hr cooling and 16,600 Btu/hr heating. This heat pump could be downsized from a 1.5 ton to a 1 ton heat pump, but that will cut it extremely close. The heat pump on the extreme days might be straining to keep up. Therefore this heat pump will not be downsized.

Water Loop Heat Pumps

Next the water to water heat pumps were selected. A Trane Axiom GEV 018 for the smaller apartments and a GEV 024 for the larger apartments. Refer to Appendix L: Trane Heat Pumps.

GEV 018	570 CFM	4.2 GPM
Absorbed Heat into the Water Loop	14.75 MBH	
Released Heat into the Water Loop	25 MBH	
GEV 024	750 CFM	5.5 GPM
Absorbed Heat into the Water Loop	20.3 MBH	
Released Heat into the Water Loop	32.6 MBH	

Boiler Size = 10*20.3 + 55*14.75 = 1,014 MBH

Condenser Size = (10*25 + 55*32.65) / 12 = 170.25 Tons

Water Loop Distribution Sizing

Next the distribution piping system was designed for the apartments. The flow rates of all the heat pumps were added up and the piping was sized of the chart in Figure 11.

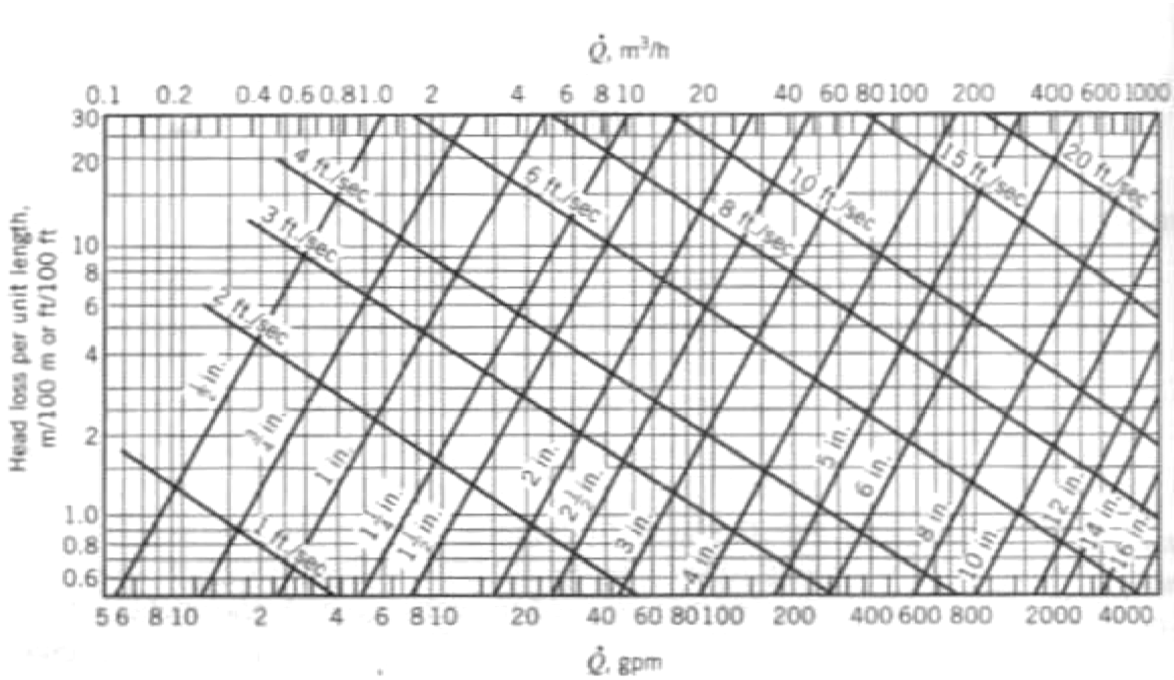

Figure 11: Friction Loss Due to Flow of Water in Steel Pipe (schedule 40)

Table 6: Pipe Work Calculations					
1 BR Shaft			2 Bedroom Shaft		
Story	Flow Rate	Size	Story	Flow Rate	Size
			7	38.5	1.5
6	25.2	1.5	6	33	1.5
5	21	1.25	5	27.5	1.5
4	16.8	1.25	4	22	1.25
3	12.6	1	3	16.5	1.25
2	8.4	1	2	11	1
1	4.2	0.75	1	5.5	0.75

Table 7: Pipe Quantities				
Type	Quantity	Length for shafts	Length at roof	Total
4			80	80
2.5			100	100
2			248	248
1.5	32	576	678	1254
1.25	16	288		288
1	16	288		288
0.75	12	216		216

Energy Recovery Ventilator

The ERV is sized based off of using the previous cfm from the existing unit 75 cfm. The ERV is only 70 cfm however this can just be run a little longer or the previous design was potentially oversized. Refer to Appendix K: EV70 Specifications.

Mechanical Estimate

The estimate for the mechanical system shown in Table 8 shows the costs per apartment.

Table 8: Mechanical Redesign ERV Estimate													
Item	Size	Type	Unit	Labor Hours	Materials	Labor	Total	Tot. 2 BR	Total	Time	Tot. 1 BR	Total	Time
Existing													
Spiral	6"	straight	LF	0.057	$ 1.76	$ 2.17	$ 3.93	72	$ 280.00	4	30	$ 117.90	1.71
Ductwork	6"	connector	Ea	0.182	$ 2.60	$ 6.90	$ 9.50	4	$ 38.00	1	2	$ 19.00	0.36
	6"	elbow	Ea	0.364	$ 5.75	$ 13.80	$ 19.55	4	$ 78.20	1	2	$ 39.10	0.73
Brick Vent	6"		Ea	0.333	$ 25.00	$ 14.05	$ 39.05	2	$ 78.10	1	1	$ 39.05	0.33
Exhaust fan	130	Nutone QT140L	Ea	0.83	$ 200.00	$ 32.50	$ 232.50	2	$ 465.00	2	1	$ 232.50	0.83
Heat Pump	2.5	Air Source	Ea	13.333	$ 1,625.00	$ 515.00	$ 2,140.00	1	$ 2,140.00	13	0	$ -	0.00
Heat Pump	1.5	Air Source	Ea	13.115	$ 1,575.00	$ 510.00	$ 2,085.00	0	$ -	0	1	$ 2,085.00	13.12
Total									**$ 3,079.30**	**22**		**$ 2,532.55**	**17.08**
Total All Apts.									**$ 169,361.50**	**1207**		**$ 25,325.50**	**171**
Proposed With ERV													
Spiral	6"	straight	LF	0.057	$ 1.76	$ 2.17	$ 3.93	66	$ 260.00	4	42	$ 165.06	2.39
Ductwork	6"	connector	Ea	0.182	$ 2.60	$ 6.90	$ 9.50	5	$ 47.50	1	4	$ 38.00	0.73
	6"	elbow	Ea	0.364	$ 5.75	$ 13.80	$ 19.55	2	$ 39.10	1	3	$ 58.65	1.09
	6"	tee	Ea	0.533	$ 8.20	$ 20.00	$ 28.20	1	$ 28.20	1	0	$ -	0.00
Flex Ductwork	8"	non-insulated	LF	0.08	$ 2.20	$ 3.03	$ 5.23	24	$ 125.52	2	8	$ 41.84	0.64
Can Light		recessed	Ea	0.4	$ 77.50	$ 16.80	$ 94.30	2	$ 188.60	1	1	$ 94.30	0.40
Heat Pump	2	Water Source	Ea	9.412	$ 1,300.00	$ 365.00	$ 1,665.00	1	$ 1,665.00	9	0	$ -	0.00
Heat Pump	1.5	Water Source	Ea	10	$ 1,375.00	$ 390.00	$ 1,765.00	0	$ -	0	1	$ 1,765.00	10.00
ERV		Renewair 70	Ea	5	$ 675.40	$ 500.00	$ 1,175.40	1	$ 1,175.40	5	1	$ 1,175.40	5.00
Total									**$ 3,529.32**	**23**		**$ 3,338.25**	**20.25**
Total All Apts.									**$ 194,112.60**	**1269**		**$ 33,382.50**	**203**

As seen the new system is more expensive however is able to make the previous system less expensive for multiple reasons. For the 2 bedroom apartments the ductwork for the bathroom was consolidated into one run straight to the ERV. Also the ERV is being used as the ventilation fan allowing the $200 Exhaust fans to be eliminated.

Working with Sound Geothermal Inc, calculations were performed, refer to Appendix K: EV70 Specifications, which show that the energy used by the heap pump will decrease and save $163.88 per year per smaller unit. Using a ratio to find out how much that equates to for the 2 ton heat pump $163.88 * 2/1.5 = $218.51 per year per larger heat pump. This equates to a 2 year pay back on the larger heat pump and a 5 year payback on the small heat pump. Overall it is a 2.4 year payback for designing the ERV into the apartments.

Table 9: Mechanical Redesign Water Loop Estimate												
Proposed Water Loop												
Piping	0.75	Schedule 40	LF	0.131	$ 2.40	$ 5.60	$ 8.00	212	$ 260.00	28		
	1	Schedule 40	LF	0.151	$ 3.47	$ 6.45	$ 9.92	288	$ 2,856.96	43		
	1.25	Schedule 40	LF	0.18	$ 4.56	$ 6.90	$ 11.46	288	$ 3,300.48	52		
	1.5	Schedule 40	LF	0.2	$ 5.35	$ 7.70	$ 13.05	1254	$ 16,364.70	251		
	2	Schedule 40	LF	0.25	$ 7.10	$ 9.60	$ 16.70	248	$ 4,141.60	62		
	2.5	Schedule 40	LF	0.32	$ 11.00	$ 12.30	$ 23.30	100	$ 2,330.00	32		
	4	Water Source	LF	0.444	$ 21.00	$ 17.10	$ 38.10	80	$ 3,048.00	36		
Pump	600		Ea	14.118	$ 3,150.00	$ 340.00	$ 3,490.00	1	$ 3,490.00	14		
Boiler	1275	MBH	Ea	80	$ 10,300.00	$ 3,275.00	$ 13,575.00	1	$ 13,575.00	80		
Cooling Tower	167	Tons	Ea	32	$ 25,900.00	$ 1,275.00	$ 27,175.00	1	$ 27,175.00	32		
Total									**$ 76,541.74**	**630**		
Total with both systems									**$ 304,036.84**	**2101**	**$ 194,687.00**	**1378**

Implementing the water loop is a larger investment then the ERV for several reasons. It requires a great amount of plumbing and 3 expensive pieces of equipment. It shows how expensive distribution can be. Everything installed in this system is completely addition and will not be able to help downsize the system. Potentially downsize the 1 bedroom apartment's heat pump; however it is still too close to call without fully modeling the entire system. The system costs an additional $76,541.74. Per apartment, that amounts to $1,177.57.

After talking to industry the ranges for how much energy this system would save, 8% - 12% were common numbers. Assuming this to be true and that an ERV is already installed, energy bills are now $621 a month for small apartments and then calculating based of a ratio of the size of the heat pump, the larger is $828 per month. The average yearly bill would be $796. 8% - 12% of that is equal to $63.38 to $95.52 saved per apartment per year. That means a 12.3 to an 18.5 year payback.

Mechanical Schedule

As seen in Table 8 the time to construct each is fairly similar meaning no change in the schedule. However when looking at the water loop, this is 630 man hours that is additional. With a crew of 4 this will take 4 weeks to accomplish. Refer to Appendix A1: Proposed Project Schedule.

Summary

The design behind the mechanical system is one such that it fits with the building the way it is designed and built, yet adds the owner value. This mechanical system will provide the owner with a good investment.

The first piece of the mechanical system that was implemented was an Energy Recovery Unit (ERV). This unit will run the outside fresh air past the exhaust air and exchanged the heat and the humidity between the two. This allows for less heating and cooling, hence saving energy. This was able to reduce the size of the heat pump in the 2 bedroom apartment from 2.5 tons - 2 tons. It also replaced the exhaust fans in all the apartments. Overall this system will cost more upfront but only $33,000 more, but will save about $200 a month. This will amount to a payback in 2.4 years.

The second system is a water loop that will run water throughout the building to all the heat pumps supplying 60°F to 90°F water. This water will be maintained by a 170 ton condenser and a 1,014 MBH boiler. Each apartment's heat pump will exchange heat with this water loop. There will be times where some apartments will be heating and some will be cooling. During this the heat pumps will be able to exchange heat with each other and the water loop will remain within the temperature range. Overall this system will cost an additional $76,500 giving a payback between 12.3 years to 18.5 years.

Summary

In analysis 1, the survey showed that almost half of the students want more out of their housing in every way, whether that is health, energy independency, or environmental sensitivity. Out of the other half, most want more as well but are not willing to pay as much.

The addition of this green roof can add major interest to the building. The addition of this green roof will cost about $180,000 more then the existing, due to a small increase in structure and the cost of the green roof itself. Renting this space to a café or a resturant would bring in $5,000 - $10,000 a month. This alone makes the payback period 1.5 to 3.0 years. Including the residents paying, it can cut the pay back time practically in half. Assuming residents will pay as much as they said they would the payback is in 9 months.

The first piece of the mechanical system that was implemented was an Energy Recovery Unit (ERV). Overall this system will cost $33,000 more, but will save about $200 a month per apartment. This will amount to a payback in 2.4 years. The second system is a water loop that will run water throughout the building to all the heat pumps supplying 60°F to 90°F water. Overall this system will cost an additional $76,500 giving a payback between 12.3 years to 18.5 years.

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Poole Anderson

Michael Norris
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Nic Jones
Sound Geothermal Inc.

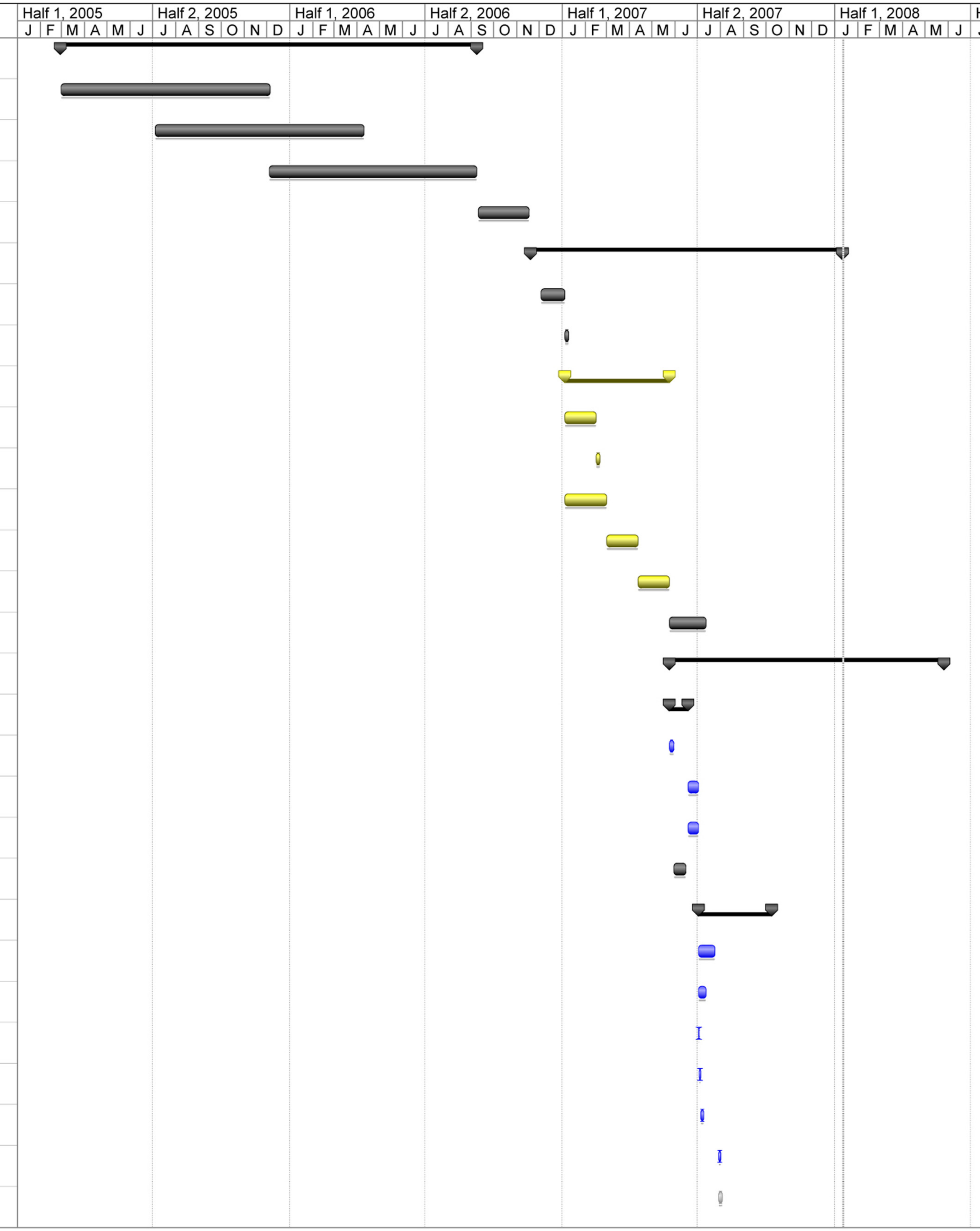
The MorningStar & Natural Fusion Teams

Appendices

Appendix A

Detailed Project schedule

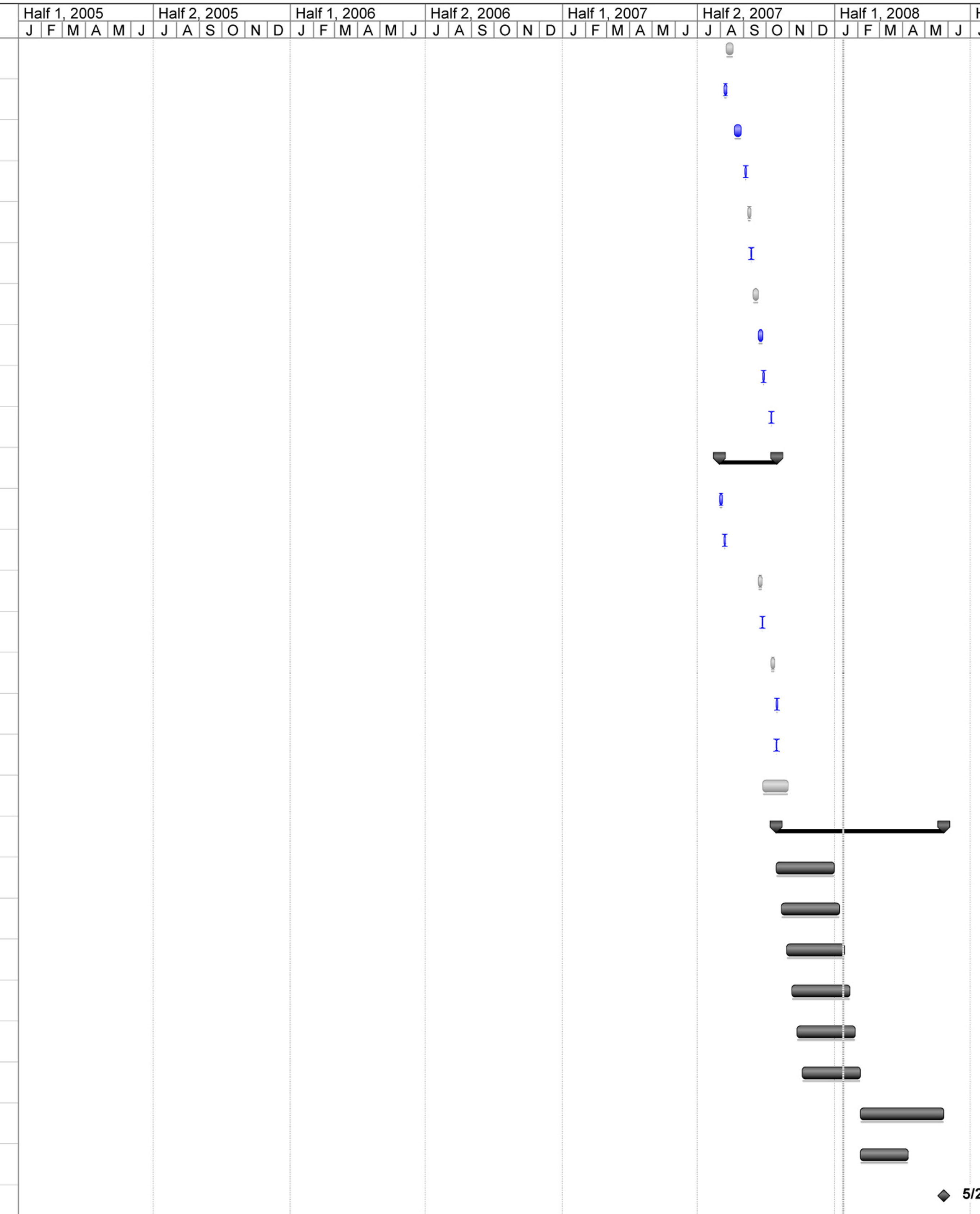
ID	Task Name	Duration	Start	Finish	Predecessors
1	**Design Phase**	400 days	Mon 2/28/05	Fri 9/8/06	
2	Schematic Design	200 days	Tue 3/1/05	Mon 12/5/05	
3	Design Development	200 days	Tue 7/5/05	Mon 4/10/06	
4	Construction Documents	200 days	Mon 12/5/05	Fri 9/8/06	
5	**Bidding**	50 days	Mon 9/11/06	Fri 11/17/06	4
6	**Procurement of construction services**	300 days	Mon 11/20/06	Fri 1/11/08	5
7	**Demolition**	24 days	Mon 12/4/06	Thu 1/4/07	5FS+10 days
8	Temporary Electrical Connection	3 days	Fri 1/5/07	Tue 1/9/07	7
9	**Excavation**	100 days	Fri 1/5/07	Thu 5/24/07	7
10	Shoring Pipes	30 days	Fri 1/5/07	Thu 2/15/07	7
11	Pour Shoring Pipes	3 days	Fri 2/16/07	Tue 2/20/07	10
12	Drill Pre-Split holes	40 days	Fri 1/5/07	Thu 3/1/07	7
13	Blasting	30 days	Fri 3/2/07	Thu 4/12/07	12
14	Soil and Rock Removal	30 days	Fri 4/13/07	Thu 5/24/07	13
15	**Contaminated Soil Removal**	35 days	Fri 5/25/07	Thu 7/12/07	9
16	**Construction Phase**	262 days	Fri 5/25/07	Mon 5/26/08	9
17	**Foundations**	17 days	Fri 5/25/07	Mon 6/18/07	9
18	Elevator Slab	4 days	Fri 5/25/07	Wed 5/30/07	9
19	Exterior Footers	10 days	Tue 6/19/07	Mon 7/2/07	9,17
20	Interior Footers	10 days	Tue 6/19/07	Mon 7/2/07	9,17
21	Crane Setup	12 days	Thu 5/31/07	Fri 6/15/07	18
22	**Parking Garage Structure**	70 days	Tue 7/3/07	Mon 10/8/07	19,21
23	Exterior Wall	16 days	Tue 7/3/07	Tue 7/24/07	19,21
24	Colums and Interior Walls 1st Level	8 days	Tue 7/3/07	Thu 7/12/07	20,21
25	Lay Stone for Basement Slab	1 day	Tue 7/3/07	Tue 7/3/07	19,20
26	Install Vapor Barrier	2 days	Wed 7/4/07	Thu 7/5/07	25
27	Instal WWF for Basement Slab	2 days	Fri 7/6/07	Mon 7/9/07	26
28	Beams First Level	3 days	Mon 7/30/07	Wed 8/1/07	23FS+3 days,24FS+3 days
29	Ground Flloor CMU Walls	5 days	Mon 7/30/07	Fri 8/3/07	23FS+3 days,24FS+3 days



Project: 320 Beaver Ave 2
Date: Sat 1/12/08

Task | Smaller Summary | Overview Summary | Milestone
General Contractor : Poole Anderson Construction | Site Work : Glen O. Hawbaker | Concrete : Lorne G. Seifert | Masonry Work & Plank Setting : Harris Masonry

ID	Task Name	Duration	Start	Finish	Predecessors
30	Precast Floor 2nd level	7 days	Thu 8/9/07	Fri 8/17/07	28FS+5 days
31	Basement Slab	4 days	Mon 8/6/07	Thu 8/9/07	27,29
32	Cast in Place Walls 2nd level	7 days	Mon 8/20/07	Tue 8/28/07	30
33	Ground level Beams	2 days	Mon 9/3/07	Tue 9/4/07	32FS+3 days
34	Place 2nd level CMU	2 days	Fri 9/7/07	Mon 9/10/07	32FS+7 days
35	Pour Topping Slab 2nd level	1 day	Tue 9/11/07	Tue 9/11/07	34
36	Precast Floor Ground Level Parking	5 days	Fri 9/14/07	Thu 9/20/07	33FS+7 days
37	Ground Level Parking Walls and Columns	4 days	Fri 9/21/07	Wed 9/26/07	36
38	Beams 2nd Floor Above Parking	2 days	Thu 9/27/07	Fri 9/28/07	37
39	Pour Topping Ground Floor Parking	1 day	Mon 10/8/07	Mon 10/8/07	37FS+7 days
40	**Commercial Space Structure**	55 days	Tue 7/31/07	Mon 10/15/07	23FS+4 days
41	Commercial Footers	4 days	Tue 7/31/07	Fri 8/3/07	23FS+4 days
42	Ground Floor Slab on Grade	2 days	Mon 8/6/07	Tue 8/7/07	41
43	Precast Floor Ground Level Commercial	3 days	Fri 9/21/07	Tue 9/25/07	36
44	Ground Level Walls and Columns	1 day	Wed 9/26/07	Wed 9/26/07	43
45	Ground Floor CMU	5 days	Mon 10/8/07	Fri 10/12/07	44FS+7 days
46	Beams 2nd Floor	2 days	Mon 10/15/07	Tue 10/16/07	45
47	Pour Topping Ground Level	1 day	Mon 10/15/07	Mon 10/15/07	45
48	Brick first floor only	24 days	Thu 9/27/07	Tue 10/30/07	44
49	**Apartments**	161 days	Mon 10/15/07	Mon 5/26/08	38,45
50	**Floor 2**	56 days	Mon 10/15/07	Mon 12/31/07	38,45
51	**Floor 3**	56 days	Mon 10/22/07	Mon 1/7/08	50FS-51 days
52	**Floor 4**	56 days	Mon 10/29/07	Mon 1/14/08	51FS-51 days
53	**Floor 5**	56 days	Mon 11/5/07	Mon 1/21/08	52FS-51 days
54	**Floor 6**	56 days	Mon 11/12/07	Mon 1/28/08	53FS-51 days
55	**Floor 7**	56 days	Mon 11/19/07	Mon 2/4/08	54FS-51 days
56	Finishes	80 days	Tue 2/5/08	Mon 5/26/08	55
57	Landscape	46 days	Tue 2/5/08	Tue 4/8/08	55
58	Occupancy	0 days	Mon 5/26/08	Mon 5/26/08	57,56



Project: 320 Beaver Ave 2
Date: Sat 1/12/08

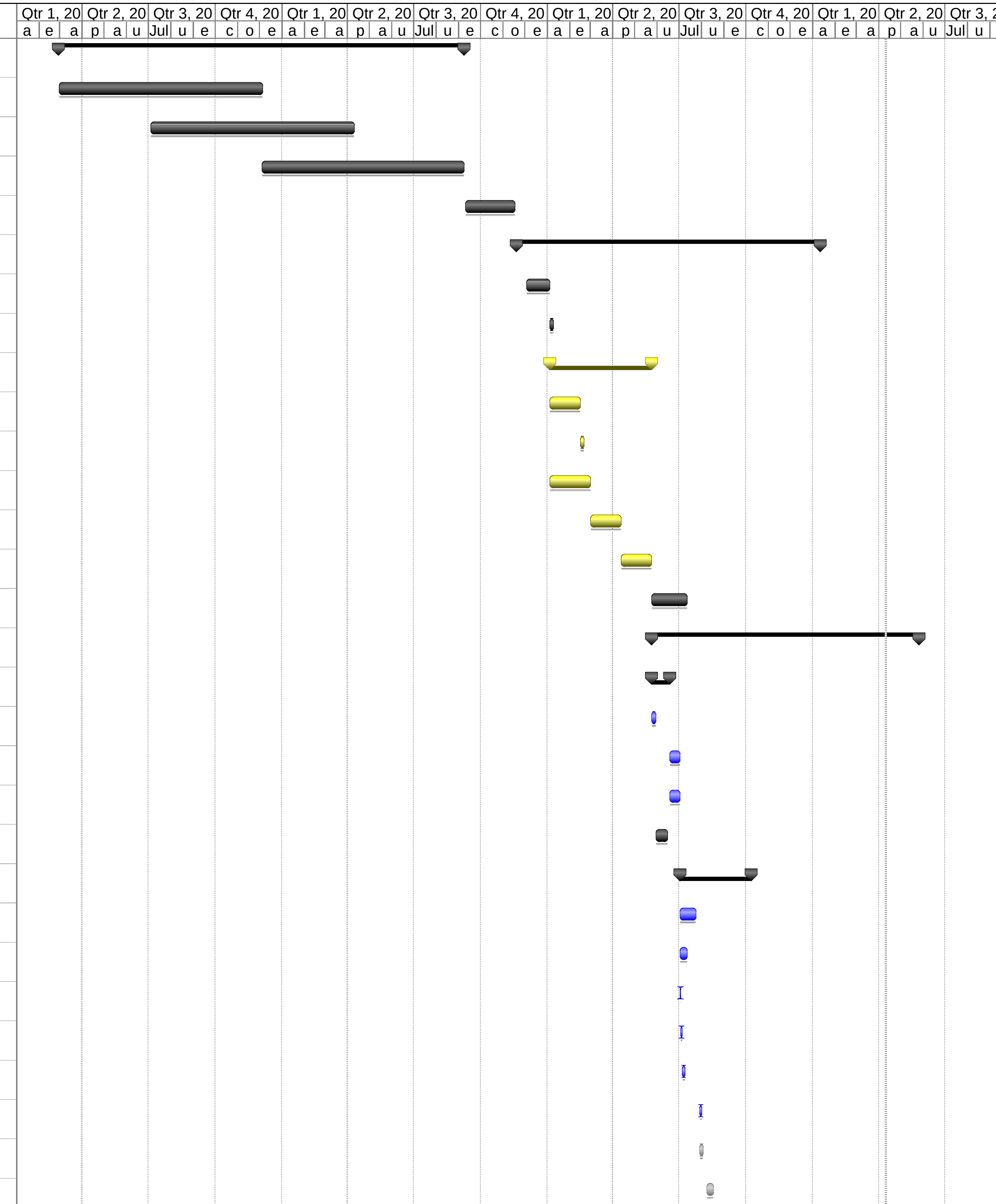
Task | Smaller Summary | Overview Summary | Milestone
General Contractor : Poole Anderson Construction | Site Work : Glen O. Hawbaker | Concrete : Lorne G. Seifert | Masonry Work & Plank Setting : Harris Masonry

Appendix A1

Proposed Project schedule

Appendix A: Green Roof and Mechanical Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Design Phase**	400 days	Mon 2/28/05	Fri 9/8/06	
2	Schematic Design	200 days	Tue 3/1/05	Mon 12/5/05	
3	Design Development	200 days	Tue 7/5/05	Mon 4/10/06	
4	Construction Documents	200 days	Mon 12/5/05	Fri 9/8/06	
5	**Bidding**	50 days	Mon 9/11/06	Fri 11/17/06	4
6	**Procurement of construction services**	300 days	Mon 11/20/06	Fri 1/11/08	5
7	**Demolition**	24 days	Mon 12/4/06	Thu 1/4/07	5FS+10 days
8	Temporary Electrical Connection	3 days	Fri 1/5/07	Tue 1/9/07	7
9	**Excavation**	100 days	Fri 1/5/07	Thu 5/24/07	7
10	Shoring Pipes	30 days	Fri 1/5/07	Thu 2/15/07	7
11	Pour Shoring Pipes	3 days	Fri 2/16/07	Tue 2/20/07	10
12	Drill Pre-Split holes	40 days	Fri 1/5/07	Thu 3/1/07	7
13	Blasting	30 days	Fri 3/2/07	Thu 4/12/07	12
14	Soil and Rock Removal	30 days	Fri 4/13/07	Thu 5/24/07	13
15	**Contaminated Soil Removal**	35 days	Fri 5/25/07	Thu 7/12/07	9
16	**Construction Phase**	262 days	Fri 5/25/07	Mon 5/26/08	9
17	**Foundations**	17 days	Fri 5/25/07	Mon 6/18/07	9
18	Elevator Slab	4 days	Fri 5/25/07	Wed 5/30/07	9
19	Exterior Footers	10 days	Tue 6/19/07	Mon 7/2/07	9,17
20	Interior Footers	10 days	Tue 6/19/07	Mon 7/2/07	9,17
21	Crane Setup	12 days	Thu 5/31/07	Fri 6/15/07	18
22	**Parking Garage Structure**	70 days	Tue 7/3/07	Mon 10/8/07	19,21
23	Exterior Wall	16 days	Tue 7/3/07	Tue 7/24/07	19,21
24	Colums and Interior Walls 1st Level	8 days	Tue 7/3/07	Thu 7/12/07	20,21
25	Lay Stone for Basement Slab	1 day	Tue 7/3/07	Tue 7/3/07	19,20
26	Install Vapor Barrier	2 days	Wed 7/4/07	Thu 7/5/07	25
27	Instal WWF for Basement Slab	2 days	Fri 7/6/07	Mon 7/9/07	26
28	Beams First Level	3 days	Mon 7/30/07	Wed 8/1/07	23FS+3 days,24FS+3 days
29	Ground Flloor CMU Walls	5 days	Mon 7/30/07	Fri 8/3/07	23FS+3 days,24FS+3 days
30	Precast Floor 2nd level	7 days	Thu 8/9/07	Fri 8/17/07	28FS+5 days

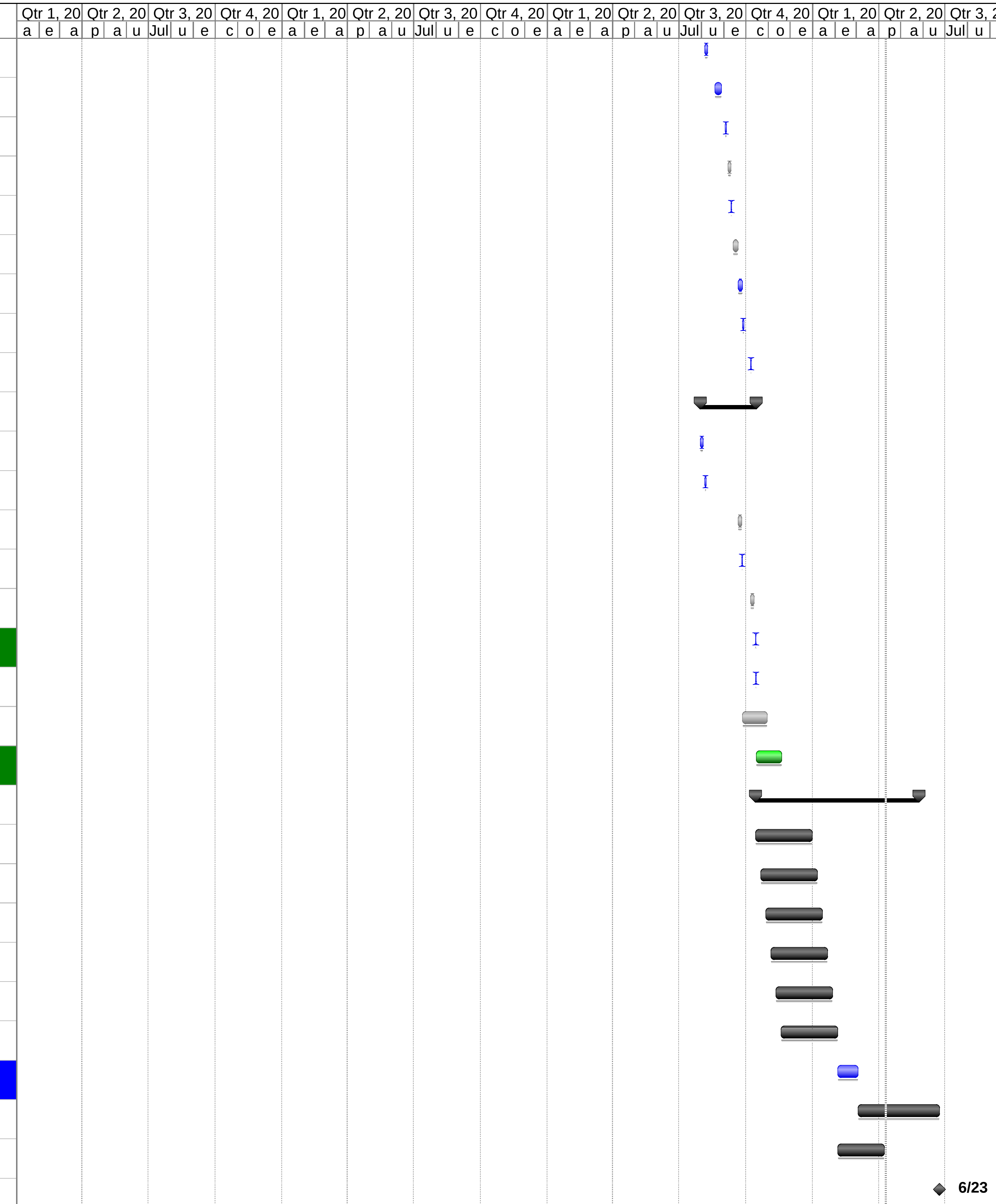


Project: The Palmerton
Date: Thu 4/10/08

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

Appendix A: Green Roof and Mechanical Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
31	Basement Slab	4 days	Mon 8/6/07	Thu 8/9/07	27,29
32	Cast in Place Walls 2nd level	7 days	Mon 8/20/07	Tue 8/28/07	30
33	Ground level Beams	2 days	Mon 9/3/07	Tue 9/4/07	32FS+3 days
34	Place 2nd level CMU	2 days	Fri 9/7/07	Mon 9/10/07	32FS+7 days
35	Pour Topping Slab 2nd level	1 day	Tue 9/11/07	Tue 9/11/07	34
36	Precast Floor Ground Level Parking	5 days	Fri 9/14/07	Thu 9/20/07	33FS+7 days
37	Ground Level Parking Walls and Columns	4 days	Fri 9/21/07	Wed 9/26/07	36
38	Beams 2nd Floor Above Parking	2 days	Thu 9/27/07	Fri 9/28/07	37
39	Pour Topping Ground Floor Parking	1 day	Mon 10/8/07	Mon 10/8/07	37FS+7 days
40	**Commercial Space Structure**	55 days	Tue 7/31/07	Mon 10/15/07	23FS+4 days
41	Commercial Footers	4 days	Tue 7/31/07	Fri 8/3/07	23FS+4 days
42	Ground Floor Slab on Grade	2 days	Mon 8/6/07	Tue 8/7/07	41
43	Precast Floor Ground Level Commercial	3 days	Fri 9/21/07	Tue 9/25/07	36
44	Ground Level Walls and Columns	1 day	Wed 9/26/07	Wed 9/26/07	43
45	Ground Floor CMU	5 days	Mon 10/8/07	Fri 10/12/07	44FS+7 days
46	Beams 2nd Floor	0.25 days	Mon 10/15/07	Mon 10/15/07	45
47	Pour Topping Ground Level	1 day	Mon 10/15/07	Mon 10/15/07	45
48	Brick first floor only	24 days	Thu 9/27/07	Tue 10/30/07	44
49	Green Roof	25 days	Tue 10/16/07	Mon 11/19/07	40
50	**Apartments**	161 days	Mon 10/15/07	Mon 5/26/08	38,45
51	**Floor 2**	56 days	Mon 10/15/07	Mon 12/31/07	38,45
52	**Floor 3**	56 days	Mon 10/22/07	Mon 1/7/08	51FS-51 days
53	**Floor 4**	56 days	Mon 10/29/07	Mon 1/14/08	52FS-51 days
54	**Floor 5**	56 days	Mon 11/5/07	Mon 1/21/08	53FS-51 days
55	**Floor 6**	56 days	Mon 11/12/07	Mon 1/28/08	54FS-51 days
56	**Floor 7**	56 days	Mon 11/19/07	Mon 2/4/08	55FS-51 days
57	Water Loop	20 days	Tue 2/5/08	Mon 3/3/08	56
58	Finishes	80 days	Tue 3/4/08	Mon 6/23/08	57
59	Landscape	46 days	Tue 2/5/08	Tue 4/8/08	56
60	Occupancy	0 days	Mon 6/23/08	Mon 6/23/08	59,58



Project: The Palmerton
Date: Thu 4/10/08

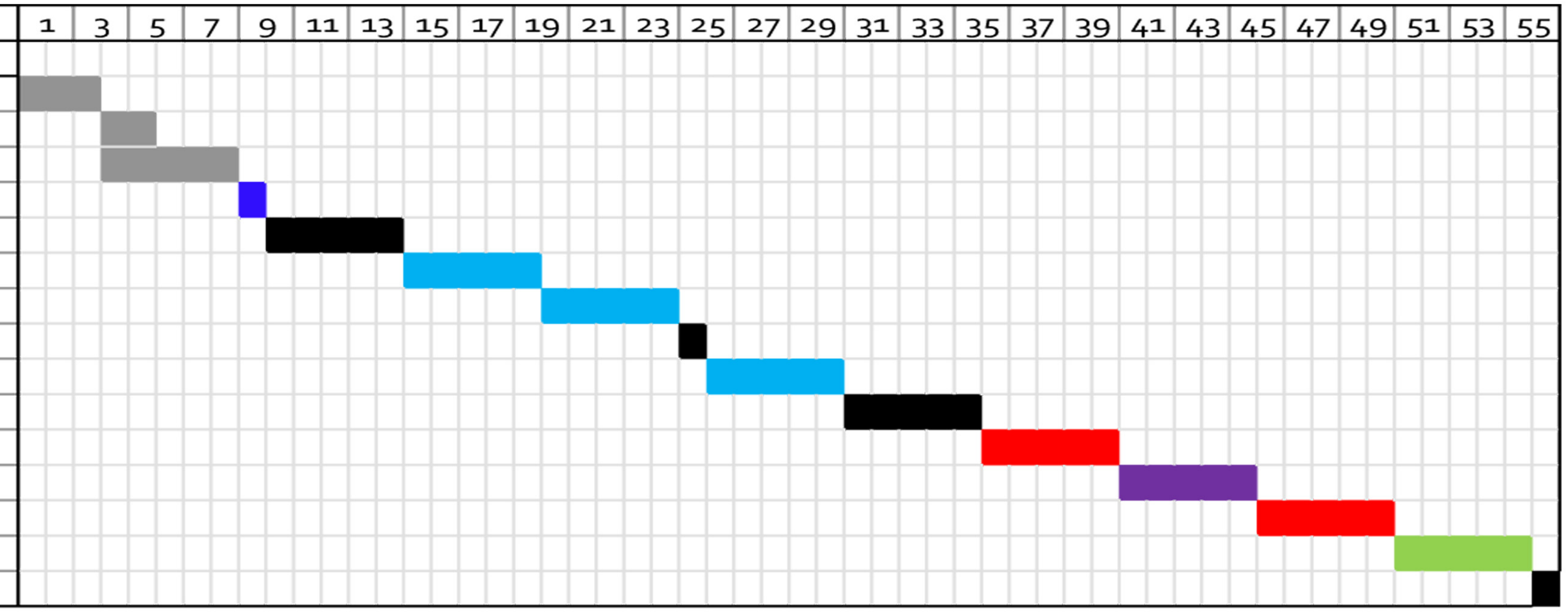
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Appendix B

SIPS Schedule, Typical Floor Plan

Appendix B: Sips Schedule, Typical Floor Plan

Sips Schedule, Typical Floor			Days
	Task Name	Duration	Predecessor
1	Hollow Core Planks	3 days	
2	Plank Connections	2 days	1
3	CMU Walls	5 days	1
4	Pour Topping Slab	1 day	2,3
5	Exterior Walls	5 days	4
6	Exterior Sheathing	5 days	5
7	Water Proofing	5 days	6
8	Windows	1 day	7
9	EIFS	5 days	8
10	Interior Framing	5 days	5
11	Mechanical Rough-In	5 days	10
12	Plumbing Rough-In	5 days	11
13	Electrical Rough-In	5 days	13
14	Drywall	5 days	13
15	Paint	1 day	15



Legend
Harris Masonry
Lorne G. Seifert
Poole Anderson Construction
Macron Roofing
Allied Mechanical and Electrical
R&R Plaster

Appendix D

Assemblies Estimate

Appendix D: Mechanical Assemblies Estimate							
			Unit Cost		Total Cost		
	#	Units	Material Unit Cost	Labor Unit Cost	Material Cost	Labor Cost	Total
2 BR Apartment							
Heat Pump	1	Each	$2,350.00	$1,050.00	$2,350.00	$1,050.00	$3,400.00
14" Flex Duct	6	Feet	$3.30	$6.49	$19.80	$38.94	$58.74
Ductwork	245	Lb	$0.46	$3.21	$112.70	$786.45	$899.15
Diffuser	3	Each	$37.50	$21.50	$112.50	$64.50	$177.00
6" EXH Duct	63	Feet	$3.16	$2.67	$199.08	$168.21	$367.29
Exhaust Fan	2	Each	$55.17	$31.17	$110.34	$62.34	$172.68
Wall Heater	2	Each	$100.00	$32.00	$200.00	$64.00	$264.00
Total					$2,904.42	$2,170.44	$5,074.86
Total	55				$159,743.10	$119,374.20	**$279,117.30**
1 BR Apartment							
Heat Pump	1	Each	$1,746.00	$704.00	$1,746.00	$704.00	$2,450.00
14" Flex Duct	4	Feet	$3.30	$6.49	$13.20	$25.96	$39.16
Ductwork	80	Lb	$0.46	$3.21	$36.80	$256.80	$293.60
Diffuser	2	Each	$37.50	$21.50	$75.00	$43.00	$118.00
6" EXH Duct	30	Feet	$3.16	$2.67	$94.80	$80.10	$174.90
Exhaust Fan	1	Each	$55.17	$31.17	$55.17	$31.17	$86.34
Wall Heater	1	Each	$100.00	$32.00	$100.00	$32.00	$132.00
Total					$2,120.97	$1,173.03	$3,294.00
Total	10				$21,209.70	$11,730.30	**$32,940.00**
Roof Top AC	3	Each	$4,855.00	$830.00	$14,565.00	$2,490.00	$17,055.00
Condensing Unit	1	Each	$3,250.00	$533.00	$3,250.00	$533.00	$3,783.00
Make Up AHU	1	Each	$5,983.00	$270.00	$5,983.00	$270.00	$6,253.00
Electric Wall Heaters	7	Each	$267.00	$82.67	$1,869.00	$578.69	$2,447.69
	3	Each	$400.00	$124.00	$1,200.00	$372.00	$1,572.00
	1	Each	$400.00	$124.00	$400.00	$124.00	$524.00
	2	Each	$667.00	$206.67	$1,334.00	$413.34	$1,747.34
Total					$17,815.00	$3,023.00	$33,382.03
Total		Location			0.96		**$437,740.72**
		Time			1.32		

Appendix E

Detailed Structural Estimate

Typical Floor (3-6) Structural Cost				Unit Cost			
Type	Quantity	Units	Total SF	Material	Labor	Equipment	Total Cost
8" CMU		SF		$1.56	$2.81	$0.00	$4.37
	2	505.55	1011.10	$1,577.32	$2,841.20	$0.00	$4,418.53
	2	259.72	519.44	$810.32	$1,459.62	$0.00	$2,269.94
	4	61.11	244.46	$381.36	$686.93	$0.00	$1,068.28
	2	194.45	388.90	$606.68	$1,092.80	$0.00	$1,699.47
	2	148.61	297.23	$463.68	$835.21	$0.00	$1,298.89
	1	134.98	134.98	$210.57	$379.29	$0.00	$589.86
	1	15.97	15.97	$24.91	$44.87	$0.00	$69.78
	1	61.80	61.80	$96.41	$173.66	$0.00	$270.08
	1	145.83	145.83	$227.50	$409.79	$0.00	$637.29
	2	287.16	574.31	$895.93	$1,613.82	$0.00	$2,509.75
	4	250.70	1002.79	$1,564.36	$2,817.84	$0.00	$4,382.20
	2	306.59	613.19	$956.57	$1,723.06	$0.00	$2,679.63
	2	616.67	1233.33	$1,924.00	$3,465.67	$0.00	$5,389.67
	2	399.05	798.11	$1,245.05	$2,242.68	$0.00	$3,487.73
	4	250.70	1002.79	$1,564.36	$2,817.84	$0.00	$4,382.20
	2	297.22	594.44	$927.32	$1,670.37	$0.00	$2,597.69
	1	157.99	157.99	$246.46	$443.95	$0.00	$690.41
	2	125.70	251.40	$392.18	$706.42	$0.00	$1,098.60
	1	79.51	79.51	$124.04	$223.42	$0.00	$347.46
	1	28.47	28.47	$44.41	$80.00	$0.00	$124.41
	1	78.47	78.47	$122.41	$220.50	$0.00	$342.91
	2	258.33	516.67	$806.00	$1,451.83	$0.00	$2,257.83
	2	116.67	233.33	$364.00	$655.67	$0.00	$1,019.67
	1	42.36	42.36	$66.09	$119.04	$0.00	$185.13
Doors RO	2	20.56	41.12	$64.15	$115.55	$0.00	$179.69
	15	22.22	333.30	$519.95	$936.57	$0.00	$1,456.52
	6	26.67	160.02	$249.63	$449.66	$0.00	$699.29
Window RO	1	7.75	7.75	$12.09	$21.78	$0.00	$33.87
Total			9484.68	$14,796.10	$26,651.95	$0.00	$41,448.05
10" CMU		SF		$2.18	$3.46	$0.00	$5.64
Total	1	140.00	140.00	$305.20	$484.40	$0.00	$789.60
8" Hollow Core Plank		SF		$5.00	$0.75	$0.53	$6.28
Total		13971.10	13971.10	$69,855.50	$10,478.33	$7,404.68	$87,738.51
Topping Slab		CY		$74.00	$10.15	$4.70	
Total		91.00	91.00	$6,734.00	$923.65	$427.70	$8,085.35
Steel		LF		$12.13	$3.10	$2.37	$17.60
W 8X18	10	8.67	86.67	$1,051.27	$268.67	$205.40	$1,525.33
W 8X18	10	6.33	63.33	$768.23	$196.33	$150.10	$1,114.67
Total			150.00	$1,819.50	$465.00	$355.50	$2,640.00
Total	All 4 Floors			**$98,968.80**	**$40,398.32**	**$9,254.38**	**$562,806.02**

Floor 7 Structural Cost				Unit Cost			
Type	uanti	Units	Total SF	Material	Labor	Equipment	Total Cost
8" CMU		SF		$1.56	$2.81	$0.00	$4.37
	2	185.33	370.66	$578.23	$1,041.55	$0.00	$1,619.78
	1	129.58	129.58	$202.14	$364.12	$0.00	$566.26
	1	15.33	15.33	$23.91	$43.08	$0.00	$66.99
	1	59.33	59.33	$92.55	$166.72	$0.00	$259.27
	1	134.67	134.67	$210.09	$378.42	$0.00	$588.51
	2	275.67	551.34	$860.09	$1,549.27	$0.00	$2,409.36
	2	592.00	1184.00	$1,847.04	$3,327.04	$0.00	$5,174.08
	4	240.67	962.68	$1,501.78	$2,705.13	$0.00	$4,206.91
	2	383.09	766.18	$1,195.24	$2,152.97	$0.00	$3,348.21
	2	240.67	481.34	$750.89	$1,352.57	$0.00	$2,103.46
	1	285.33	285.33	$445.11	$801.78	$0.00	$1,246.89
	1	151.67	151.67	$236.61	$426.19	$0.00	$662.80
	3	120.67	362.01	$564.74	$1,017.25	$0.00	$1,581.98
	1	40.33	40.33	$62.91	$113.33	$0.00	$176.24
	1	71.00	71.00	$110.76	$199.51	$0.00	$310.27
Doors RO	2	20.56	41.12	$64.15	$115.55	$0.00	$179.69
	15	22.22	333.30	$519.95	$936.57	$0.00	$1,456.52
	6	26.67	160.02	$249.63	$449.66	$0.00	$699.29
Window RO	1	7.75	7.75	$12.09	$21.78	$0.00	$33.87
Total			5023.26	$7,836.29	$14,115.36	$0.00	$21,951.65
10" CMU		SF		$2.18	$3.46	$0.00	$5.64
Total	1	140.00	140.00	$305.20	$484.40	$0.00	$789.60
8" Hollow Core Plank		SF		$5.00	$0.75	$0.53	$6.28
	1	13971.10	13971.10	$69,855.50	$10,478.33	$7,404.68	$87,738.51
	1	7522.00	7522.00	$37,610.00	$5,641.50	$3,986.66	$47,238.16
Total			21493.10	$107,465.50	$16,119.83	$11,391.34	$134,976.67
Topping Slab		CY		$74.00	$10.15	$4.70	$88.85
	1	91.00	91.00	$6,734.00	$923.65	$427.70	$8,085.35
	1	46.43	46.43	$3,435.82	$471.26	$218.22	$4,125.31
Total			137.43	$10,169.82	$1,394.91	$645.92	$12,210.66
Steel		LF		$12.13	$3.10	$2.37	$17.60
W 8X18	5	8.67	43.33	$525.63	$134.33	$102.70	$762.67
W 8X18	5	6.33	31.67	$384.12	$98.17	$75.05	$557.33
Total			75.00	$909.75	$232.50	$177.75	$1,320.00
Total				**$126,686.56**	**$32,347.00**	**$12,215.01**	**$171,248.57**

Floor 2 Structural Cost				Unit Cost			
Type	Quantity	Units	Total SF	Material	Labor	Equipment	Total Cost
Cast in Place		CY		$134.09	$97.73	$12.46	$244.28
	2	14.30	28.61	$3,835.85	$2,795.62	$356.50	$6,987.97
	2	7.35	14.70	$1,970.60	$1,436.20	$183.14	$3,589.95
	4	1.73	6.92	$927.41	$675.91	$86.19	$1,689.51
	2	5.50	11.00	$1,475.36	$1,075.26	$137.12	$2,687.75
	2	4.20	8.41	$1,127.61	$821.81	$104.80	$2,054.22
	1	3.82	3.82	$512.07	$373.21	$47.59	$932.87
	1	0.45	0.45	$60.58	$44.15	$5.63	$110.36
	1	1.75	1.75	$234.46	$170.88	$21.79	$427.13
	1	4.13	4.13	$553.25	$403.22	$51.42	$1,007.89
	2	8.12	16.25	$2,178.78	$1,587.93	$202.49	$3,969.20
	4	7.09	28.37	$3,804.32	$2,772.64	$353.56	$6,930.52
	2	8.67	17.35	$2,326.26	$1,695.41	$216.20	$4,237.88
	2	17.45	34.89	$4,678.93	$3,410.07	$434.85	$8,523.84
	2	11.29	22.58	$3,027.80	$2,206.70	$281.40	$5,515.90
	4	7.09	28.37	$3,804.32	$2,772.64	$353.56	$6,930.52
	2	8.41	16.82	$2,255.13	$1,643.57	$209.59	$4,108.29
	1	4.47	4.47	$599.37	$436.83	$55.70	$1,091.90
	2	3.56	7.11	$953.73	$695.09	$88.64	$1,737.45
	1	2.25	2.25	$301.64	$219.84	$28.03	$549.51
	1	0.81	0.81	$108.00	$78.71	$10.04	$196.75
	1	2.22	2.22	$297.69	$216.96	$27.67	$542.31
	2	7.31	14.62	$1,960.09	$1,428.54	$182.17	$3,570.80
	2	3.30	6.60	$885.20	$645.15	$82.27	$1,612.62
	1	1.20	1.20	$160.72	$117.13	$14.94	$292.79
Doors RO	2	0.58	1.16	$156.00	$113.69	$14.50	$284.19
	15	0.63	9.43	$1,264.45	$921.55	$117.52	$2,303.51
	6	0.75	4.53	$607.07	$442.44	$56.42	$1,105.93
Window RO	1	0.22	0.22	$29.40	$21.43	$2.73	$53.56
Total			268.34	$35,982.26	$26,224.36	$3,344.11	$65,550.73
10" CMU		SF		$2.18	$3.46	$0.00	$5.64
Total	1	140.00	140.00	$305.20	$484.40	$0.00	$789.60
8" Precast Planks		SF		$5.00	$0.75	$0.53	$6.28
Total		13971.10	13971.10	$69,855.50	$52,391.63	$27,767.56	$150,014.69
Topping Slab		CY		$74.00	$10.15	$4.70	
Total		91.00	91.00	$6,734.00	$923.65	$427.70	$8,085.35
Steel		LF		$12.13	$3.10	$2.37	$17.60
W 8X18	10	8.67	86.67	$1,051.27	$268.67	$205.40	$1,525.33
W 8X18	10	6.33	63.33	$768.23	$196.33	$150.10	$1,114.67
Total			150.00	$1,819.50	$465.00	$355.50	$2,640.00
Total				**$114,696.46**	**$80,489.03**	**$31,894.87**	**$227,080.36**

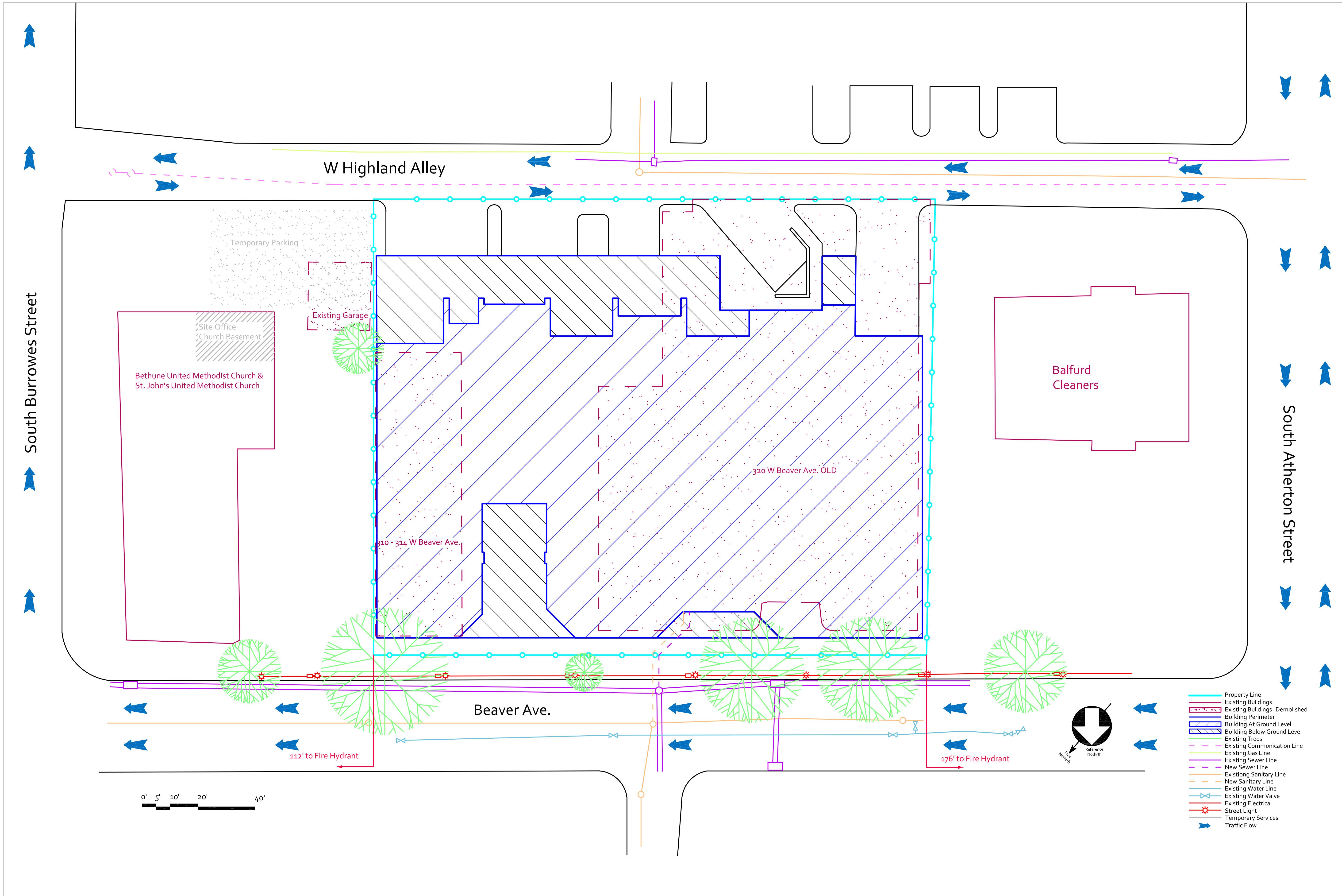
Footers				Unit Cost			
Spread	CY			$92.00	$40.00	$0.44	$132.44
	32	7.88	252.16	$23,198.72	$708.57	$0.00	$23,907.29
Strip Edge Footer	CY			$92.50	$52.50	$0.58	$145.58
	1	237.00	237.00	$21,922.50	$12,442.50	$137.46	$34,502.46
Strip Interior Footer 5'X1'8"	CY			$29.78	$25.74	$0.00	$55.52
	1	92.00	92.00	$2,739.76	$2,368.08	$0.00	$5,107.84
Strip Interior Footer 2'X1'	CY			$11.26	$14.54	$0.00	$25.80
	1	9.00	9.00	$9,461.40	$2,418.00	$1,848.60	$13,728.00
Strip Interior Footer 3'X1'	CY			$92.50	$52.50	$0.58	$145.58
	1	16.50	16.50	$1,526.25	$866.25	$9.57	$2,402.07
Total				$58,848.63	$18,803.40	$1,995.63	**$79,647.66**
Parking Garage							
Extrerior Wall	CY			$149.00	$219.00	$26.50	$394.50
	1	481.00	481.00	$71,669.00	$105,339.00	$12,746.50	$189,754.50
Slab on Grade	SF			$1.15	$0.55	$0.01	$1.71
	1	25711.00	25711.00	$29,567.65	$14,141.05	$257.11	$43,965.81
Precast Panels				$5.00	$0.75	$0.53	$6.28
	1	26730.00	26730.00	$133,650.00	$20,047.50	$14,166.90	$167,864.40
1st Level							
Interior Walls							
1'-4"	CY			$139.00	$54.00	$6.95	$199.95
	8	22.76	182.08	$25,309.12	$9,832.32	$1,265.46	$36,406.90
1'-0"	CY			$158.00	$91.50	$11.70	$261.20
	1	0.46	0.46	$72.68	$42.09	$5.38	$120.15
	1	3.88	3.88	$613.04	$355.02	$45.40	$1,013.46
	1	0.08	0.08	$12.64	$7.32	$0.94	$20.90
	1	1.51	1.51	$238.58	$138.17	$17.67	$394.41
	2	0.44	0.88	$139.04	$80.52	$10.30	$229.86
	2	0.93	1.86	$293.88	$170.19	$21.76	$485.83
	1	0.94	0.94	$148.52	$86.01	$11.00	$245.53
Total			2.80	$1,518.38	$879.32	$112.44	$2,510.13
Columns	CY			$139.00	$91.50	$11.70	$242.20
1'-4"	16	2.46	39.36	$5,471.04	$3,601.44	$460.51	$9,532.99
CMU Walls 8"	CY			$1.56	$2.81	$0.00	$4.37
	3	9.56	28.68	$44.74	$80.59	$0.00	$125.33
	1	14.21	14.21	$22.17	$39.93	$0.00	$62.10
	1	19.00	19.00	$29.64	$53.39	$0.00	$83.03
	1	20.00	20.00	$31.20	$56.20	$0.00	$87.40
	1	5.83	5.83	$9.09	$16.38	$0.00	$25.48
	1	13.11	13.11	$20.45	$36.84	$0.00	$57.29
Total			18.94	$157.29	$283.33	$0.00	$440.63

T Beams	LF			$147.80	$11.47	$0.00	$159.27
	1	1348.19	1348.19	$199,262.48	$15,463.74	$0.00	$214,726.22
1'-0"	CY			$158.00	$91.50	$11.70	$261.20
	1	484.00	484.00	$76,472.00	$44,286.00	$5,662.80	$126,420.80
Total				$86.13	$13.25	$7.07	**$840,072.40**
Commercial				Unit Cost			
Precast Panels	SF			$5.00	$0.75	$0.53	$6.28
	1	6980.00	6980.00	$34,900.00	$5,235.00	$3,699.40	$43,834.40
	1	6365.86	6365.86	$31,829.30	$4,774.40	$3,373.91	$39,977.60
Total			13345.86	$343,038.46	$70,196.28	$7,073.31	$83,812.00
Slab on Grade	CY			$84.50	$43.00	$0.58	$128.08
	1	18.00	18.00	$1,521.00	$774.00	$10.44	$2,305.44
Columns	CY			$139.00	$54.00	$6.95	$199.95
1'-4"	2	2.28	4.56	$633.84	$246.24	$31.69	$911.77
Strip Footer	CY			$92.50	$52.50	$0.58	$145.58
3'X1'	1	16.50	16.50	$1,526.25	$866.25	$9.57	$2,402.07
	CY			$92.00	$40.00	$0.44	$132.44
Spread Footings	8	12.77	102.16	$9,398.72	$4,086.40	$44.95	$13,530.07
Strip Footer	CY			$11.26	$14.50	$0.00	$25.76
2'X1'	1	18.00	18.00	$202.68	$261.00	$0.00	$463.68
Footers	CY			$84.50	$43.00	$0.58	$128.08
	1	18.00	18.00	$1,521.00	$774.00	$10.44	$2,305.44
CMU Walls	SF			$1.56	$2.81	$0.00	$4.37
	1	927.00	927.00	$1,446.12	$2,604.87	$0.00	$4,050.99
Steel	LF			$23.50	$2.29	$1.75	$27.54
W12X35	1	20.00	20.00	$470.00	$45.80	$35.00	$550.80
Steel	Each			$660.00	$38.50	$29.50	$728.00
HSS 12X8X5/8	1	8.00	8.00	$5,280.00	$308.00	$236.00	$5,824.00
Steel	Lb			$0.43	$0.38	$0.00	$0.81
L6X6X5/8	1	4646.40	4646.40	$1,997.95	$1,765.63	$0.00	$3,763.58
Total				$49,703.49	$12,242.89	$3,806.49	**$119,919.85**

Total	Time Factor	$0.96	**$2,535,381.89**
	Location Factor	$1.32	

Appendix C

Site Layout Planning



320 W. Beaver Ave.

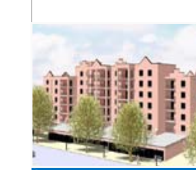
State College, PA

Site Plan Existing Cosditions

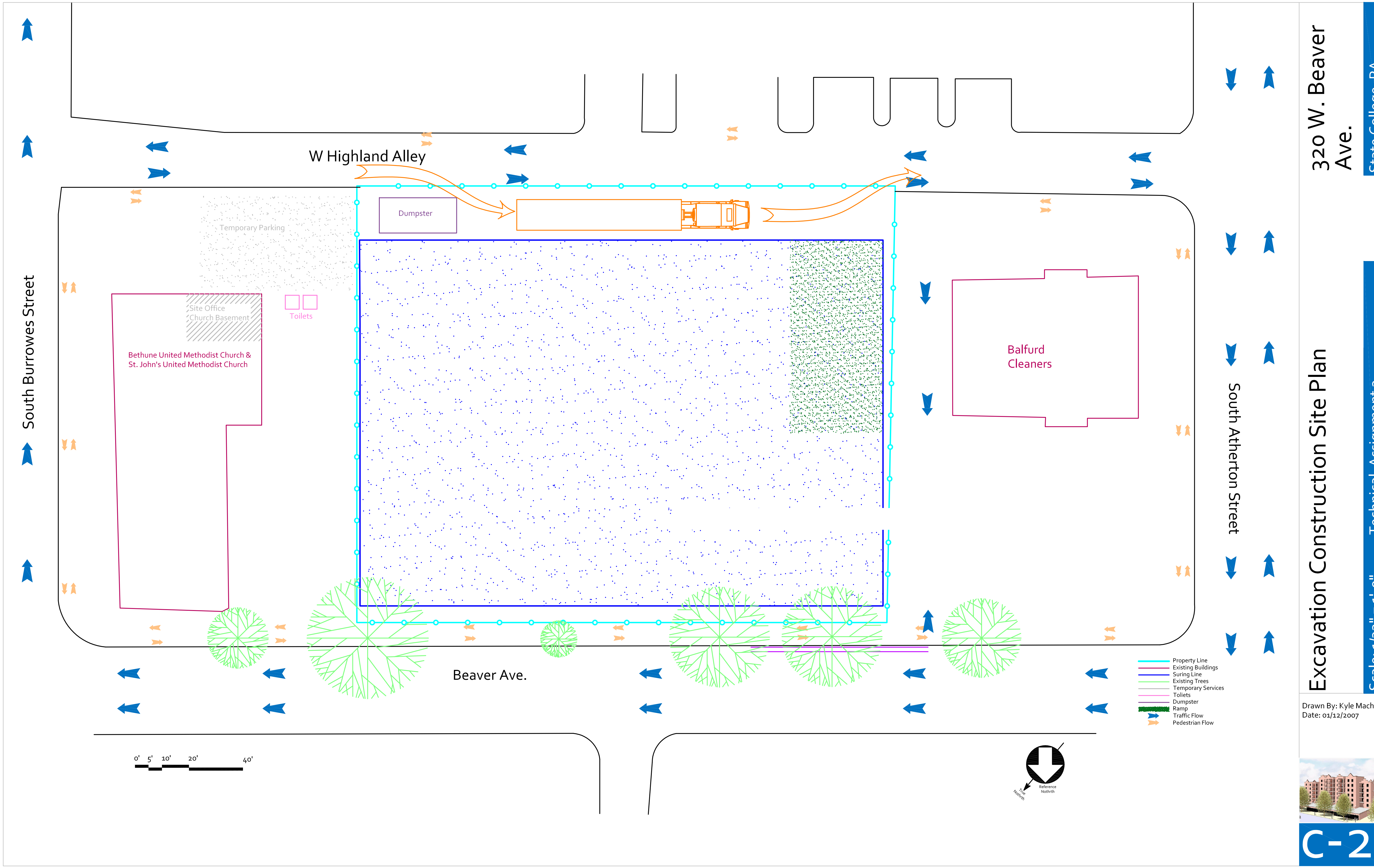
Technical Assignment 1

Scale: 1/32" = 1'-0"

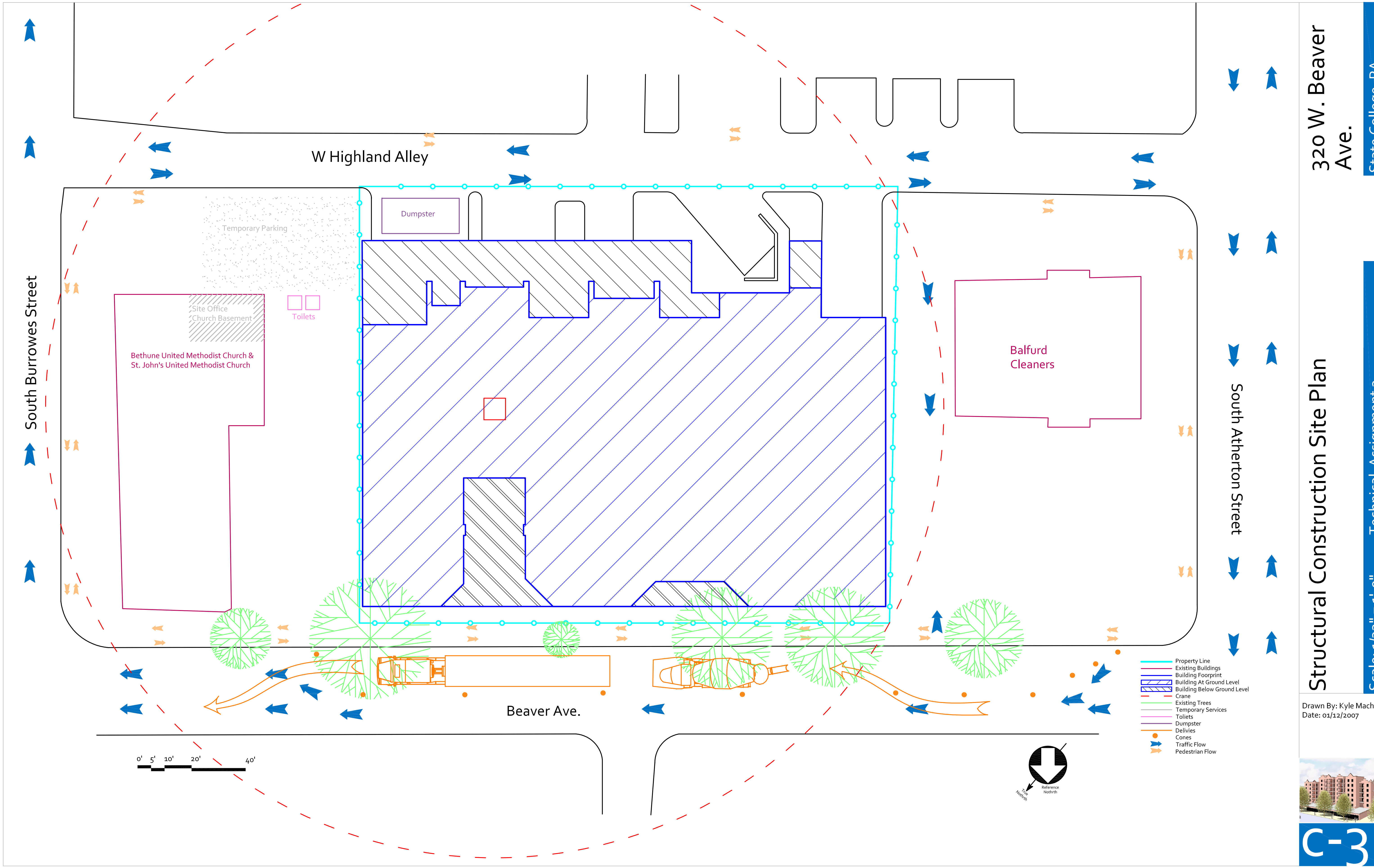
Drawn By: Kyle Macht
Date: 12/10/2007

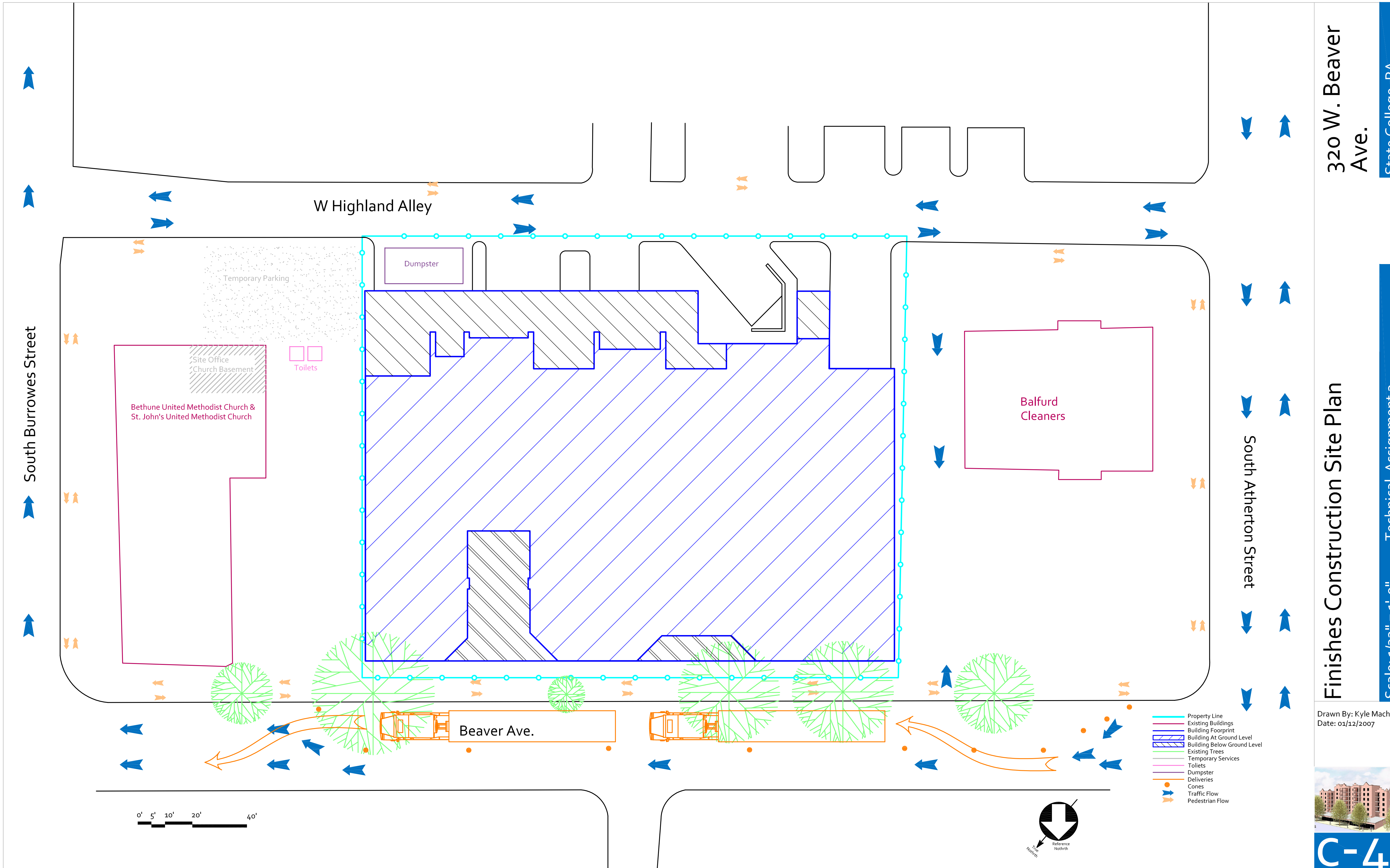


C-1



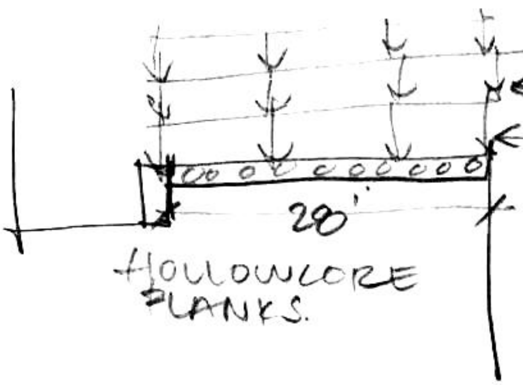
W Highland Alley
Dumpster
Temporary Parking
Site Office
Church Basement
Toilets
Bethune United Methodist Church &
St. John's United Methodist Church
Balfurd
Cleaners
South Burrowes Street
South Atherton Street
Beaver Ave.
0' 5' 10' 20' 40'
Property Line
Existing Buildings
Suring Line
Existing Trees
Temporary Services
Toliets
Dumpster
Ramp
Traffic Flow
Pedestrian Flow
320 W. Beaver Ave.
State College, PA
Excavation Construction Site Plan
Technical Assignment 2
Scale: 1/32" = 1'-0"
Drawn By: Kyle Macht
Date: 01/12/2007
C-2


W Highland Alley
South Burrowes Street
South Atherton Street
Beaver Ave.
Dumpster
Temporary Parking
Site Office
Church Basement
Toilets
Bethune United Methodist Church &
St. John's United Methodist Church
Balfurd
Cleaners
0' 5' 10' 20' 40'
Property Line
Existing Buildings
Building Foorprint
Building At Ground Level
Building Below Ground Level
Crane
Existing Trees
Temporary Services
Toliets
Dumpster
Delivies
Cones
Traffic Flow
Pedestrian Flow
320 W. Beaver
Ave.
State College, PA
Structural Construction Site Plan
Technical Assignment 2
Scale: 1/32" = 1'-0"
Drawn By: Kyle Macht
Date: 01/12/2007
C-3


W Highland Alley
South Burrowes Street
South Atherton Street
Beaver Ave.
Dumpster
Temporary Parking
Site Office
Church Basement
Toilets
Bethune United Methodist Church &
St. John's United Methodist Church
Balfurd
Cleaners
0' 5' 10' 20' 40'
Reference
Nothrth
True
Northh
Property Line
Existing Buildings
Building Foorprint
Building At Ground Level
Building Below Ground Level
Existing Trees
Temporary Services
Toliets
Dumpster
Deliveries
Cones
Traffic Flow
Pedestrian Flow
320 W. Beaver
Ave.
State College, PA
Finishes Construction Site Plan
Technical Assignment 2
Scale: 1/32" = 1'-0"
Drawn By: Kyle Macht
Date: 01/12/2007
C-4

Appendix G

Structural Calculations, **Breadth 1**



← 30 PSF SNOW LOAD FROM DRAWINGS

← 35 PSF DEAD LOAD

← 100PSF LIVE LOAD COMMUNITY SPACE

TECTA GREEN ROOF
2"-6" 16-35 PSF FOR GREEN ROOF SYSTEM
CHOOSE 35 PSF CONSERVATIVELY

100 PSF LIVE + 35 PSF DEAD.

135 PSF > 133 PSF ∴ UP THE PLANK TO 10"
8" EXISTING W/ 15 STRANDS 28' SPAN.

135 PSF < 197 PSF FOR 8'x10" PLANK 15 STRANDS

SUPER IMPOSED LOAD WITH 10" PLANK

135 + 95.65 = **230.65 PSF**

LOAD COMBINATION

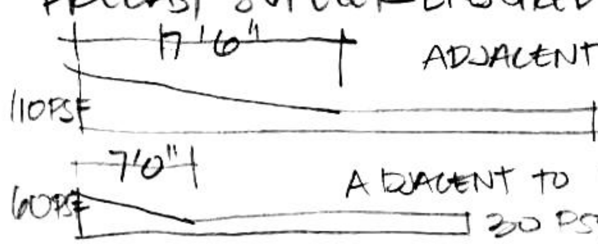
1.2 D + 1.6 L + 0.5 S

1.2 (95.65 + 35) + 1.6 (100) + 0.5 (30) = **331.78 PSF**

- 10" HOLLOWCORE PLANK TAKEN FROM WM. S. LONG INC., THE PLANK SUPPLIER
- SNOW IS NOT A FACTOR DUE TO THE LIVE LOAD

DRIFT LOAD

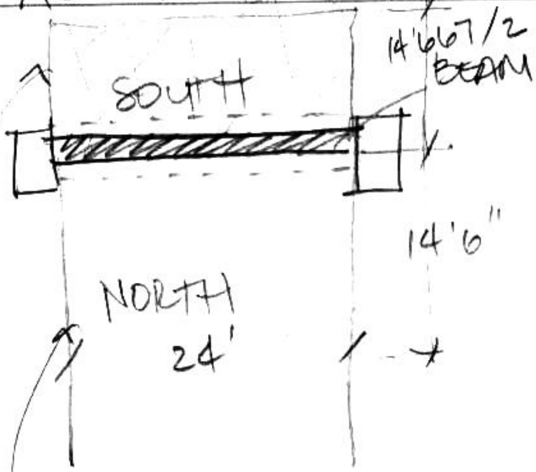
PRECAST SUPLIER ENSURED SNOW LOADS FOR STATE COLLEGE

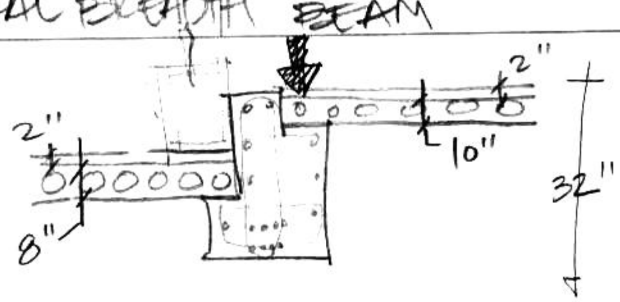


ADJACENT TO HIGH ROOF

ADJACENT TO PARAPET

AE THESIS — STRUCTURAL BREADTH BEAM





NORTH SAFE SUPERIMPOSED LOAD

230.65 PSF · 14'6" = **3344.425 PLF**

LOAD COMBINATION

331.78 PSF · 14'6" = **4810.81 PLF**

SOUTH SAFE SUPERIMPOSED LOAD

$\frac{14.667'}{2}(20 + 35 + 87.6) =$ **1045.76 PLF**

LOAD COMBINATION

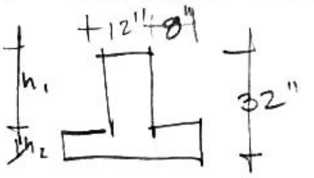
$\frac{14.667'}{2}\left((20)(1.6) + (35 + 87.6)(1.2) + (30)(.5)\right) =$ **1423.55 PLF**

PLANTER BOX 35 PSF · 3 + 2X8 FRAMING W/ BRICK = **125 PLF**

4" ⟶ 12"

LOAD COMBINATION 125 · 1.2 = **150 PLF**

ASSUME PCI



$h_1 / h_2 = 20/12$

600 PLF

SAFE SUPERIMPOSED LOAD

3344.425 + 1045.76 + 125 = **4515.19 PLF**

@ 24' SPAN 7,521 PLF

4515.19 PLF < 7,521 ∴ OK

LOAD COMBINATION 4810.81 + 1423.55 + 150 + 600 · 1.2

= **7104.36 PLF**

① ASSUMING SAME h_1/h_2 ON EACH SIDE HIGHER LOAD WILL HAVE A LARGER h_1/h_2 ANYWAYS. MEANING IT CAN SUPPORT MORE.
② ASSUMING NO TORSIONAL FACTOR.

BUILDING DESIGNED FOR AN 8TH FLOOR THEREFORE THE WEIGHT OF THAT FLOOR CAN CANCEL OUT THE ADDED WEIGHT FROM THE GREEN ROOF WITH RESPECT TO THE BEAMS.

ADDITIONAL WEIGHT ON THE COLUMNS

80 PSF LIVE LOAD ADDITIONAL
20 PSF DEAD LOAD
· ASSUMING 15 PSF FOR REGULAR ROOF DEAD LOAD.
95.65 - 87.6 = 8.05 PSF DEAD LOAD FROM 10" PLANK

$(80)1.6 + (20+8.05)1.2 = 161.66$ PSF

$161.66 \cdot 14'6" = 2344.07$ PLF

PLANTER BOX 150 PLF
20 PSF FOR NORTH ROOF $1.2(20) \cdot \frac{14.67}{2} = 176.04$ PLF

$2344.07 + 150 + 176.04 = $ **2670.11 PLF**

$2670.11 \text{ PLF} \left(\frac{23'8"}{2} + \frac{12'}{6}\right) = $ **47,616.96 lbs**

47.62 KIPS

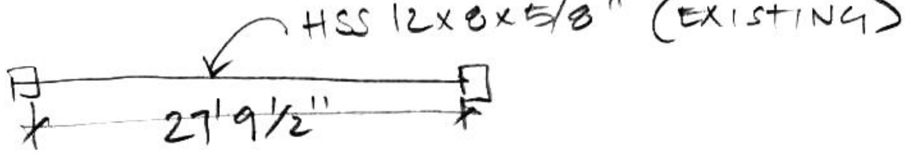
AREA WITH LARGEST INCREASE IN WEIGHT IF 8^{TH} FLOOR WAS ADDED

8TH FLOOR WEIGHT

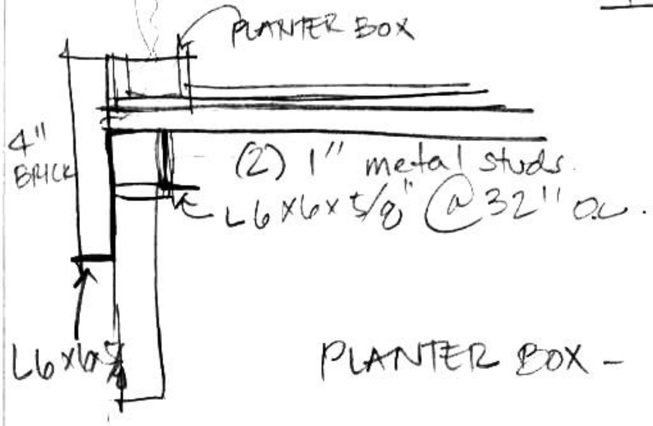
- 200 SF $\cdot (87.6 \cdot 1.2 + 40 \cdot 1.6) = 33,824$ lbs
- × 9' = 119.25 SF · 69 psf = 8228.25 lbs
  CMU WALLS
- STUD WALLS 8 PSF 29' × 8'2" = 1,894.67 lbs
  INTERIOR
- EXTERIOR 16 PSF 17.83' × 8'2" = 2329.79 lbs
- ½ GYPSUM 2 PSF 44' × 8'2" = 718.67 lbs
- FLOOR FINISH 2 PSF 200 SF = 400 lbs
- W8X18 6'4" + 9' 15.33 · 18 = 276 lbs.

TOTAL = 47671.37

47.67k > 47.62k ∴ OK



LOAD COMBINATION = **4010.81 PLF**



PLANTER BOX – 121 PLF

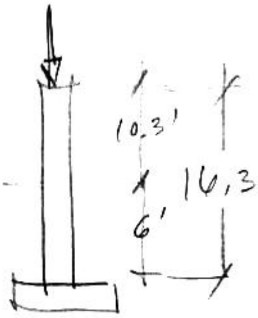
– BRICK	39 PSF	3'1½"	=	121.88 PLF
– 2x4 (2x4)	w/ ½ GYP 8 PSF	2.3'	=	18.4 PLF
–(2) 2x1"	8 PSF	1'1"	=	8.67 PLF
– 1/2.5	L 6x6x5/8	@ 34" O.C.	=	9.68 PLF
	L 6x6x5/8		=	24.2 PLF
	TOTAL		=	182.83 PLF

$(121 + 182.83)\,1.2 = 364.6$ PLF

TOTAL $4810.81 + 364.6 =$ **5175.41 PLF**

$$M_n = \frac{w\ell^2}{12} = \frac{5175.41 \cdot 28^2}{12} = 338.126\ \text{kft}$$

HSS 14x10x5/8 414 kft 93.1 PLF SELF WEIGHT



5175.41 PLF + (93.1) 1.2

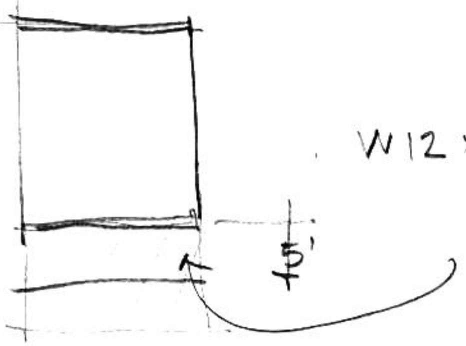
5287.13 PLF · 24'

126.89 kips

HSS 10 x 5 x 1/4 $\phi_c P_n = 157$ ∴ OK

24.1 PLF

Green Roof Hole



W12 x 35 (EXISTING)

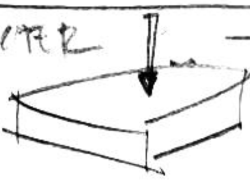
331.78 PSF × 5' = 1658.9 PLF

$M_n = \frac{w l^2}{8} = \frac{1658.9 (24)^2}{8} = 119.44$ kft

W12 x 35 @ 24' = 64 kft ∴ NO GOOD

W12 x 72 @ 24' = 135 kft ∴ OK

FOOTER



$126.89 \text{ kips} + \frac{24.1 \cdot 16}{1000} (1.2)$

= 127.35 kips

FROM RS MEANS. 2008.

150 K & SOIL CAPACITY 3 ksf

= 7'6" SQUARE
18" DEEP

Appendix F

General Conditions Estimate

Appendix F: General Conditions Estimate					
Item	Quantity	Amount	Unit Cost	Units	Total
Staff					
VP of Operations	1	10.00	$1,950.00	/wk	$19,500.00
General Superintendent	1	5.00	$1,910.00	/wk	$9,550.00
Project Manager	1	70.00	$1,620.00	/wk	$113,400.00
Project Engineer	1	70.00	$1,125.00	/wk	$78,750.00
Superintendent	1	60.00	$1,300.00	/wk	$78,000.00
Estimator	1	5.00	$1,430.00	/wk	$7,150.00
Field Engineer	1	10.00	$850.00	/wk	$8,500.00
Total					$314,850.00
General Site Work					
Dumpster	1	20.00	$425.00	each	$8,500.00
Final Cleanup	1	13300.00	$0.10	SF	$1,330.00
Saftey Rails	6	384.00	$2.50	LF	$5,760.00
Fire Extinguisher	5	1.00	$65.00	each	$325.00
Site Fence	1	720.00	$5.00	LF	$3,600.00
Total					$19,515.00
Temporary Utilities					
Electrical Connection	1	1.00	$3,000.00	each	$3,000.00
Electrical Monthly Rate	1	76.00	$400.00	/wk	$30,400.00
Telephone Service	1	76.00	$45.00	/wk	$3,420.00
Cell Phone	3	76.00	$60.00	/wk	$13,680.00
Water	1	76.00	$10.00	/wk	$760.00
Sanitary Facilities	2	76.00	$30.00	/mo	$4,560.00
Total					$55,820.00
Temporary Facilities					
Computer	2	76.00	$17.00	/wk	$2,584.00
Internet	1	17.00	$50.00	/mo	$850.00
Printer / Scanenr / Fax	1	1.00	$100.00	each	$100.00
Walkie Talkies	4	1.00	$25.00	each	$100.00
Office Expenses	1	76.00	$20.00	/wk	$1,520.00
Total					$5,154.00
Total					$395,339.00

Appendix H

Hollow Core Planks

Wm. S. LONG INC.

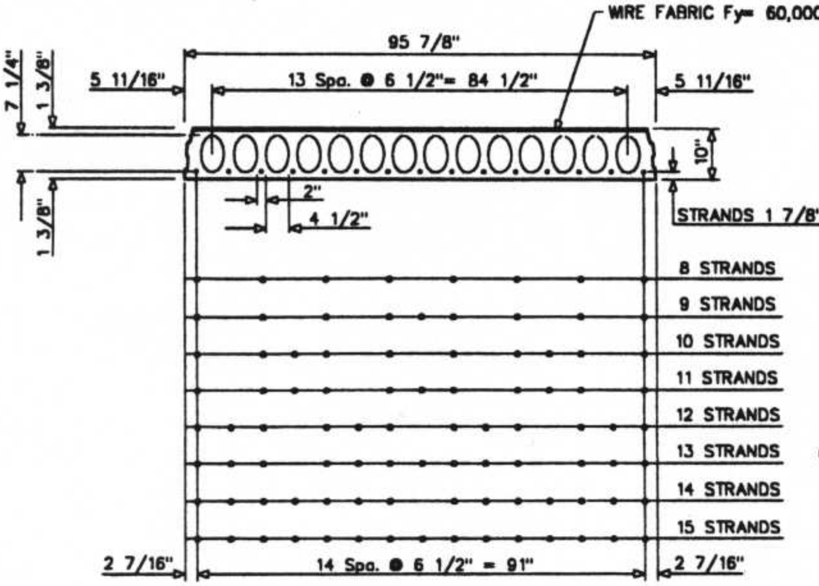
127 BREAKNECK ST.
P.O. BOX AC
CALLERY, PA. 16024

Manufacturers of Precast Prestressed Concrete

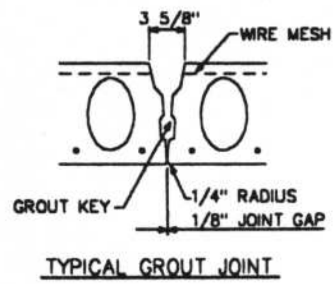
(724) 538-3775
FAX (724) 538-5588

Dynaspan®

8'-0" X 10" Normal Weight Concrete @ 150 PCF



SECTION PROPERTIES
UNTOPPED
A=532.00 in^2
I=6422 in^4
Yb=4.96 (In.)
V/S=2.51 (In.)
WT=554.00 PLF
69.25 PSF



TYPICAL GROUT JOINT

Table of safe superimposed service loads (psf) — **No Topping**

Number & Size of 270K Strands Per 8'-0" Width	Span, Ft.																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
8-1/2"	183	162	143	127	112	99	88	77	68	60	52	45	39	34	28						
9-1/2"	211	187	166	148	132	117	105	93	83	74	65	58	51	44	38	33	28				
10-1/2"	238	212	189	169	151	135	121	108	97	87	78	69	62	55	48	42	37	32	27		
11-1/2"	265	236	211	189	170	153	137	124	111	100	90	81	72	64	57	50	44	38	33	28	
12-1/2"	282	260	233	209	188	170	153	138	125	112	101	90	81	72	65	57	51	45	39	34	29
13-1/2"		267	252	228	205	185	166	150	135	122	110	99	89	80	72	64	57	51	45	39	34
14-1/2"				239	219	198	178	161	146	132	119	108	97	88	79	71	64	57	51	45	40
15-1/2"					228	210	190	172	156	142	128	116	106	96	86	78	70	63	57	51	45

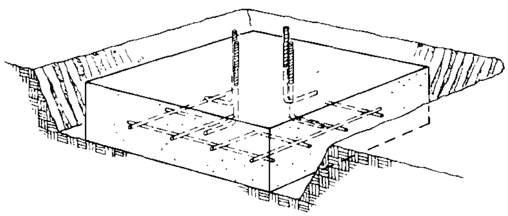
Table of safe superimposed service loads (psf) — **2" Normal Weight Topping**

Number & Size of 270K Strands Per 8'-0" Width	Span, Ft.																				
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
8-1/2"	223	196	172	152	134	118	103	89	74	61	49	39									
9-1/2"	257	227	201	178	158	140	122	105	89	75	63	51	41	31	23						
10-1/2"	291	258	229	204	182	160	139	121	104	89	76	64	53	42	33	24					
11-1/2"	324	288	257	229	203	178	156	137	119	103	89	76	64	53	43	34	26				
12-1/2"	348	318	284	251	222	196	173	152	134	117	102	88	75	64	53	44	35	27			
13-1/2"		329	307	272	241	214	189	167	148	130	114	100	86	74	63	53	44	35	27		
14-1/2"			311	292	260	231	205	182	162	143	126	111	97	85	73	62	53	44	35	28	
15-1/2"				295	278	248	221	197	176	156	139	123	108	95	83	72	61	52	43	35	28

Appendix I

RS Means Structural Data

A1010 Standard Foundations



The Spread Footing System includes: excavation; backfill; forms (four uses); all reinforcement; 3,000 p.s.i. concrete (chute placed); and screed finish.

Footing systems are priced per individual unit. The Expanded System Listing at the bottom shows footings that range from 3′ square x 12″ deep, to 18′ square x 52″ deep. It is assumed that excavation is done by a truck mounted hydraulic excavator with an operator and oiler.

Backfill is with a dozer, and compaction by air tamp. The excavation and backfill equipment is assumed to operate at 30 C.Y. per hour.

Please see the reference section for further design and cost information.

System Components	QUANTITY	UNIT	COST EACH MAT.	COST EACH INST.	COST EACH TOTAL
SYSTEM A1010 210 7100					
SPREAD FOOTINGS, LOAD 25K, SOIL CAPACITY 3 KSF, 3′ SQ X 12″ DEEP					
Bulk excavation	.590	C.Y.		4.66	4.66
Hand trim	9.000	S.F.		7.20	7.20
Compacted backfill	.260	C.Y.		.84	.84
Formwork, 4 uses	12.000	S.F.	8.40	52.20	60.60
Reinforcing, fy = 60,000 psi	.006	Ton	5.85	6.45	12.30
Dowel or anchor bolt templates	6.000	L.F.	5.22	21.60	26.82
Concrete, f′c = 3,000 psi	.330	C.Y.	36.30		36.30
Place concrete, direct chute	.330	C.Y.		6.59	6.59
Screed finish	9.000	S.F.		2.34	2.34
TOTAL			55.77	101.88	157.65

A1010 210	Spread Footings	COST EACH MAT.	COST EACH INST.	COST EACH TOTAL
7090	Spread footings, 3000 psi concrete, chute delivered			
7100	Load 25K, soil capacity 3 KSF, 3′-0″ sq. x 12″ deep	56	102	158
7150	Load 50K, soil capacity 3 KSF, 4′-6″ sq. x 12″ deep (RA1010-120)	120	176	296
7200	Load 50K, soil capacity 6 KSF, 3′-0″ sq. x 12″ deep	56	102	158
7250	Load 75K, soil capacity 3 KSF, 5′-6″ sq. x 13″ deep	190	248	438
7300	Load 75K, soil capacity 6 KSF, 4′-0″ sq. x 12″ deep	96.50	150	246.50
7350	Load 100K, soil capacity 3 KSF, 6′-0″ sq. x 14″ deep	241	297	538
7410	Load 100K, soil capacity 6 KSF, 4′-6″ sq. x 15″ deep	147	207	354
7450	Load 125K, soil capacity 3 KSF, 7′-0″ sq. x 17″ deep	385	430	815
7500	Load 125K, soil capacity 6 KSF, 5′-0″ sq. x 16″ deep	190	249	439
7550	Load 150K, soil capacity 3 KSF 7′-6″ sq. x 18″ deep	460	500	960
7610	Load 150K, soil capacity 6 KSF, 5′-6″ sq. x 18″ deep	254	315	569
7650	Load 200K, soil capacity 3 KSF, 8′-6″ sq. x 20″ deep	660	660	1,320
7700	Load 200K, soil capacity 6 KSF, 6′-0″ sq. x 20″ deep	330	385	715
7750	Load 300K, soil capacity 3 KSF, 10′-6″ sq. x 25″ deep	1,225	1,075	2,300
7810	Load 300K, soil capacity 6 KSF, 7′-6″ sq. x 25″ deep	630	650	1,280
7850	Load 400K, soil capacity 3 KSF, 12′-6″ sq. x 28″ deep	1,925	1,625	3,550
7900	Load 400K, soil capacity 6 KSF, 8′-6″ sq. x 27″ deep	880	850	1,730
7950	Load 500K, soil capacity 3 KSF, 14′-0″ sq. x 31″ deep	2,675	2,100	4,775
8010	Load 500K, soil capacity 6 KSF, 9′-6″ sq. x 30″ deep	1,200	1,100	2,300

B1010 Floor Construction

B1010 208 Steel Columns

	LOAD (KIPS)	UNSUPPORTED HEIGHT (FT.)	WEIGHT (P.L.F.)	SIZE (IN.)	TYPE	COST PER V.L.F.	
						MAT.	INST.
3200	100	20	40	8	A	51.50	7.20
3220			28.55	8	B	36.50	7.20
3240			81	8-5/8	C	38	7.20
3260			25.82	8	D	33	7.20
3280			66	7	E	30	7.20
3300			27.59	8x6	F	35.50	7.20
3320			70	8x6	G	43	7.20
3400	125	10	31	8	A	45.50	9.65
3420			28.57	6	B	42	9.65
3440			81	8	C	43.50	9.65
3460			22.42	7	D	33	9.65
3480			49	6	E	29	9.65
3500			22.42	8x6	F	33	9.65
3520			64	8x6	G	34	9.65
3600	125	16	40	8	A	54	7.20
3620			28.55	8	B	38.50	7.20
3640			81	8	C	40	7.20
3660			25.82	8	D	35	7.20
3680			66	7	E	31.50	7.20
3700			27.59	8x6	F	37.50	7.20
3720			64	8x6	G	31.50	7.20
3800		20	48	8	A	61.50	7.20
3820			40.48	10	B	52	7.20
3840			81	8	C	38	7.20
3860			25.82	8	D	33	7.20
3880			66	7	E	30	7.20
3900			37.59	10x6	F	48	7.20
3920			60	8x6	G	43	7.20
4000	150	10	35	8	A	51	9.65
4020			40.48	10	B	59.50	9.65
4040			81	8-5/8	C	43.50	9.65
4060			25.82	8	D	38	9.65
4080			66	7	E	34	9.65
4100			27.48	7x5	F	40	9.65
4120			64	8x6	G	34	9.65
4200		16	45	10	A	61	7.20
4220			40.48	10	B	55	7.20
4240			81	8-5/8	C	40	7.20
4260			31.84	8	D	43	7.20
4280			66	7	E	31.50	7.20
4300			37.69	10x6	F	51	7.20
4320			70	8x6	G	45.50	7.20
4400		20	49	10	A	63	7.20
4420			40.48	10	B	52	7.20
4440			123	10-3/4	C	54.50	7.20
4460			31.84	8	D	41	7.20
4480			82	8	E	35	7.20
4500			37.69	10x6	F	48.50	7.20
4520			86	10x6	G	42.50	7.20

B1010 Floor Construction

B1010 214 "T" Shaped Precast Beams

	SPAN (FT.)	SUPERIMPOSED LOAD (K.L.F.)	SIZE W X D (IN.)	BEAM WEIGHT (P.L.F.)	TOTAL LOAD (K.L.F.)	COST PER L.F.		
						MAT.	INST.	TOTAL
3100	20	1.46	12x16	260	1.72	143	13.80	156.80
3200		2.28	12x20	355	2.64	142	13.80	155.80
3300		3.28	12x24	445	3.73	166	14.70	180.70
3400		4.49	12x28	515	5.00	179	14.70	193.70
3500		7.32	12x36	680	8.00	203	15.60	218.60
3600		11.26	12x44	840	12.10	229	16.55	245.55
3700		4.70	18x24	595	5.30	182	14.70	196.70
3800		6.51	18x28	690	7.20	197	15.60	212.60
3900		10.7	18x36	905	11.61	225	16.55	241.55
4300		16.19	18x44	1115	17.31	259	23	282
4400		22.77	18x52	1330	24.10	288	23	311
4500		6.15	24x24	745	6.90	201	15.60	216.60
4600		8.54	24x28	865	9.41	218	16.55	234.55
4700		14.17	24x36	1130	15.30	250	23	273
4800		21.41	24x44	1390	22.80	286	23	309
4900		30.25	24x52	1655	31.91	330	30.50	360.50
5000	25	2.68	12x28	515	3.2	181	11.95	192.95
5050		4.44	12x36	680	5.12	205	13.80	218.80
5100		6.90	12x44	840	7.74	233	18.40	251.40
5200		9.75	12x52	1005	10.76	261	18.40	279.40
5300		13.43	12x60	1165	14.60	287	18.40	305.40
5350		3.92	18x28	690	4.61	200	13.80	213.80
5400		6.52	18x36	905	7.43	229	18.40	247.40
5500		9.96	18x44	1115	11.08	214	18.40	232.40
5600		14.09	18x52	1330	15.42	298	25	323
5650		19.39	18x60	1540	20.93	325	25	350
5700		3.67	24x24	745	4.42	204	13.80	217.80
5750		5.15	24x28	865	6.02	222	18.40	240.40
5800		8.66	24x36	1130	9.79	205	18.40	223.40
5850		13.20	24x44	1390	14.59	295	25	320
5900		18.76	24x52	1655	20.42	330	25	355
5950		25.35	24x60	1916	27.27	355	25	380
6000	30	2.88	12x36	680	3.56	208	15.60	223.60
6100		4.54	12x44	840	5.38	239	15.60	254.60
6200		6.46	12x52	1005	7.47	272	20	292
6250		8.97	12x60	1165	10.14	296	20	316
6300		4.25	18x36	905	5.16	230	15.60	245.60
6350		6.57	18x44	1115	7.69	267	20	287
6400		9.38	18x52	1330	10.71	295	20	315
6500		13.00	18x60	1540	14.54	325	20	345
6700		3.31	24x28	865	4.18	222	15.60	237.60
6750		5.67	24x36	1130	6.80	259	20	279
6800		8.74	24x44	1390	10.13	293	20	313
6850		12.52	24x52	1655	14.18	279	20	299
6900		17.00	24x60	1215	18.92	360	20	380

B1010 Floor Construction

B1010 229 Precast Plank with No Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1700	45	40	12	70	110	9.70	1.84	11.54

B1010 230 Precast Plank with 2″ Concrete Topping

	SPAN (FT.)	SUPERIMPOSED LOAD (P.S.F.)	TOTAL DEPTH (IN.)	DEAD LOAD (P.S.F.)	TOTAL LOAD (P.S.F.)	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
2000	10	40	6	75	115	6.80	5.05	11.85
2100		75	8	75	150	8.15	4.61	12.76
2200		100	8	75	175	8.15	4.61	12.76
2500	15	40	8	75	115	8.15	4.61	12.76
2600		75	8	75	150	8.15	4.61	12.76
2700		100	8	75	175	8.15	4.61	12.76
2800	20	40	8	75	115	8.15	4.61	12.76
2900		75	8	75	150	8.15	4.61	12.76
3000		100	8	75	175	8.15	4.61	12.76
3100	25	40	8	75	115	8.15	4.61	12.76
3200		75	8	75	150	8.15	4.61	12.76
3300		100	10	80	180	8.80	4.28	13.08
3400	30	40	10	80	120	8.80	4.28	13.08
3500		75	10	80	155	8.80	4.28	13.08
3600		100	10	80	180	8.80	4.28	13.08
3700	35	40	12	95	135	9.35	4.03	13.38
3800		75	12	95	170	9.35	4.03	13.38
3900		100	14	95	195	10.60	3.82	14.42
4000	40	40	12	95	135	9.35	4.03	13.38
4500		75	14	95	170	10.60	3.82	14.42
5000	45	40	14	95	135	10.60	3.82	14.42

B2010 Exterior Walls

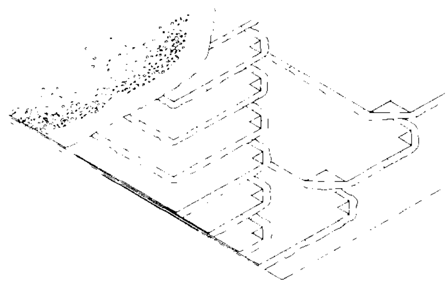
B2010 129 Brick Veneer/Wood Stud Backup

	FACE BRICK	STUD BACKUP	STUD SPACING (IN.)	BOND		COST PER S.F.		
						MAT.	INST.	TOTAL
4500	Norwegian	2x6-wood	24	running		6.75	10.30	17.[illegible]
4520				common		7.65	11.40	19.[illegible]
4540				Flemish		8.25	13.20	21.[illegible]
4560				English		9.05	13.75	22.[illegible]

B2010 130 Brick Veneer/Metal Stud Backup

	FACE BRICK	STUD BACKUP	STUD SPACING (IN.)	BOND		COST PER S.F.		
						MAT.	INST.	TOTAL
5100	Standard	25ga.x6"NLB	24	running		8.40	14.20	22.[illegible]
5120				common		9.70	16.05	25.[illegible]
5140				Flemish		10.25	18.25	28.[illegible]
5160				English		11.80	19.85	31.[illegible]
5200		20ga.x3-5/8"NLB	16	running		8.55	14.80	23.[illegible]
5220				common		9.85	16.65	26.[illegible]
5240				Flemish		10.80	19.40	30.[illegible]
5260				English		11.95	20.50	32.[illegible]
5300			24	running		8.40	14.35	22.[illegible]
5320				common		9.70	16.20	25.[illegible]
5340				Flemish		10.65	18.95	29.[illegible]
5360				English		11.80	20	31.[illegible]
5400		16ga.x3-5/8"LB	16	running		9.35	15	24.[illegible]
5420				common		10.65	16.85	27.[illegible]
5440				Flemish		11.60	19.60	31.[illegible]
5460				English		12.75	20.50	33.[illegible]
5500			24	running		9	14.60	23.[illegible]
5520				common		10.30	16.45	26.[illegible]
5540				Flemish		11.25	19.20	30.[illegible]
5560				English		12.40	20.50	32.[illegible]
5700	Glazed	25ga.x6"NLB	24	running		12.10	14.65	26.[illegible]
5720				common		14.20	16.70	30.[illegible]
5740				Flemish		15.60	19.85	35.[illegible]
5760				English		17.35	21	38.[illegible]
5800		20ga.x3-5/8"NLB	24	running		12.10	14.80	26.[illegible]
5820				common		14.20	16.85	31.[illegible]
5840				Flemish		15.60	20	35.[illegible]
5860				English		17.35	21	38.[illegible]
6000		16ga.x3-5/8"LB	16	running		13.05	15.45	28.[illegible]
6020				common		15.15	17.50	32.[illegible]
6040				Flemish		16.55	20.50	37.[illegible]
6060				English		18.30	22	40.[illegible]
6100			24	running		12.70	15.05	27.[illegible]
6120				common		14.80	17.10	31.[illegible]
6140				Flemish		16.20	20.50	36.[illegible]
6160				English		17.95	21.50	39.[illegible]
6300	Engineer	25ga.x6"NLB	24	running		6.55	12.65	19.[illegible]
6320				common		7.45	14.20	21.[illegible]
6340				Flemish		8.10	16.70	24.[illegible]
6360				English		8.90	17.50	26.[illegible]
6400		20ga.x3-5/8"NLB	16	running		6.65	13.25	19.[illegible]
6420				common		7.60	14.80	22.[illegible]
6440				Flemish		8.25	17.30	25.[illegible]
6460				English		9.05	18.10	27.[illegible]

B3010 Roof Coverings

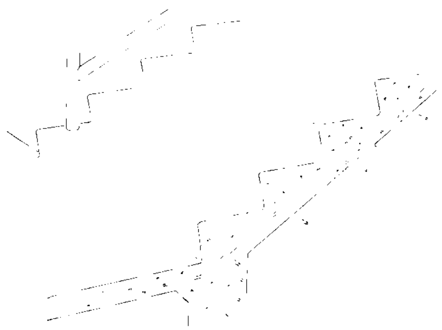


Multiple ply roofing is the most popular covering for minimum pitch roofs. Lines 1200 through 6300 list the costs of the various types, plies and weights per S.F.

System Components	QUANTITY	UNIT	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
SYSTEM B3010 105 2500					
ASPHALT FLOOD COAT, W/GRAVEL, 4 PLY ORGANIC FELT					
Organic #30 base felt	1.000	S.F.	.05	.08	
Organic #15 felt, 3 plies	3.000	S.F.	.14	.23	
Asphalt mopping of felts	4.000	S.F.	.30	.70	
Asphalt flood coat	1.000	S.F.	.19	.57	
Gravel aggregate, washed river stone	4.000	Lb.	.07	.13	
TOTAL			.75	1.71	

B3010 105	Built-Up	COST PER S.F. MAT.	COST PER S.F. INST.	COST PER S.F. TOTAL
1200	Asphalt flood coat w/gravel; not incl. insul, flash., nailers			
1300				
1400	Asphalt base sheets & 3 plies #15 asphalt felt, mopped	.74	1.55	
1500	On nailable deck	.78	1.62	
1600	4 plies #15 asphalt felt, mopped	1.02	1.70	
1700	On nailable deck	.92	1.79	
1800	Coated glass base sheet, 2 plies glass (type IV), mopped	.76	1.55	
1900	For 3 plies	.90	1.70	
2000	On nailable deck	.85	1.79	
2300	4 plies glass fiber felt (type IV), mopped	1.10	1.70	
2400	On nailable deck	.99	1.79	
2500	Organic base sheet & 3 plies #15 organic felt, mopped	.75	1.71	
2600	On nailable deck	.77	1.79	
2700	4 plies #15 organic felt, mopped	.96	1.55	
2750				
2800	Asphalt flood coat, smooth surface, not incl. insul, flash., nailers			
2850				
2900	Asphalt base sheet & 3 plies #15 asphalt felt, mopped	.78	1.42	
3000	On nailable deck	.73	1.48	
3100	Coated glass fiber base sheet & 2 plies glass fiber felt, mopped	.70	1.36	
3200	On nailable deck	.66	1.42	
3300	For 3 plies, mopped	.84	1.48	
3400	On nailable deck	.79	1.55	
3700	4 plies glass fiber felt (type IV), mopped	.99	1.48	
3800	On nailable deck	.93	1.55	
3900	Organic base sheet & 3 plies #15 organic felt, mopped	.77	1.42	
4000	On nailable decks	.71	1.48	
4100	4 plies #15 organic felt, mopped	.90	1.55	
4200	Coal tar pitch with gravel surfacing			
4300	4 plies #15 tarred felt, mopped	1.49	1.62	
4400	3 plies glass fiber felt (type IV), mopped	1.22	1.79	
4500	Coated glass fiber base sheets 2 plies glass fiber felt, mopped	1.22	1.79	

C2010 Stair Construction



General Design: See reference section for code requirements. Maximum height between landings is 12′; usual stair angle is 20° to 50° with 30° to 35° best. Usual relation of riser to treads is:

Riser + tread = 17.5.
2x (Riser) – tread = 25.
Riser x tread = 70 or 75.

Maximum riser height is 7″ for commercial, 8-1/4″ for residential.
Usual riser height is 6-1/2″ to 7-1/4″.

Minimum tread width is 11″ for commercial and 9″ for residential.

For additional information please see reference section.

Cost Per Flight: Table below lists the cost per flight for 4′-0″ wide stairs.
Side walls are not included.
Railings are included.

System Components	QUANTITY	UNIT	COST PER FLIGHT MAT.	INST.	TOTAL
SYSTEM C2010 110 0560					
STAIRS, C.I.P. CONCRETE WITH LANDING, 12 RISERS					
Concrete in place, free standing stairs not incl. safety treads	48.000	L.F.	292.80	1,647.84	1,940.64
Concrete in place, free standing stair landing	32.000	S.F.	160	455.68	615.68
Stair tread C.I. abrasive 4″ wide	48.000	L.F.	624	285.60	909.60
Industrial railing, welded, 2 rail 3′-6′ high 1-1/2″ pipe	18.000	L.F.	468	187.56	655.56
Wall railing with returns, steel pipe	17.000	L.F.	238	177.14	415.14
TOTAL			1,782.80	2,753.82	4,536.62

C2010 110	Stairs	COST PER FLIGHT MAT.	INST.	TOTAL
0470	Stairs, C.I.P. concrete, w/o landing, 12 risers, w/o nosing (RC2010 -100)	1,000	2,000	3,000
0480	With nosing	1,625	2,275	3,900
0550	W/landing, 12 risers, w/o nosing	1,150	2,475	3,625
0560	With nosing	1,775	2,775	4,550
0570	16 risers, w/o nosing	1,425	3,100	4,525
0580	With nosing	2,250	3,475	5,725
0590	20 risers, w/o nosing	1,675	3,725	5,400
0600	With nosing	2,725	4,200	6,925
0610	24 risers, w/o nosing	1,925	4,375	6,300
0620	With nosing	3,175	4,950	8,125
0630	Steel, grate type w/nosing & rails, 12 risers, w/o landing	4,750	1,050	5,800
0640	With landing	6,200	1,450	7,650
0660	16 risers, with landing	7,775	1,825	9,600
0680	20 risers, with landing	9,350	2,175	11,525
0700	24 risers, with landing	10,900	2,525	13,425
0710	Cement fill metal pan & picket rail, 12 risers, w/o landing	6,175	1,050	7,225
0720	With landing	8,125	1,575	9,700
0740	16 risers, with landing	10,200	1,950	12,150
0760	20 risers, with landing	12,200	2,300	14,500
0780	24 risers, with landing	14,300	2,650	16,950
0790	Cast iron tread & pipe rail, 12 risers, w/o landing	6,175	1,050	7,225
0800	With landing	8,125	1,575	9,700
0820	16 risers, with landing	10,200	1,950	12,150
0840	20 risers, with landing	12,200	2,300	14,500
0860	24 risers, with landing	14,300	2,650	16,950
0870	Pan tread & flat bar rail, pre-assembled, 12 risers, w/o landing	5,100	800	5,900
0880	With landing	9,250	1,250	10,500
0900	16 risers, with landing	10,200	1,375	11,575
0920	20 risers, with landing	11,900	1,675	13,575
0940	24 risers, with landing	13,600	1,925	15,525

Appendix J

HVAC Calculations

Student Apartment Building
HVAC Load Analysis

for

MICHAEL L. NORRIS & ASSOCIATES, INC.
CONSULTING ENGINEERS

1006 W. College Ave Suite 202 State College, PA 16801 Phone: 814-867-3823 Fax: 814-867-4823 miken@mlnai.com

Prepared By:

4-4-05

Air Handler #1 - TWU-1 - Summary Loads

Zn No	Description Peak Time	Area People Volume	Htg.Loss Htg.CFM CFM/Sqft	Sen.Gain Clg.CFM CFM/Sqft	Lat.Gain S.Exh W.Exh	Htg.O.A. Req.CFM Act.CFM	Clg.O.A. Req.CFM Act.CFM
1	Living/Dining A 5pm August	381 2 3,050	4,672 113 0.30	5,613 419 1.10	440 35 35	15/P 30 23	15/P 30 27
2	Bedroom #1 A 5pm August	250 1 2,000	3,310 80 0.32	3,977 275 1.10	220 0 0	15/P 15 16	15/P 15 18
3	Bedroom #2 A 5pm August	250 1 2,000	4,797 116 0.46	4,175 275 1.10	220 0 0	15/P 15 23	15/P 15 18
4	Hall/Bathrooms A 9pm July	228 0 1,824	1,626 39 0.17	2,643 126 0.55	0 35 35	15/P 0 8	15/P 0 8
	Zone Peak Totals: Total Zones: 4 Unique Zones: 4	1,109 4 8,874	14,405 348 0.31	16,408 1,095 0.99	880 70 70	 60 70	 60 70

Air Handler #1 - TWU-1 - Total Load Summary

Air Handler Description: TWU-1 Constant Volume - Sum of Peaks
Sensible Heat Ratio: 0.96 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time: 5pm in July.
Outdoor Conditions: 88° DB, 72° WB, 97.98 grains

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in August at 5pm is different from the total system peak time, hence the air system CFM was computed using a zone sensible load of 16,214.

Summer: Exhaust controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	14,405	Btuh				
Infiltration sensible loss:	0	Btuh	0	CFM		
Outside Air sensible loss:	5,796	Btuh	70	CFM		
Supply Duct sensible loss:	0	Btuh				
Return Duct sensible loss:	0	Btuh				
Return Plenum sensible loss:	0	Btuh				
Total System sensible loss:					20,201	Btuh
Heating Supply Air: 14,405 / (.958 X 1.08 X 40) =			348	CFM		
Winter Vent Outside Air (20.1% of supply) =			70	CFM		
Zone space sensible gain:	16,064	Btuh				
Infiltration sensible gain:	0	Btuh				
Draw-thru fan sensible gain:	0	Btuh				
Supply duct sensible gain:	0	Btuh				
Reserve sensible gain:	6,799	Btuh				
Total sensible gain on supply side of coil:					22,862	Btuh
Cooling Supply Air: 23,013 / (.958 X 1.1 X 20) =			1,096	CFM		
Summer Vent Outside Air (6.4% of supply) =			70	CFM		
Return duct sensible gain:	0	Btuh				
Return plenum sensible gain:	0	Btuh				
Outside air sensible gain:	1,181	Btuh	70	CFM		
Blow-thru fan sensible gain:	0	Btuh				
Total sensible gain on return side of coil:					1,181	Btuh
Total sensible gain on air handling system:					24,043	Btuh
Zone space latent gain:	880	Btuh				
Infiltration latent gain:	0	Btuh				
Outside air latent gain:	1,780	Btuh				
Total latent gain on air handling system:					2,660	Btuh
Total system sensible and latent gain:					26,703	Btuh

Check Figures

Total Air Handler Supply Air (based on a 20° TD):	1,096	CFM
Total Air Handler Vent. Air (6.39% of Supply):	70	CFM
Total Conditioned Air Space:	1,109	Sq.ft
Supply Air Per Unit Area:	0.9880	CFM/Sq.ft
Area Per Cooling Capacity:	498.4786	Sq.ft/Ton
Cooling Capacity Per Area:	0.0020	Tons/Sq.ft
Total Heating Required With Outside Air:	20,201	Btuh
Total Cooling Required With Outside Air:	2.23	Tons

Air Handler #2 - TWU-2 - Summary Loads

Zn No	Description Peak Time	Area People Volume	Htg.Loss Htg.CFM CFM/Sqft	Sen.Gain Clg.CFM CFM/Sqft	Lat.Gain S.Exh W.Exh	Htg.O.A. Req.CFM Act.CFM	Clg.O.A. Req.CFM Act.CFM
5	Living/Dining B 5pm August	381 2 3,050	5,416 131 0.34	5,781 419 1.10	440 35 35	15/P 30 26	15/P 30 27
6	Bedroom #1 B 5pm August	250 1 2,000	3,310 80 0.32	3,977 275 1.10	220 0 0	15/P 15 16	15/P 15 18
7	Bedroom #2 B 5pm August	250 1 2,000	4,054 98 0.39	4,076 275 1.10	220 0 0	15/P 15 20	15/P 15 18
8	Hall/Bathrooms B 9pm July	228 0 1,824	1,626 39 0.17	2,643 126 0.55	0 35 35	15/P 0 8	15/P 0 8
	Zone Peak Totals: Total Zones: 4 Unique Zones: 4	1,109 4 8,874	14,405 348 0.31	16,478 1,095 0.99	880 70 70	 60 70	 60 70

Air Handler #2 - TWU-2 - Total Load Summary

Air Handler Description: TWU-2 Constant Volume - Sum of Peaks
Sensible Heat Ratio: 0.96 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time: 5pm in July.
Outdoor Conditions: 88° DB, 72° WB, 97.98 grains

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in August at 5pm is different from the total system peak time, hence the air system CFM was computed using a zone sensible load of 16,284.

Summer: Exhaust controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	14,405 Btuh			
Infiltration sensible loss:	0 Btuh	0 CFM		
Outside Air sensible loss:	5,796 Btuh	70 CFM		
Supply Duct sensible loss:	0 Btuh			
Return Duct sensible loss:	0 Btuh			
Return Plenum sensible loss:	0 Btuh			
Total System sensible loss:			20,201	Btuh
Heating Supply Air: 14,405 / (.958 X 1.08 X 40) =		348 CFM		
Winter Vent Outside Air (20.1% of supply) =		70 CFM		
Zone space sensible gain:	16,133 Btuh			
Infiltration sensible gain:	0 Btuh			
Draw-thru fan sensible gain:	0 Btuh			
Supply duct sensible gain:	0 Btuh			
Reserve sensible gain:	6,730 Btuh			
Total sensible gain on supply side of coil:			22,863	Btuh
Cooling Supply Air: 23,013 / (.958 X 1.1 X 20) =		1,096 CFM		
Summer Vent Outside Air (6.4% of supply) =		70 CFM		
Return duct sensible gain:	0 Btuh			
Return plenum sensible gain:	0 Btuh			
Outside air sensible gain:	1,181 Btuh	70 CFM		
Blow-thru fan sensible gain:	0 Btuh			
Total sensible gain on return side of coil:			1,181	Btuh
Total sensible gain on air handling system:			24,043	Btuh
Zone space latent gain:	880 Btuh			
Infiltration latent gain:	0 Btuh			
Outside air latent gain:	1,780 Btuh			
Total latent gain on air handling system:			2,660	Btuh
Total system sensible and latent gain:			26,704	Btuh

Check Figures

Total Air Handler Supply Air (based on a 20° TD):	1,096	CFM
Total Air Handler Vent. Air (6.39% of Supply):	70	CFM
Total Conditioned Air Space:	1,109	Sq.ft
Supply Air Per Unit Area:	0.9880	CFM/Sq.ft
Area Per Cooling Capacity:	498.4729	Sq.ft/Ton
Cooling Capacity Per Area:	0.0020	Tons/Sq.ft
Total Heating Required With Outside Air:	20,201	Btuh
Total Cooling Required With Outside Air:	2.23	Tons

Air Handler #3 - TWU-3 - Summary Loads

Zn No	Description Peak Time	Area People Volume	Htg.Loss Htg.CFM CFM/Sqft	Sen.Gain Clg.CFM CFM/Sqft	Lat.Gain S.Exh W.Exh	Htg.O.A. Req.CFM Act.CFM	Clg.O.A. Req.CFM Act.CFM
9	Living/Dining C 5pm August	265 2 2,116	4,151 100 0.38	4,401 291 1.10	440 35 35	15/P 30 26	15/P 30 31
10	Bedroom C 5pm August	250 1 2,000	4,730 114 0.46	4,166 275 1.10	220 0 0	15/P 15 30	15/P 15 30
11	Hall/Bathroom C 10pm July	132 0 1,056	2,279 55 0.42	1,779 84 0.64	0 35 35	15/P 0 14	15/P 0 9
	Zone Peak Totals: Total Zones: 3 Unique Zones: 3	647 3 5,172	11,159 270 0.42	10,346 650 1.01	660 70 70	 45 70	 45 70

Air Handler #3 - TWU-3 - Total Load Summary

Air Handler Description: TWU-3 Constant Volume - Sum of Peaks
Sensible Heat Ratio: 0.95 --- This system occurs 1 time(s) in the building. ---

Air System Peak Time: 5pm in July.
Outdoor Conditions: 88° DB, 72° WB, 97.98 grains

Because of the diversity in zone, plenum and ventilation loads, the zone sensible peak time in August at 5pm is different from the total system peak time, hence the air system CFM was computed using a zone sensible load of 10,083.

Summer: Exhaust controls outside air, ----- Winter: Exhaust controls outside air.

Zone Space sensible loss:	11,159 Btuh			
Infiltration sensible loss:	0 Btuh	0	CFM	
Outside Air sensible loss:	5,796 Btuh	70	CFM	
Supply Duct sensible loss:	0 Btuh			
Return Duct sensible loss:	0 Btuh			
Return Plenum sensible loss:	0 Btuh			
Total System sensible loss:				16,955 Btuh
Heating Supply Air: 11,159 / (.958 X 1.08 X 40) =		270	CFM	
Winter Vent Outside Air (26.0% of supply) =		70	CFM	
Zone space sensible gain:	10,043 Btuh			
Infiltration sensible gain:	0 Btuh			
Draw-thru fan sensible gain:	0 Btuh			
Supply duct sensible gain:	0 Btuh			
Reserve sensible gain:	3,679 Btuh			
Total sensible gain on supply side of coil:				13,722 Btuh
Cooling Supply Air: 13,761 / (.958 X 1.1 X 20) =		650	CFM	
Summer Vent Outside Air (10.8% of supply) =		70	CFM	
Return duct sensible gain:	0 Btuh			
Return plenum sensible gain:	0 Btuh			
Outside air sensible gain:	1,181 Btuh	70	CFM	
Blow-thru fan sensible gain:	0 Btuh			
Total sensible gain on return side of coil:				1,181 Btuh
Total sensible gain on air handling system:				14,902 Btuh
Zone space latent gain:	660 Btuh			
Infiltration latent gain:	0 Btuh			
Outside air latent gain:	1,780 Btuh			
Total latent gain on air handling system:				2,440 Btuh
Total system sensible and latent gain:				17,343 Btuh

Check Figures

Total Air Handler Supply Air (based on a 20° TD):	650	CFM
Total Air Handler Vent. Air (10.76% of Supply):	70	CFM
Total Conditioned Air Space:	647	Sq.ft
Supply Air Per Unit Area:	1.0060	CFM/Sq.ft
Area Per Cooling Capacity:	447.3372	Sq.ft/Ton
Cooling Capacity Per Area:	0.0022	Tons/Sq.ft
Total Heating Required With Outside Air:	16,955	Btuh
Total Cooling Required With Outside Air:	1.45	Tons

Air System #1 (TWU-1) Psychrometric Analysis

System Load Analysis	Latent	Grains	Sensible	Temp	CFM
Leaving Coil Condition		57.235		52.079	
Draw-Thru Fan			0	0.000	0
Misc Load on Supply Side			0	0.000	0
Supply Air Duct			0	0.000	0
Zone Loads	880	1.232	16,214	14.035	772
Sensible Reserve			6,799	5.885	324
Zone Condition	880	58.467	23,013	72.000	1,096
Return Air Duct			0	0.000	
Return Air Plenum			0	0.000	
Misc Load on Return Side			0	0.000	
Vent Air 70 CFM	1,780	2.493	1,181	1.022	
Blow-Thru Fan			0	0.000	
Entering Coil Condition	2,660	60.960	24,194	73.022	1,096

General Psychrometric Equations Used In Analysis:

PR = (Barometric pressure of site / Standard ASHRAE pressure of 29.921)
TSH = PR x 1.10 x CFM x (DB entering - DB leaving)
TLH = PR x 0.68 x CFM x (Grains entering - Grains leaving)
GTH = PR x 4.50 x CFM x (Enthalpy entering - Enthalpy leaving)

TSH	=	0.958	x	1.10	x	1,096	x (	73.022	-	52.079	) =	24,194	Btuh
TLH	=	0.958	x	0.68	x	1,096	x (	60.960	-	57.235	) =	2,660	Btuh
												----------	
SUM	=											26,854	Btuh
GTH	=	0.958	x	4.50	x	1,096	x (	27.049	-	21.365	) =	26,863	Btuh
Total System Load											=	26,703	Btuh

Chilled and Hot Water Flow Rates and Steam Requirement

Cooling GPM	=	26,863	/ (	0.00	x	500	)	=	0.0	GPM
Heating GPM	=	20,201	/ (	0.00	x	500	)	=	0.0	GPM
Steam Req.	=	20,201	/	970				=	20.8	lb./hr

Entering Cooling Coil Conditions

Dry bulb temperature:	73.02	
Wet bulb temperature:	60.26	
Relative humidity:	48.32	
Enthalpy:	27.05	Btu/lbm

Entering Heating Coil Conditions

Dry bulb temperature: 53.91

Leaving Cooling Coil Conditions

Dry bulb temperature:	52.08	
Wet bulb temperature:	51.28	
Relative humidity:	95.00	
Enthalpy:	21.36	Btu/lbm

Leaving Heating Coil Conditions

Dry bulb temperature: 110.00

Air System #2 (TWU-2) Psychrometric Analysis

System Load Analysis	Latent	Grains	Sensible	Temp	CFM
Leaving Coil Condition		57.235		52.079	
Draw-Thru Fan			0	0.000	0
Misc Load on Supply Side			0	0.000	0
Supply Air Duct			0	0.000	0
Zone Loads	880	1.232	16,284	14.095	775
Sensible Reserve			6,730	5.825	320
Zone Condition	880	58.467	23,013	72.000	1,096
Return Air Duct			0	0.000	
Return Air Plenum			0	0.000	
Misc Load on Return Side			0	0.000	
Vent Air 70 CFM	1,780	2.492	1,181	1.022	
Blow-Thru Fan			0	0.000	
Entering Coil Condition	2,660	60.960	24,194	73.022	1,096

General Psychrometric Equations Used In Analysis:

PR = (Barometric pressure of site / Standard ASHRAE pressure of 29.921)
TSH = PR x 1.10 x CFM x (DB entering - DB leaving)
TLH = PR x 0.68 x CFM x (Grains entering - Grains leaving)
GTH = PR x 4.50 x CFM x (Enthalpy entering - Enthalpy leaving)

TSH	=	0.958	x	1.10	x	1,096	x (	73.022	-	52.079	) =	24,194	Btuh
TLH	=	0.958	x	0.68	x	1,096	x (	60.960	-	57.235	) =	2,660	Btuh
												----------	
SUM	=											26,854	Btuh
GTH	=	0.958	x	4.50	x	1,096	x (	27.049	-	21.365	) =	26,864	Btuh
Total System Load											=	26,704	Btuh

Chilled and Hot Water Flow Rates and Steam Requirement

Cooling GPM	=	26,864	/ (	0.00	x	500	)	=	0.0	GPM
Heating GPM	=	20,201	/ (	0.00	x	500	)	=	0.0	GPM
Steam Req.	=	20,201	/	970				=	20.8	lb./hr

Entering Cooling Coil Conditions			Entering Heating Coil Conditions	
Dry bulb temperature:	73.02		Dry bulb temperature:	53.91
Wet bulb temperature:	60.26			
Relative humidity:	48.32			
Enthalpy:	27.05	Btu/lbm		

Leaving Cooling Coil Conditions			Leaving Heating Coil Conditions	
Dry bulb temperature:	52.08		Dry bulb temperature:	110.00
Wet bulb temperature:	51.28			
Relative humidity:	95.00			
Enthalpy:	21.36	Btu/lbm		

Air System #3 (TWU-3) Psychrometric Analysis

System Load Analysis	Latent	Grains	Sensible	Temp	CFM
Leaving Coil Condition		56.911		51.927	
Draw-Thru Fan			0	0.000	0
Misc Load on Supply Side			0	0.000	0
Supply Air Duct			0	0.000	0
Zone Loads	660	1.557	10,083	14.707	477
Sensible Reserve			3,679	5.366	174
Zone Condition	660	58.468	13,761	72.000	650
Return Air Duct			0	0.000	
Return Air Plenum			0	0.000	
Misc Load on Return Side			0	0.000	
Vent Air 70 CFM	1,780	4.200	1,181	1.722	
Blow-Thru Fan			0	0.000	
Entering Coil Condition	2,440	62.668	14,942	73.722	650

General Psychrometric Equations Used In Analysis:

PR = (Barometric pressure of site / Standard ASHRAE pressure of 29.921)
TSH = PR x 1.10 x CFM x (DB entering - DB leaving)
TLH = PR x 0.68 x CFM x (Grains entering - Grains leaving)
GTH = PR x 4.50 x CFM x (Enthalpy entering - Enthalpy leaving)

TSH	=	0.958	x	1.10	x	650	x (	73.722	-	51.927	) =	14,942 Btuh
TLH	=	0.958	x	0.68	x	650	x (	62.668	-	56.911	) =	2,440 Btuh

SUM	=											17,382 Btuh
GTH	=	0.958	x	4.50	x	650	x (	27.487	-	21.278	) =	17,414 Btuh
Total System Load											=	17,343 Btuh

Chilled and Hot Water Flow Rates and Steam Requirement

Cooling GPM	=	17,414	/ (	0.00	x	500	)	=	0.0 GPM
Heating GPM	=	16,955	/ (	0.00	x	500	)	=	0.0 GPM
Steam Req.	=	16,955	/	970				=	17.5 lb./hr

Entering Cooling Coil Conditions

Dry bulb temperature:	73.72
Wet bulb temperature:	60.89
Relative humidity:	48.51
Enthalpy:	27.49 Btu/lbm

Entering Heating Coil Conditions

Dry bulb temperature:	49.23

Leaving Cooling Coil Conditions

Dry bulb temperature:	51.93
Wet bulb temperature:	51.13
Relative humidity:	95.00
Enthalpy:	21.28 Btu/lbm

Leaving Heating Coil Conditions

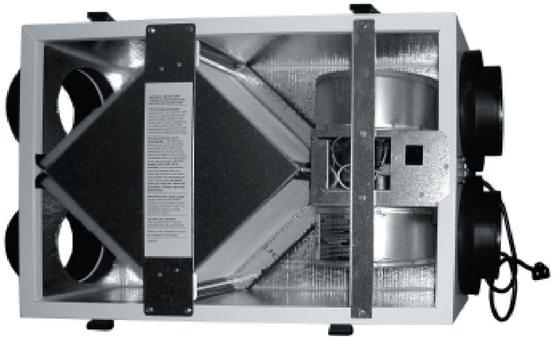
Dry bulb temperature:	110.00

Appendix K

EV70 Specifications

EV70

Indoor Unit



Specifications

Ventilation Type: Static Plate, Heat and Humidity Transfer				
Typical Airflow Range: 40-70 CFM				
Unit may be mounted in any orientation.				
Number Motors: One, 0.1 hp				
V	HZ	Phase	Input Watts	FLA
120	60	Single	94 @ 69 CFM	1.0
Control Voltage: 24 VAC				
Filters: Cleanable, spun polyester media. 7 1/2” x 10 1/2” x 1”				
Weight: 44 lbs (unit), 52 lbs (in carton)				
Shipping Dimensions: 21” W x 29 1/2” L x 15” H				
Options: PT - Percentage timer control PB - Push Button point-of-use controls FM - Percentage timer control with furnace interlock DH24 - Dehumidistat control Wall caps				

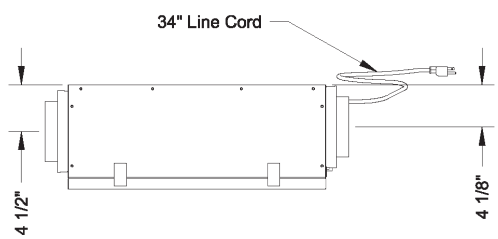
G4 Performance

Airflow CFM	ESP in H20	Temp EFF%	Total EFF% Winter/Summer*
46	0.40	81	74/60
59	0.30	78	71/57
69	0.25	75	69/54
73	0.20	74	68/53
86	0.10	71	64/49

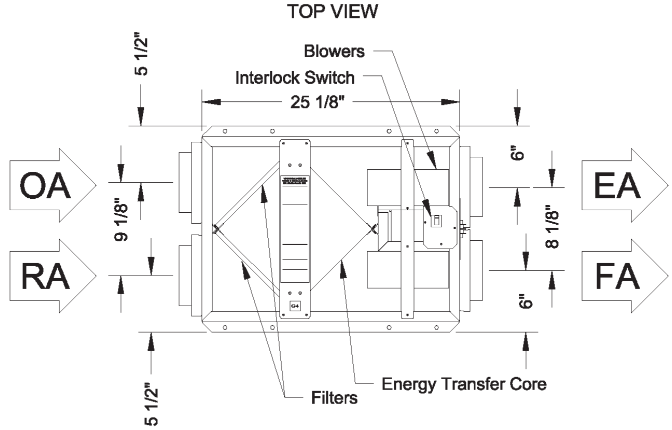
* (See HVI certification report on page 11 for complete certified rating).

Dimensions

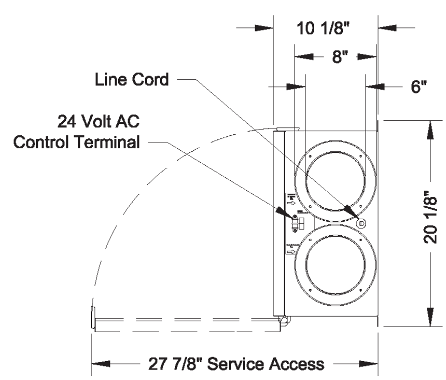
EA: Exhaust Air to outdoors
OA: Outdoor Air intake
RA: Room Air to be exhausted
FA: Fresh Air to inside



TOP VIEW



FRONT VIEW



RIGHT VIEW

SOUND GEOTHERMAL CORPORATION
ENERGY ANALYSIS
Kyle Macht 900 ^ft. Dorm
4/7/2008

Heating Calculations

F= HL x 24 x DD / E x P x T.D.

Tons: 1.5
City: State College, PA

Annual Fuel Consumption	
45,788.62	Gas(cubic feet)
543.11	Propane (gal)
382.61	Fuel Oil (gal)
12,376.21	Electricity (kW)
3,640.06	GSHP (kW)

18,000	HL - Design heating load in BTU
6,160	DD - Degree Days
0.90	E - Seasonal Efficiency Gas
0.85	E - Seasonal Efficiency Propane
0.80	E - Seasonal Efficiency Fuel Oil
1.00	E - Seasonal Efficiency Electricity
3.40	E - Seasonal Efficiency HP (COP)
70	Winter Setpoint (Deg. F)
7	Winter Design Temperature
63	T.D. - Design Temp. difference

P - Heating value of Fuel	
1,025	Gas - BTU/cubic Foot
91,500	Propane - gallon
138,000	Fuel Oil - gallon
3,413	Electricity - BTU/kWh

Annual Cost		Fuel Cost	
$ 434.99	Gas	$ 0.950	Term
$ 1,629.86	Propane	$ 3.001	gal.
$ 1,446.26	Fuel Oil	$ 3.780	gal.
$ 1,113.86	Electricity	$ 0.090	kW
$ 327.61	GSHP		

Cooling Calculations

Cooling kW/year= CLH*QC / 1000*SEER

Tons: 0.75
City: State College, PA

9,000	QC - Design Cooling Load
2,523	CLH - Cooling Degree Days
11.00	SEER - Seasonal Efficiency - AC
17.50	SEER - Seasonal Efficiency of GSHP
y	Heat Pump (y or n)

Cooling kW/year=	2,064
GSHP Cooling $$/yr=	1,298
$$/year=	$ 185.78
GSHP $$/Year=	$ 116.78

TOTAL ESTIMATED BUILDING FUEL COST

HVAC Fuel	Conventional
Electricity	$ 1,300
Propane + Electricity	$ 1,816
Gas + Electricity	$ 621
Fuel oil + Electricity	$ 1,632

Renewaire Size	70	
Effectivness	0.8	
Air Changes/hour	0.33	
Home Sq. Footage	900	Sq. Ft
Ceiling Height	8	Feet

Estimated Energy Savings With RenewAire 163.88

SOUND GEOTHERMAL, INC.

Ground Source Heat Pumps * Commercial / Residential * Forced Air / Radiant *
Process Applications Consulting / Loop Design * Distribution / Dealer Support
IGSHPA Certified Installer Training * Member IGSHPA / GHPC**
Web Site: soundgt.com e-mail: soundgt@soundgt.com
3962 Alpine Valley Circle, Sandy UT 84092 801-942-6100 801-942-6127 (fax)

DEALER QUOTE

Dealer: Kyle Macht

Project Name:
Freight Address:

Loop Type:
Date: 4/8/2008

Product	Qty	Description	Dealer Cost	Dealer Total
EV70	1	RenewAire Energy Recovery Ventilator	$ 567.00	$ 567.00

See Terms & Conditions Page.

Customer is responsible for all taxes!

ESTIMATED FREIGHT: $ 128.80

Total: $ 695.80

Approved by: Kyle Macht

Date

Please note: This order may contain NON STOCK items. We must have your signature verifying accuracy of the above before this order can be placed. See Terms and Conditions Page!

Appendix L

Trane Heat Pumps

High Efficiency Horizontal & Vertical Water Source Comfort System

Axiom™ 1/2 - 5 Tons — 60 Hz Model GEH/GEV

June 2007

WSHP-PRC001-EN

Introduction

Imagine a full range of comfort utilizing efficiency, sound attenuation, integrated controls, and superior maintenance accessibility... Trane imagined it, and designed an advanced mechanical system.

Introducing models GEH and GEV water source comfort solutions.

Model GEH (pictured below) is a ceiling hung product that provides a sleek, innovative shape, along with convertibility of the supply-air and the return-air arrangement; serviceability to maintenance components; indoor air quality standards; sound attenuation; and best of all, higher efficiencies with certified ARI-ISO 13256-1 performance and ASHRAE 90.1 standards.

Trane's new design incorporates system advantages such as:

1. Maximum return-air and supply-air flexibility
2. Superior maintenance accessibility
3. Dual-sloped, plastic drain pan
4. Multi-speed motor
5. Insulated enclosure for quiet unit design
6. Integrated controls
7. Orifice ring motor mounting device as standard for ease of motor service
8. High and low pressure safeties as standard
9. Internal air-to-refrigerant coil (horizontal design)

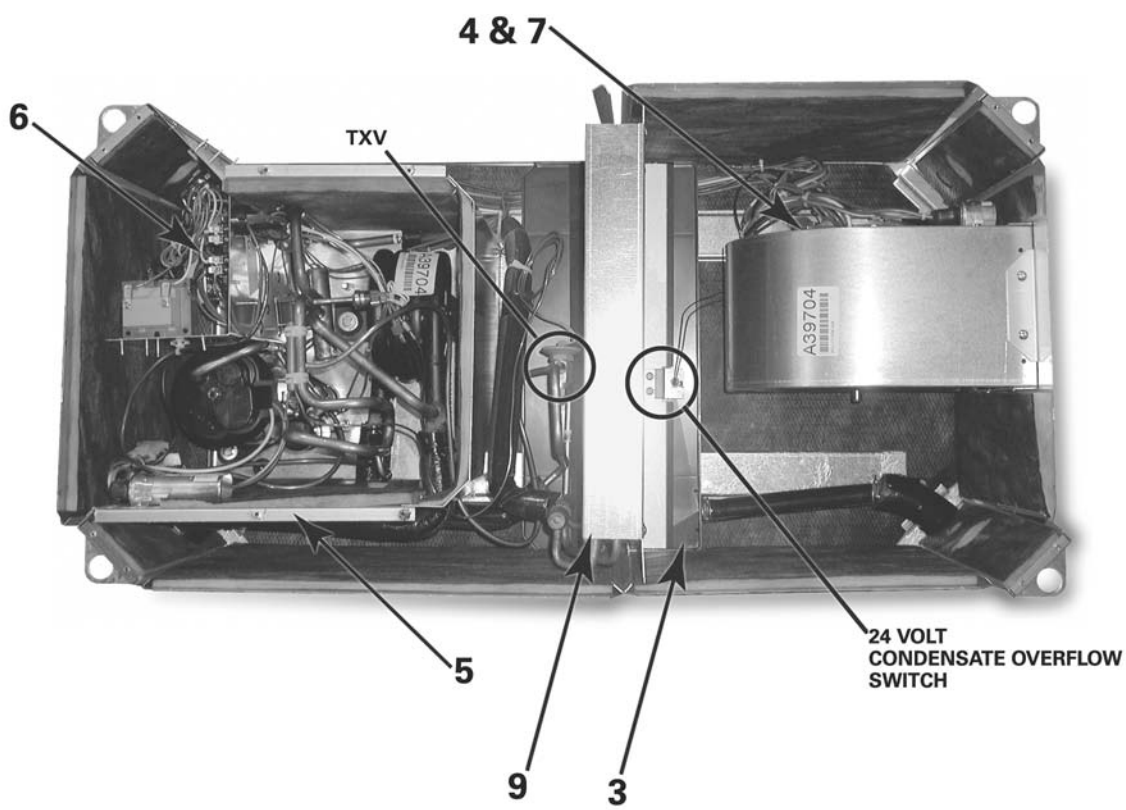


Table 23. GEH/GEV 018 Cooling Performance

EWT	GPM	Total Mbtuh	Sen Mbtuh	SHR	Power kW	Reject Mouth	LWT	Feet Head
45	2.7	23.87	16.44	0.69	1.14	27.77	65.20	3
45	3.3	24.20	16.62	0.69	1.11	27.99	61.70	4.3
45	3.7	24.32	16.67	0.69	1.09	28.04	59.93	5.3
45	4.2	24.47	16.75	0.68	1.08	28.15	58.23	6.6
45	4.4	24.56	16.86	0.69	1.07	28.22	57.64	7.2
45	4.6	24.59	16.80	0.68	1.07	28.22	57.08	7.7
45	5	24.69	16.89	0.68	1.06	28.29	56.12	9
55	2.7	22.87	16.03	0.70	1.26	27.19	74.69	2.9
55	3.3	23.18	16.19	0.70	1.23	27.36	71.25	4.1
55	3.7	23.33	16.24	0.70	1.21	27.45	69.55	5.1
55	4.2	23.47	16.28	0.69	1.19	27.53	67.87	6.3
55	4.4	23.56	16.31	0.69	1.19	27.61	67.31	6.9
55	4.6	23.57	16.35	0.69	1.18	27.59	66.78	7.5
55	5	23.64	16.36	0.69	1.17	27.63	65.86	8.6
68	2.7	21.43	15.44	0.72	1.41	26.23	86.86	2.8
68	3.3	21.73	15.59	0.72	1.37	26.42	83.58	4
68	3.7	21.88	15.65	0.72	1.36	26.52	81.96	4.8
68	4.2	22.03	15.71	0.71	1.34	26.61	80.36	6.1
68	4.4	22.07	15.73	0.71	1.34	26.64	79.80	6.6
68	4.6	22.11	15.74	0.71	1.33	26.66	79.31	7.1
68	5	22.19	15.77	0.71	1.33	26.71	78.42	8.3
77	2.7	20.39	15.02	0.74	1.50	25.51	95.24	2.7
77	3.3	20.67	15.14	0.73	1.47	25.69	92.06	3.8
77	3.7	20.81	15.20	0.73	1.46	25.78	90.49	4.7
77	4.2	20.93	15.24	0.73	1.44	25.86	88.93	5.9
77	4.4	20.99	15.27	0.73	1.44	25.90	88.41	6.4
77	4.6	21.02	15.28	0.73	1.43	25.91	87.92	6.9
77	5	21.10	15.32	0.73	1.43	25.97	87.08	8
86	2.7	19.29	14.56	0.75	1.59	24.73	103.55	2.6
86	3.3	19.55	14.65	0.75	1.57	24.89	100.49	3.7
86	3.7	19.69	14.73	0.75	1.55	24.99	98.99	4.6
86	4.2	19.82	14.79	0.75	1.54	25.08	97.50	5.7
86	4.4	19.87	14.81	0.75	1.54	25.11	96.99	6.2
86	4.6	19.89	14.80	0.74	1.53	25.12	96.52	6.7
86	5	19.97	14.85	0.74	1.53	25.17	95.70	7.8
95	2.7	18.16	14.13	0.78	1.68	23.89	111.83	2.6
95	3.3	18.41	14.22	0.77	1.66	24.06	108.90	3.6
95	3.7	18.54	14.30	0.77	1.64	24.14	107.45	4.5
95	4.2	18.64	14.30	0.77	1.63	24.20	106.01	5.6
95	4.4	18.34	14.15	0.77	1.67	24.03	105.48	6.1
95	4.6	18.73	14.34	0.77	1.62	24.27	105.09	6.6
95	5	18.80	14.37	0.76	1.62	24.32	104.31	7.6
105	2.7	16.86	13.59	0.81	1.77	22.91	120.97	2.5
105	3.3	17.09	13.70	0.80	1.75	23.07	118.19	3.5
105	3.7	17.16	13.69	0.80	1.74	23.11	116.79	4.3
105	4.2	17.32	13.80	0.80	1.73	23.23	115.46	5.4
105	4.4	17.35	13.81	0.80	1.73	23.25	115.00	5.9
105	4.6	17.39	13.82	0.79	1.73	23.28	114.58	6.4
105	5	17.47	13.87	0.79	1.72	23.34	113.84	7.4
115	2.7	15.52	13.07	0.84	1.86	21.87	130.06	2.4
115	3.3	15.69	13.13	0.84	1.84	21.97	127.41	3.5
115	3.7	15.84	13.22	0.83	1.83	22.10	126.15	4.2
115	4.2	15.94	13.26	0.83	1.83	22.18	124.87	5.3
115	4.4	15.94	13.22	0.83	1.82	22.16	124.41	5.7
115	4.6	15.99	13.27	0.83	1.82	22.19	124.02	6.2

Table 23. GEH/GEV 018 Cooling Performance (continued)

115	5	16.03	13.27	0.83	1.81	22.22	123.31	7.2
120	2.7	14.83	12.79	0.86	1.90	21.31	134.57	2.4
120	3.3	15.05	12.88	0.86	1.88	21.47	132.05	3.4
120	3.7	15.11	12.89	0.85	1.87	21.51	130.77	4.2
120	4.2	15.23	12.96	0.85	1.87	21.61	129.55	5.2
120	4.4	15.25	12.94	0.85	1.86	21.61	129.12	5.7
120	4.6	15.28	12.98	0.85	1.86	21.63	128.74	6.1
120	5	15.33	12.99	0.85	1.86	21.67	128.05	7.1

Cooling performance data is tabulated at 80.6 F DB/66.2 F WB entering air at ARI/ISO 13256-1 rated CFM. For ARI/ISO 13256-1 certified ratings, see Table 10. See Performance correction tables to correct performance at conditions other than those tabulated. Data shown is for unit performance only. Interpolation is permissible. Extrapolation is not.
Rated GPM: 4.2 Maximum CFM 684; Rated CFM 570; Maximum CFM 456

Table 24. GEH/GEV 018 Heating Performance

EWT	GPM	Htg. Cap. Mbtuh	Absorb Mbtuh	Power kW	LWT	Feet Head
25	2.7	10.92	6.97	1.16	18.57	4.3
25	3.3	11.21	7.22	1.17	19.58	6.2
25	3.7	11.36	7.35	1.17	20.09	7.5
25	4.2	11.50	7.48	1.18	20.62	9.4
25	4.4	11.54	7.51	1.18	20.80	10.2
25	4.6	11.61	7.57	1.18	20.95	11.0
25	5.0	11.69	7.63	1.19	21.25	12.7
32	2.7	12.71	8.51	1.23	24.62	4.0
32	3.3	13.07	8.82	1.25	25.77	5.7
32	3.7	13.26	8.98	1.25	26.31	6.8
32	4.2	13.45	9.17	1.25	26.95	8.6
32	4.4	13.51	9.21	1.26	27.14	9.2
32	4.6	13.46	9.17	1.26	27.23	10.6
32	5.0	13.56	9.26	1.26	27.57	12.3
45	2.7	16.10	11.46	1.36	35.70	3.4
45	3.3	16.56	11.86	1.38	37.15	4.8
45	3.7	16.82	12.09	1.39	37.87	5.9
45	4.2	17.07	12.31	1.40	38.61	7.3
45	4.4	17.14	12.38	1.40	38.87	7.9
45	4.6	17.21	12.43	1.40	39.12	8.6
45	5.0	17.34	12.55	1.40	39.54	9.9
55	2.7	18.74	13.78	1.46	43.95	3.3
55	3.3	19.29	14.25	1.48	45.67	4.6
55	3.7	19.57	14.50	1.49	46.54	5.6
55	4.2	19.86	14.75	1.50	47.42	7.0
55	4.4	19.99	14.87	1.50	47.71	7.6
55	4.6	20.08	14.95	1.50	47.99	8.2
55	5.0	20.25	15.10	1.51	48.49	9.5
68	2.7	22.19	16.81	1.58	54.61	3.1
68	3.3	22.89	17.43	1.60	56.65	4.4
68	3.7	23.25	17.75	1.61	57.70	5.4
68	4.2	23.59	18.04	1.63	58.78	6.7
68	4.4	23.71	18.14	1.63	59.15	7.3
68	4.6	23.82	18.24	1.64	59.49	7.9
68	5.0	24.01	18.41	1.64	60.10	9.1
75	2.7	24.11	18.50	1.65	60.28	3.1
75	3.3	24.84	19.14	1.67	62.55	4.3
75	3.7	25.17	19.43	1.68	63.73	5.3
75	4.2	25.55	19.77	1.69	64.90	6.6
75	4.4	25.66	19.87	1.70	65.31	7.1
75	4.6	25.80	20.00	1.70	65.68	7.7

Table 24. GEH/GEV 018 Heating Performance (continued)

75	5.0	25.99	20.16	1.71	66.35	8.9
86	2.7	27.02	21.08	1.74	69.24	2.9
86	3.3	27.80	21.77	1.77	71.84	4.2
86	3.7	28.22	22.14	1.78	73.16	5.1
86	4.2	28.59	22.48	1.79	74.52	6.3
86	4.4	28.73	22.60	1.80	74.98	6.9
86	4.6	28.77	22.65	1.80	75.44	7.4
86	5.0	28.83	22.71	1.80	76.26	8.6

Heating performance data is tabulated at 68 F DB entering air at ARI/ISO 13256-1 rated CFM. For ARI/ISO 13256-1 certified ratings, see Table 10. See Performance correction tables to correct performance at conditions other than those tabulated. Data shown is for unit performance only. Interpolation is permissible. Extrapolation is not.
Rated GPM: 4.2 Maximum CFM 684; Rated CFM 570; Minimum CFM 456

Table 25. 018 Fan Correction Factors

Entering CFM	Cooling Capacity	Sensible Capacity	Cooling Input Watts	Heating Capacity	Heating Input Watts
456	0.952	0.887	0.992	0.960	1.046
485	0.966	0.918	0.994	0.972	1.033
513	0.978	0.945	0.996	0.982	1.020
542	0.990	0.973	0.998	0.992	1.011
570	1.000	1.000	1.000	1.000	1.000
627	1.021	1.059	1.003	1.015	0.981
656	1.029	1.086	1.005	1.023	0.973
684	1.038	1.115	1.006	1.029	0.965

Table 26. GEH/GEV 024 Cooling Performance

EWT	GPM	Total Mbtuh	Sen Mbtuh	SHR	Power kW	EER	Reject Mbtuh	LWT	Feet Head
45	3.6	30.4	21.8	0.72	1.69	18.0	36.2	65.1	4.7
45	4.4	30.7	21.7	0.71	1.65	18.6	36.3	61.5	6.4
45	5.0	30.9	21.8	0.71	1.62	19.1	36.4	59.6	7.9
45	5.5	31.0	21.7	0.70	1.61	19.3	36.5	58.3	9.1
45	5.8	31.0	21.7	0.70	1.60	19.4	36.5	57.6	9.9
45	6.1	31.1	21.7	0.70	1.59	19.6	36.5	57.0	10.7
45	6.6	31.2	21.6	0.69	1.58	19.7	36.6	56.1	12.0
55	3.6	29.6	20.8	0.70	1.79	16.5	35.7	74.8	4.5
55	4.4	29.9	20.8	0.70	1.74	17.2	35.8	71.3	6.1
55	5.0	30.0	20.9	0.70	1.72	17.4	35.9	69.4	7.4
55	5.5	30.1	21.0	0.70	1.70	17.7	35.9	68.1	8.6
55	5.8	30.2	21.0	0.70	1.69	17.9	36.0	67.4	9.3
55	6.1	30.2	21.0	0.70	1.68	18.0	35.9	66.8	10.1
55	6.6	30.3	21.0	0.69	1.67	18.1	36.0	65.9	11.3
68	3.6	27.5	20.0	0.73	1.97	14.0	34.2	87.0	4.1
68	4.4	27.8	20.0	0.72	1.92	14.5	34.4	83.6	5.6
68	5.0	28.0	20.1	0.72	1.89	14.8	34.5	81.8	6.8
68	5.5	28.1	20.2	0.72	1.88	14.9	34.5	80.6	7.9
68	5.8	28.1	20.2	0.72	1.87	15.0	34.5	79.9	8.6
68	6.1	28.2	20.3	0.72	1.86	15.2	34.6	79.3	9.3
68	6.6	28.3	20.3	0.72	1.85	15.3	34.6	78.5	10.5
77	3.6	26.2	19.4	0.74	2.11	12.4	33.4	95.6	3.8
77	4.4	26.5	19.4	0.73	2.07	12.8	33.6	92.3	5.3
77	5.0	26.7	19.5	0.73	2.04	13.1	33.7	90.5	6.4
77	5.5	26.8	19.6	0.73	2.02	13.3	33.7	89.3	7.5
77	5.8	26.8	19.7	0.74	2.02	13.3	33.7	88.6	8.1
77	6.1	26.9	19.7	0.73	2.01	13.4	33.8	88.1	8.8
77	6.6	27.0	19.7	0.73	1.99	13.6	33.8	87.3	10.0
86	3.6	24.6	18.8	0.76	2.26	10.9	32.3	104.0	3.6
86	4.4	24.9	18.8	0.76	2.22	11.2	32.5	100.8	4.9
86	5.0	25.1	18.9	0.75	2.20	11.4	32.6	99.1	6.1
86	5.5	25.2	19.0	0.75	2.18	11.6	32.6	97.9	7.1
86	5.8	25.2	19.0	0.75	2.17	11.6	32.6	97.3	7.7
86	6.1	25.3	19.1	0.75	2.17	11.7	32.7	96.8	8.3
86	6.6	25.3	19.1	0.75	2.15	11.8	32.6	95.9	9.5
95	3.6	22.8	18.2	0.80	2.41	9.5	31.0	112.3	3.3
95	4.4	23.1	18.1	0.78	2.38	9.7	31.2	109.3	4.6
95	5.0	23.2	18.2	0.78	2.36	9.8	31.3	107.6	5.7
95	5.5	23.3	18.3	0.79	2.34	10.0	31.3	106.4	6.7
95	5.8	23.4	18.4	0.79	2.33	10.0	31.4	105.9	7.3
95	6.1	23.4	18.4	0.79	2.32	10.1	31.3	105.3	7.9
95	6.6	23.5	18.4	0.78	2.31	10.2	31.4	104.6	9.0
105	3.6	20.7	17.5	0.85	2.57	8.1	29.5	121.5	3.1
105	4.4	21.0	17.4	0.83	2.54	8.3	29.7	118.6	4.4
105	5.0	21.2	17.5	0.83	2.52	8.4	29.8	117.0	5.4
105	5.5	21.3	17.6	0.83	2.50	8.5	29.8	115.9	6.4
105	5.8	21.3	17.7	0.83	2.50	8.5	29.8	115.4	6.9
105	6.1	21.4	17.7	0.83	2.49	8.6	29.9	114.9	7.6
105	6.6	21.4	17.7	0.83	2.48	8.6	29.9	114.1	8.6
115	3.6	18.8	16.9	0.90	2.70	7.0	28.0	130.7	2.9
115	4.4	19.1	16.7	0.87	2.67	7.2	28.2	128.0	4.2
115	5.0	19.2	16.9	0.88	2.66	7.2	28.3	126.4	5.2
115	5.5	19.3	16.9	0.88	2.64	7.3	28.3	125.4	6.1
115	5.8	19.4	17.0	0.88	2.64	7.3	28.4	124.9	6.7

Table 26. GEH/GEV 024 Cooling Performance (continued)

115	6.1	19.4	17.0	0.88	2.63	7.4	28.4	124.4	7.3
115	6.6	19.5	17.1	0.88	2.62	7.4	28.4	123.7	8.3
120	3.6	17.9	16.5	0.92	2.74	6.5	27.3	135.3	2.9
120	4.4	18.2	16.4	0.90	2.73	6.7	27.5	132.7	4.1
120	5.0	18.4	16.5	0.90	2.71	6.8	27.7	131.2	5.1
120	5.5	18.5	16.6	0.90	2.70	6.9	27.7	130.2	6.0
120	5.8	18.5	16.7	0.90	2.70	6.9	27.7	129.7	6.6
120	6.1	18.6	16.7	0.90	2.69	6.9	27.8	129.2	7.2
120	6.6	18.6	16.7	0.90	2.68	6.9	27.8	128.5	8.2

Cooling performance data is tabulated at 80.6 F DB/66.2 F entering air at ARI/ISO 13256-1 rated CFM. For ARI/ISO 13256-1 certified ratings, see Table 10. See Performance correction tables to correct performance at conditions other than those tabulated. Data shown is for unit performance only. Interpolation is permissible. Extrapolation is not. Rated GPM: 5.5 Maximum CFM 608; Rated CFM 760; Maximum CFM 912

Table 27. GEH/GEV 024 Heating Performance

EWT	GPM	Htg Cap Mbtuh	Absorb Mbtuh	Power kW	COP	LWT	Feet Head
25	3.6	16.1	10.7	1.59	3.0	19.1	5.0
25	4.4	16.5	11.0	1.61	3.0	20.0	7.0
25	5.0	16.8	11.3	1.62	3.0	20.5	8.7
25	5.5	17.0	11.4	1.63	3.1	20.8	10.1
25	5.8	17.1	11.5	1.63	3.1	21.0	10.9
25	6.1	17.2	11.6	1.64	3.1	21.2	11.8
25	6.6	17.4	11.8	1.64	3.1	21.4	13.3
32	3.6	18.5	12.7	1.70	3.2	24.9	4.9
32	4.4	19.0	13.1	1.72	3.2	26.0	6.9
32	5.0	19.2	13.3	1.73	3.3	26.7	8.4
32	5.5	19.4	13.5	1.74	3.3	27.1	9.7
32	5.8	19.5	13.6	1.74	3.3	27.3	10.6
32	6.1	19.6	13.6	1.75	3.3	27.5	11.4
32	6.6	19.8	13.8	1.75	3.3	27.8	12.9
45	3.6	22.8	16.5	1.85	3.6	35.8	4.7
45	4.4	23.4	17.0	1.87	3.7	37.3	6.4
45	5.0	23.6	17.2	1.88	3.7	38.1	7.9
45	5.5	23.8	17.4	1.89	3.7	38.7	9.1
45	5.8	23.9	17.5	1.89	3.7	39.0	9.9
45	6.1	24.0	17.5	1.90	3.7	39.3	10.7
45	6.6	24.2	17.7	1.90	3.7	39.6	12.0
55	3.6	26.1	19.3	1.98	3.9	44.3	4.5
55	4.4	26.7	19.9	2.00	3.9	46.0	6.1
55	5.0	27.0	20.1	2.01	3.9	46.9	7.4
55	5.5	27.2	20.3	2.02	3.9	47.6	8.6
55	5.8	27.3	20.4	2.03	3.9	48.0	9.3
55	6.1	27.4	20.5	2.03	4.0	48.3	10.1
55	6.6	27.5	20.5	2.04	3.9	48.8	11.3
68	3.6	29.9	22.6	2.14	4.1	55.4	4.1
68	4.4	30.5	23.1	2.16	4.1	57.5	5.6
68	5.0	30.8	23.4	2.17	4.2	58.6	6.8
68	5.5	31.0	23.6	2.18	4.2	59.4	7.9
68	5.8	31.1	23.7	2.18	4.2	59.8	8.6
68	6.1	31.2	23.7	2.19	4.2	60.2	9.3
68	6.6	31.4	23.9	2.19	4.2	60.7	10.5
75	3.6	31.7	24.2	2.19	4.2	61.5	3.9
75	4.4	32.3	24.8	2.21	4.3	63.7	5.3
75	5.0	32.6	25.0	2.22	4.3	65.0	6.5
75	5.5	32.8	25.2	2.23	4.3	65.8	7.6
75	5.8	32.9	25.3	2.24	4.3	66.3	8.2
75	6.1	33.0	25.4	2.24	4.3	66.7	8.9

Table 27. GEH/GEV 024 Heating Performance (continued)

75	6.6	33.2	25.5	2.25	4.3	67.2	10.1
86	3.6	34.1	26.3	2.29	4.4	71.3	3.6
86	4.4	34.8	26.9	2.31	4.4	73.7	4.9
86	5.0	35.1	27.2	2.32	4.4	75.1	6.1
86	5.5	35.3	27.4	2.33	4.4	76.0	7.1
86	5.8	35.4	27.4	2.34	4.4	76.5	7.7
86	6.1	35.5	27.5	2.34	4.4	76.9	8.3
86	6.6	35.6	27.6	2.35	4.4	77.6	9.5

Heating performance data is tabulated at 68 F DBentering air at ARI/ISO 13256-1 rated CFM. For ARI/ISO 13256-1 certified ratings, see Table 10. See Performance correction tables to correct performance at conditions other than those tabulated. Data shown is for unit performance only. Interpolation is permissible. Extrapolation is not. Rated GPM: 5.5 Maximum CFM 608; Rated CFM 760; Maximum CFM 912

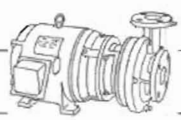
Table 28. 024 Fan Correction Factors

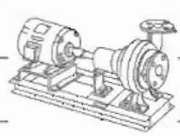
Entering CFM	Cooling Capacity	Sensible Capacity	Cooling Input Watts	Heating Capacity	Heating Input Watts
608	0.974	0.892	0.965	0.972	1.032
646	0.980	0.919	0.973	0.979	1.024
684	0.987	0.945	0.981	0.986	1.016
722	0.993	0.972	0.990	0.993	1.008
760	1.000	1.000	1.000	1.000	1.000
836	1.012	1.051	1.020	1.013	0.984
874	1.019	1.078	1.030	1.020	0.976
912	1.025	1.105	1.042	1.027	0.968

Appendix M

RS Means Mechanical Data

		CREW	OUTPUT	HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	INCL O&P	
1260	1/3 HP	Q-1	4	4	Ea.	1,475	154		1,629	1,875	200
1300	1/2 HP		4	4		1,500	154		1,654	1,900	
1340	3/4 HP		4	4		1,650	154		1,804	2,050	
1380	1 HP		4	4		2,650	154		2,804	3,150	
2000	Cast iron, flange connection										
2040	3/4" to 1-1/2" size, in line, 1/12 HP	Q-1	6	2.667	Ea.	239	102		341	420	
2060	1/8 HP		6	2.667		400	102		502	600	
2100	1/3 HP		6	2.667		445	102		547	650	
2140	2" size, 1/6 HP		5	3.200		490	123		613	725	
2180	2-1/2" size, 1/4 HP		5	3.200		625	123		748	880	
2220	3" size, 1/4 HP		4	4		640	154		794	940	
2260	1/3 HP		4	4		860	154		1,014	1,175	
2300	1/2 HP		4	4		895	154		1,049	1,225	
2340	3/4 HP		4	4		1,025	154		1,179	1,375	
2380	1 HP		4	4		1,500	154		1,654	1,900	
2600	For non-ferrous impeller, add					3%					
3000	High head, bronze impeller										
3030	1-1/2" size 1/2 HP	Q-1	5	3.200	Ea.	740	123		863	1,000	
3040	1-1/2" size 3/4 HP		5	3.200		790	123		913	1,050	
3050	2" size 1 HP		4	4		950	154		1,104	1,300	
3090	2" size 1-1/2 HP		4	4		1,100	154		1,254	1,475	
4000	Close coupled, end suction, bronze impeller										
4040	1-1/2" size, 1-1/2 HP, to 40 GPM	Q-1	3	5.333	Ea.	1,400	205		1,605	1,850	
4090	2" size, 2 HP, to 50 GPM		3	5.333		1,650	205		1,855	2,125	
4100	2" size, 3 HP, to 90 GPM		2.30	6.957		1,725	267		1,992	2,300	
4190	2-1/2" size, 3 HP, to 150 GPM		2	8		1,850	305		2,155	2,525	
4300	3" size, 5 HP, to 225 GPM		1.80	8.889		2,125	340		2,465	2,850	
4410	3" size, 10 HP, to 350 GPM		1.60	10		2,850	385		3,235	3,725	
4420	4" size, 7-1/2 HP, to 350 GPM		1.60	10		2,775	385		3,160	3,650	
4520	4" size, 10 HP, to 600 GPM	Q-2	1.70	14.118		3,150	565		3,715	4,350	
4530	5" size, 15 HP, to 1000 GPM		1.70	14.118		3,175	565		3,740	4,375	
4610	5" size, 20 HP, to 1350 GPM		1.50	16		3,375	640		4,015	4,700	
4620	5" size, 25 HP, to 1550 GPM		1.50	16		4,600	640		5,240	6,050	
5000	Base mounted, bronze impeller, coupling guard										
5040	1-1/2" size, 1-1/2 HP, to 40 GPM	Q-1	2.30	6.957	Ea.	2,650	267		2,917	3,350	
5090	2" size, 2 HP, to 50 GPM		2.30	6.957		2,900	267		3,167	3,625	
5100	2" size, 3 HP, to 90 GPM		2	8		2,925	305		3,230	3,700	
5190	2-1/2" size, 3 HP, to 150 GPM		1.80	8.889		3,150	340		3,490	4,000	
5300	3" size, 5 HP, to 225 GPM		1.60	10		2,825	385		3,210	3,725	
5410	4" size, 5 HP, to 350 GPM		1.50	10.667		2,900	410		3,310	3,825	
5420	4" size, 7-1/2 HP, to 350 GPM		1.50	10.667		3,025	410		3,435	3,950	
5520	5" size, 10 HP, to 600 GPM	Q-2	1.60	15		3,650	600		4,250	4,950	
5530	5" size, 15 HP, to 1000 GPM		1.60	15		3,800	600		4,400	5,100	
5610	6" size, 20 HP, to 1350 GPM		1.40	17.143		4,925	685		5,610	6,450	
5620	6" size, 25 HP, to 1550 GPM		1.40	17.143		5,050	685		5,735	6,600	
9000	Minimum labor/equipment charge	Q-1	3.25	4.923	Job		189		189	294	
0010	**PUMPS, CONDENSATE RETURN SYSTEM**										300
0200	Simplex, 3/4 H.P. mtr, float switch, controls, 10 Gal. C.I. rcvr, 6-15GPM	Q-1	1	16	Ea.	1,850	615		2,465	2,975	
1000	Duplex, 2 pumps, 3/4 H.P. motors, float switch,										
1060	alternator asssembly, 15 Gal. C.I. receiver	Q-1	.50	32	Ea.	5,050	1,225		6,275	7,450	
4400	Refrigerant										
4420	Refrigerant, R-22, 50 lb. disposable cylinder				Lb.	2.54			2.54	2.79	
4440	Refrigerant, R-507, 25 lb. disposable cylinder				"	11.50			11.50	12.65	
0010	**STEAM CONDENSATE METER**										800
0100	500 lb. per hour	1 Stpi	14	.571	Ea.	2,300	24.50		2,324.50	2,575	

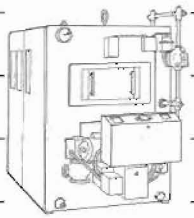




15107 | Metal Pipe & Fittings

			Crew	Daily Output	Labor-Hours	Unit	2006 Bare Costs Mat.	Labor	Equip.	Total	Total Incl O&P
560	4496	6" x 6" x 4"	Q-1	5	3.200	Ea.	244	123		367	460
	4500	Tee/wye, long turn									
	4520	1-1/2"	1 Plum	10	.800	Ea.	28.50	34		62.50	84
	4530	2"	Q-1	17	.941		35.50	36		71.50	95
	4550	3"		11	1.455		60.50	56		116.50	154
	4570	4"		9	1.778		85	68.50		153.50	200
	4650	Wye 45°, 1-1/2"	1 Plum	10	.800		21.50	34		55.50	77
	4652	2"	Q-1	17	.941		31	36		67	90
	4653	3"		11	1.455		53.50	56		109.50	146
	4654	4"		9	1.778		78.50	68.50		147	192
	4656	6"		5	3.200		200	123		323	410
	9000	Minimum labor/equipment charge	1 Plum	4	2	Job		85.50		85.50	133
620	0010	**PIPE, STEEL** R221113-50									
	0020	All pipe sizes are to Spec. A-53 unless noted otherwise									
	0030	Schedule 10, see 15107-690-0500									
	0050	Schedule 40, threaded, with couplings, and clevis type									
	0060	hangers sized for covering, 10' O.C.									
	0540	Black, 1/4" diameter	1 Plum	66	.121	L.F.	2.04	5.20		7.24	10.30
	0550	3/8" diameter		65	.123		2.03	5.25		7.28	10.40
	0560	1/2" diameter		63	.127		2.05	5.40		7.45	10.70
	0570	3/4" diameter		61	.131		2.40	5.60		8	11.35
	0580	1" diameter		53	.151		3.47	6.45		9.92	13.80
	0590	1-1/4" diameter	Q-1	89	.180		4.56	6.90		11.46	15.75
	0600	1-1/2" diameter 		80	.200		5.35	7.70		13.05	17.85
	0610	2" diameter		64	.250		7.10	9.60		16.70	23
	0620	2-1/2" diameter		50	.320		11	12.30		23.30	31
	0630	3" diameter		43	.372		14.30	14.30		28.60	37.50
	0640	3-1/2" diameter		40	.400		19.35	15.35		34.70	45.50
	0650	4" diameter		36	.444		21	17.10		38.10	49.50
	0660	5" diameter		26	.615		31.50	23.50		55	71.50
	0670	6" diameter	Q-2	31	.774		46	31		77	99
	0680	8" diameter		27	.889		71	35.50		106.50	133
	0690	10" diameter		23	1.043		99.50	41.50		141	174
	0700	12" diameter		18	1.333		110	53		163	205
	0809	A-106, gr. A/B, seamless w/cplgs. & hangers									
	0811	1/4" diameter	1 Plum	66	.121	L.F.	6.65	5.20		11.85	15.40
	0812	3/8" diameter		65	.123		6.10	5.25		11.35	14.90
	0813	1/2" diameter		63	.127		3.89	5.40		9.29	12.75
	0814	3/4" diameter		61	.131		5.40	5.60		11	14.60
	0815	1" diameter		53	.151		6.65	6.45		13.10	17.30
	0816	1-1/4" diameter	Q-1	89	.180		8.40	6.90		15.30	20
	0817	1-1/2" diameter		80	.200		10.20	7.70		17.90	23
	0819	A-53, 2" diameter		64	.250		11.50	9.60		21.10	27.50
	0821	2-1/2" diameter		50	.320		14.25	12.30		26.55	35
	0822	3" diameter		43	.372		18.55	14.30		32.85	42.50
	0823	4" diameter		36	.444		28.50	17.10		45.60	58
	1220	To delete coupling & hanger, subtract									
	1230	1/4" diam. to 3/4" diam.					31%	56%			
	1240	1" diam. to 1-1/2" diam.					23%	51%			
	1250	2" diam. to 4" diam.					23%	41%			
	1260	5" diam. to 12" diam.					21%	45%			
	1280	All pipe sizes are to Spec. A-53 unless noted otherwise									
	1281	Schedule 40, threaded, with couplings and clevis type									
	1282	hangers sized for covering, 10' O. C.									
	1290	Galvanized, 1/4" diameter	1 Plum	66	.121	L.F.	2.42	5.20		7.62	10.70
	1300	3/8" diameter		65	.123		2.68	5.25		7.93	11.10

	15510 | Heating Boilers and Accessories	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2006 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
400 3040	122 MBH (R235000-50)	Q-7	1.10	29.091	Ea.	1,850	1,200		3,050	3,875
3060	163 MBH		1	32		2,225	1,325		3,550	4,500
3080	203 MBH		1	32		2,475	1,325		3,800	4,750
3100	240 MBH		.95	33.684		2,600	1,375		3,975	5,000
3120	280 MBH		.90	35.556		2,650	1,450		4,100	5,175
3140	320 MBH		.80	40		3,050	1,650		4,700	5,900
3160	360 MBH		.71	45.070		3,475	1,850		5,325	6,700
3180	400 MBH		.64	50		3,700	2,050		5,750	7,275
3200	440 MBH		.58	54.983		3,975	2,250		6,225	7,875
3220	544 MBH		.51	62.992		6,825	2,575		9,400	11,600
3240	765 MBH		.46	70.022		8,275	2,875		11,150	13,600
3260	1,088 MBH		.40	80		10,300	3,275		13,575	16,400
3280	1,275 MBH		.36	89.888		11,800	3,700		15,500	18,700
3300	1,530 MBH		.31	104		12,400	4,300		16,700	20,300
3320	2,000 MBH		.26	125		13,400	5,125		18,525	22,800
3340	2,312 MBH		.22	148		15,500	6,075		21,575	26,600
3360	2,856 MBH		.20	160		18,300	6,575		24,875	30,300
3380	3,264 MBH		.18	179		19,400	7,375		26,775	32,800
3400	3,808 MBH		.16	195		21,400	8,000		29,400	35,900
3420	4,488 MBH		.15	210		23,800	8,650		32,450	39,500
3440	4,720 MBH		.15	220		54,000	9,050		63,050	73,500
3460	5,520 MBH		.14	228		61,000	9,375		70,375	81,500
3480	6,100 MBH		.13	250		61,500	10,300		71,800	83,500
3500	6,390 MBH		.11	285		63,000	11,700		74,700	87,000
3520	6,680 MBH		.10	310		66,500	12,700		79,200	93,000
3540	6,970 MBH		.09	359		69,000	14,800		83,800	99,000
7000	For tankless water heater, add					10%				
7050	For additional zone valves up to 312 MBH add					124			124	136
7990	Special feature gas fired boilers									
8000	Pulse combustion, standard controls / trim									
8050	88,000 BTU	Q-5	1.40	11.429	Ea.	4,000	445		4,445	5,100
8080	134,000 BTU	"	1.20	13.333	"	4,775	515		5,290	6,075
9900	Minimum labor/equipment charge	Q-6	1	24	Job		965		965	1,500
460 0010	**BOILERS, GAS/OIL** Combination with burners and controls (R235000-50)									
1000	Cast iron with insulated jacket									
2000	Steam, gross output, 720 MBH	Q-7	.43	74.074	Ea.	7,600	3,050		10,650	13,100
2020	810 MBH		.38	83.990		8,125	3,450		11,575	14,300
2040	1,084 MBH		.34	93.023		9,350	3,825		13,175	16,200
2060	1,360 MBH		.33	98.160		11,100	4,025		15,125	18,500
2080	1,600 MBH		.30	107		12,500	4,400		16,900	20,500
2100	2,040 MBH		.25	130		15,300	5,325		20,625	25,200
2120	2,450 MBH		.21	156		16,800	6,400		23,200	28,500
2140	2,700 MBH		.19	165		17,800	6,800		24,600	30,100
2160	3,000 MBH		.18	175		19,200	7,225		26,425	32,300
2180	3,270 MBH		.17	183		20,600	7,550		28,150	34,400
2200	3,770 MBH		.17	191		50,500	7,850		58,350	67,500
2220	4,070 MBH		.16	200		53,000	8,200		61,200	71,500
2240	4,650 MBH		.15	210		56,000	8,650		64,650	75,000
2260	5,230 MBH		.14	223		62,000	9,175		71,175	82,500
2280	5,520 MBH		.14	235		67,500	9,650		77,150	89,000
2300	5,810 MBH		.13	248		68,000	10,200		78,200	91,000
2320	6,100 MBH		.12	260		68,500	10,700		79,200	92,000
2340	6,390 MBH		.11	296		72,000	12,200		84,200	98,500
2360	6,680 MBH		.10	320		76,000	13,100		89,100	104,000
2380	6,970 MBH		.09	372		76,500	15,300		91,800	107,500



15640 | Packaged Cooling Towers		CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2006 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
400	0010 COOLING TOWERS Packaged units R262213-27									
	0070 Galvanized steel									
	0080 Induced draft, crossflow									
	0100 Vertical, belt drive, 61 tons	Q-6	90	.267	TonAC	87	10.70		97.70	112
	0150 100 ton		100	.240		69	9.65		78.65	91
	0200 115 ton		109	.220		67	8.85		75.85	88
	0250 131 ton		120	.200		59.50	8.05		67.55	78
	0260 162 ton		132	.182		50	7.30		57.30	66.50
	1000 For higher capacities, use multiples									
	1500 Induced air, double flow									
	1900 Vertical, gear drive, 167 ton	Q-6	126	.190	TonAC	92.50	7.65		100.15	114
	2000 297 ton		129	.186		66	7.50		73.50	84
	2100 582 ton		132	.182		54.50	7.30		61.80	71.50
	2150 849 ton		142	.169		54	6.80		60.80	70
	2200 1016 ton		150	.160		51.50	6.45		57.95	66.50
	3000 For higher capacities, use multiples									
	3500 For pumps and piping, add	Q-6	38	.632	TonAC	43.50	25.50		69	87.50
	4000 For absorption systems, add				"	75%	75%			
	5000 Fiberglass									
	5010 Draw thru									
	5100 60 ton	Q-6	1.50	16	Ea.	3,275	645		3,920	4,600
	5120 125 ton		.99	24.242		6,700	975		7,675	8,900
	5140 300 ton		.43	55.814		15,700	2,250		17,950	20,800
	5160 600 ton		.22	109		28,200	4,375		32,575	37,800
	5180 1000 ton		.15	160		48,400	6,425		54,825	63,000
	6000 Stainless steel									
	6010 Induced draft, crossflow, horizontal, belt drive									
	6100 57 ton	Q-6	1.50	16	Ea.	8,775	645		9,420	10,700
	6120 91 ton		.99	24.242		12,600	975		13,575	15,400
	6140 111 ton		.43	55.814		14,900	2,250		17,150	19,900
	6160 126 ton		.22	109		16,100	4,375		20,475	24,500
	6170 Induced draft, crossflow, vertical, gear drive									
	6172 167 ton	Q-6	.75	32	Ea.	25,900	1,275		27,175	30,500
	6174 297 ton		.43	55.814		33,300	2,250		35,550	40,100
	6176 582 ton		.23	104		52,500	4,200		56,700	64,000
	6178 849 ton		.17	141		84,000	5,675		89,675	101,500
	6180 1016 ton		.15	160		91,500	6,425		97,925	111,000
	9000 Minimum labor/equipment charge		1	24	Job		965		965	1,500
15660 | Liquid Coolers/Evap Condensers										
100	0010 CONDENSERS Ratings are for 30° F TD, R-22 R262213-27									
	0080 Air cooled, belt drive, propeller fan									
	0220 45 ton	Q-6	.70	34.286	Ea.	10,200	1,375		11,575	13,400
	0240 50 ton		.69	34.985		10,500	1,400		11,900	13,800
	0260 54 ton		.64	37.795		10,900	1,525		12,425	14,400
	0280 59 ton		.58	41.308		11,700	1,650		13,350	15,500
	0300 65 ton		.53	45.541		12,200	1,825		14,025	16,300
	0320 73 ton		.47	51.173		13,800	2,050		15,850	18,400
	0340 81 ton		.42	56.738		15,700	2,275		17,975	20,800
	0360 86 ton		.40	60.302		16,400	2,425		18,825	21,800
	0380 88 ton		.39	61.697		17,500	2,475		19,975	23,200
	0400 101 ton	Q-7	.45	70.640		20,600	2,900		23,500	27,200
	0500 159 ton		.31	102		30,800	4,225		35,025	40,400
	0600 228 ton		.22	148		44,500	6,075		50,575	58,500
	0700 314 ton		.16	203		66,500	8,375		74,875	86,500
	0800 471 ton		.11	283		80,000	11,600		91,600	106,000

MECHANICAL 15

15730 | Unitary Air Conditioning Equip

Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
0150	2 ton cooling (R262213-27)	Q-5	1.40	11.429	Ea.	1,800	445		2,245	2,675	900
1000	Ceiling mount										
1020	2 ton cooling	Q-5	1.40	11.429	Ea.	1,225	445		1,670	2,050	
1030	3 ton cooling	"	1.20	13.333	"	3,300	515		3,815	4,425	
2000	T-Bar mount										
2010	2 ton cooling	Q-5	1.40	11.429	Ea.	2,450	445		2,895	3,400	
2020	3 ton cooling		1.20	13.333		2,950	515		3,465	4,050	
2030	3-1/2 ton cooling		1.10	14.545		3,550	565		4,115	4,775	
3000	Multizone										
3010	Wall mount										
3020	2 @ 3/4 ton cooling	Q-5	1.80	8.889	Ea.	1,200	345		1,545	1,850	
5000	Cooling / Heating										
5010	Wall mount										
5110	1 ton cooling	Q-5	1.70	9.412	Ea.	890	365		1,255	1,550	
5120	1-1/2 ton cooling	"	1.50	10.667	"	1,425	415		1,840	2,225	
5300	Ceiling mount										
5310	3 ton cooling	Q-5	1	16	Ea.	3,825	620		4,445	5,175	
7000	Accessories for all split ductless systems										
7010	Add for ambient frost control	Q-5	8	2	Ea.	120	77.50		197.50	253	
7020	Add for tube / wiring kit										
7030	15' kit	Q-5	32	.500	Ea.	31.50	19.40		50.90	65	
7040	35' kit	"	24	.667	"	102	26		128	152	

15740 | Heat Pumps

Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
0010	**AIR-SOURCE HEAT PUMPS** (Not including interconnecting tubing)										100
1000	Air to air, split system, not including curbs, pads, or ductwork										
1015	1.5 ton cooling, 7 MBH heat @ 0° F (R235000-50)	Q-5	1.22	13.115	Ea.	1,575	510		2,085	2,525	
1020	2 ton cooling, 8.5 MBH heat @ 0° F		1.20	13.333		1,625	515		2,140	2,600	
1030	2.5 ton cooling, 10 MBH heat @ 0° F (R262213-27)		1	16		1,825	620		2,445	2,975	
1040	3 ton cooling, 13 MBH heat @ 0° F		.80	20		1,975	775		2,750	3,375	
1050	3.5 ton cooling, 18 MBH heat @ 0° F		.75	21.333		2,275	825		3,100	3,775	
1054	4 ton cooling, 24 MBH heat @ 0° F		.60	26.667		2,475	1,025		3,500	4,325	
1060	5 ton cooling, 27 MBH heat @ 0° F		.50	32		2,825	1,250		4,075	5,050	
1080	7.5 ton cooling, 33 MBH heat @ 0° F		.30	53.333		6,250	2,075		8,325	10,100	
1100	10 ton cooling, 50 MBH heat @ 0° F	Q-6	.38	63.158		8,375	2,550		10,925	13,200	
1120	15 ton cooling, 64 MBH heat @ 0° F		.26	92.308		11,900	3,700		15,600	18,900	
1130	20 ton cooling, 85 MBH heat @ 0° F		.20	120		15,600	4,825		20,425	24,700	
1140	25 ton cooling, 119 MBH heat @ 0° F		.20	120		18,800	4,825		23,625	28,200	
1300	Supplementary electric heat coil, included										
1500	Single package, not including curbs, pads, or plenums										
1502	1/2 ton cooling, supplementary heat not incl.	Q-5	8	2	Ea.	1,025	77.50		1,102.50	1,250	
1504	3/4 ton cooling, supplementary heat not incl.		6	2.667		1,100	103		1,203	1,350	
1506	1 ton cooling, supplementary heat not incl.		4	4		1,275	155		1,430	1,650	
1510	1.5 ton cooling, 5 MBH heat @ 0° F		1.55	10.323		2,225	400		2,625	3,075	
1520	2 ton cooling, 6.5 MBH heat @ 0° F		1.50	10.667		2,525	415		2,940	3,425	
1540	2.5 ton cooling, 8 MBH heat @ 0° F		1.40	11.429		2,750	445		3,195	3,725	
1560	3 ton cooling, 10 MBH heat @ 0° F		1.20	13.333		3,025	515		3,540	4,125	
1570	3.5 ton cooling, 11 MBH heat @ 0° F		1	16		3,300	620		3,920	4,600	
1580	4 ton cooling, 13 MBH heat @ 0° F		.96	16.667		3,550	645		4,195	4,900	
1620	5 ton cooling, 27 MBH heat @ 0° F		.65	24.615		3,825	955		4,780	5,675	
1640	7.5 ton cooling, 35 MBH heat @ 0° F		.40	40		5,850	1,550		7,400	8,825	
1648	10 ton cooling, 45 MBH heat @ 0° F	Q-6	.40	60		7,725	2,400		10,125	12,300	
1652	12 ton cooling, 50 MBH heat @ 0° F	"	.36	66.667		10,000	2,675		12,675	15,200	
1696	Supplementary electric heat coil incl., except as noted										
0010	**WATER-SOURCE HEAT PUMPS** (Not including interconnecting tubing)										800
2000	Water source to air, single package										

MECHANICAL 15

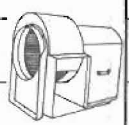
		15740 | Heat Pumps	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	2006 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
800	2100	1 ton cooling, 13 MBH heat @ 75° F	Q-5	2	8	Ea.	1,125	310		1,435	1,725
	2120	1.5 ton cooling, 17 MBH heat @ 75° F		1.80	8.889		1,250	345		1,595	1,900
	2140	2 ton cooling, 19 MBH heat @ 75° F		1.70	9.412		1,300	365		1,665	2,000
	2160	2.5 ton cooling, 25 MBH heat @ 75° F		1.60	10		1,375	390		1,765	2,125
	2180	3 ton cooling, 27 MBH heat @ 75° F		1.40	11.429		1,475	445		1,920	2,325
	2190	3.5 ton cooling, 29 MBH heat @ 75° F		1.30	12.308		1,525	475		2,000	2,450
	2200	4 ton cooling, 31 MBH heat @ 75° F		1.20	13.333		1,700	515		2,215	2,675
	2220	5 ton cooling, 29 MBH heat @ 75° F		.90	17.778		2,000	690		2,690	3,250
	2240	7.5 ton cooling, 35 MBH heat @ 75° F		.60	26.667		5,750	1,025		6,775	7,925
	2250	8.5 ton cooling, 40 MBH heat @ 75° F		.58	27.586		6,200	1,075		7,275	8,475
	2260	10 ton cooling, 50 MBH heat @ 75° F	↓	.53	30.189		6,275	1,175		7,450	8,725
	2280	15 ton cooling, 64 MBH heat @ 75° F	Q-6	.47	51.064		10,200	2,050		12,250	14,500
	2300	20 ton cooling, 100 MBH heat @ 75° F		.41	58.537		11,200	2,350		13,550	16,000
	2310	25 ton cooling, 100 MBH heat @ 75° F		.32	75		15,200	3,025		18,225	21,400
	2320	30 ton cooling		.24	102		16,700	4,100		20,800	24,800
	2340	40 ton cooling		.21	117		23,600	4,700		28,300	33,200
	2360	50 ton cooling	↓	.15	160		26,600	6,425		33,025	39,300
	3960	For supplementary heat coil, add				↓	10%				
	4000	For increase in capacity thru use									
	4020	of solar collector, size boiler at 60%									
	9000	Minimum labor/equipment charge	Q-5	1.75	9.143	Job		355		355	550

		15750 | Humidity Control Equipment	CREW	DAILY OUTPUT	LABOR-HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P
300	0010	DEHUMIDIFIERS R236000-30									
	6000	Self contained with filters and standard controls									
	6040	1.5 lb/hr, 50 cfm	1 Plum	8	1	Ea.	3,400	42.50		3,442.50	3,825
	6060	3 lb/hr, 150 cfm	Q-1	12	1.333		4,000	51		4,051	4,475
	6065	6 lb/hr, 150 cfm		9	1.778		7,200	68.50		7,268.50	8,000
	6070	16 to 20 lb/hr, 600 cfm		5	3.200		14,300	123		14,423	15,900
	6080	30 to 40 lb/hr, 1125 cfm		4	4		23,700	154		23,854	26,200
	6090	60 to 75 lb/hr, 2250 cfm		3	5.333		31,100	205		31,305	34,500
	6100	120 to 155 lb/hr, 4500 cfm		2	8		56,500	305		56,805	63,000
	6110	240 to 310 lb/hr, 9000 cfm	↓	1.50	10.667		80,000	410		80,410	88,500
	6120	400 to 515 lb/hr, 15,000 cfm	Q-2	1.60	15		108,500	600		109,100	120,500
	6130	530 to 690 lb/hr, 20,000 cfm		1.40	17.143		117,500	685		118,185	130,500
	6140	800 to 1030 lb/hr, 30,000 cfm		1.20	20		134,000	795		134,795	149,000
	6150	1060 to 1375 lb/hr, 40,000 cfm	↓	1	24	↓	187,000	955		187,955	207,500
500	0010	HUMIDIFIERS									
	0520	Steam, room or duct, filter, regulators, auto. controls, 220 V									
	0540	11 lb. per hour R236000-30	Q-5	6	2.667	Ea.	2,175	103		2,278	2,550
	0560	22 lb. per hour		5	3.200		2,400	124		2,524	2,825
	0580	33 lb. per hour		4	4		2,450	155		2,605	[illegible]
	0600	50 lb. per hour		4	4		3,025	155		3,180	[illegible]
	0620	100 lb. per hour		3	5.333		3,600	207		3,807	[illegible]
	0640	150 lb. per hour		2.50	6.400		4,775	248		5,023	[illegible]
	0660	200 lb. per hour	↓	2	8	↓	5,925	310		6,235	[illegible]
	0700	With blower									
	0720	11 lb. per hour	Q-5	5.50	2.909	Ea.	3,025	113		3,138	[illegible]
	0740	22 lb. per hour		4.75	3.368		3,250	131		3,381	[illegible]
	0760	33 lb. per hour		3.75	4.267		3,325	165		3,490	[illegible]
	0780	50 lb. per hour		3.50	4.571		4,000	177		4,177	[illegible]
	0800	100 lb. per hour		2.75	5.818		4,500	225		4,725	[illegible]
	0820	150 lb. per hour		2	8		6,675	310		6,985	[illegible]
	0840	200 lb. per hour	↓	1.50	10.667	↓	7,825	415		8,240	[illegible]
	5000	Furnace type, wheel bypass									

15 MECHANICAL

15830 | Fans

				DAILY	LABOR-		2006 BARE COSTS				TOTAL	
			CREW	OUTPUT	HOURS	UNIT	MAT.	LABOR	EQUIP.	TOTAL	INCL O&P	
100	6620	54" x 54" (R233400-10)	1 Shee	6	1.333	Ea.	208	56		264	320	100
	6630	Timer, shut off, to 12 Hr.	↓	20	.400	↓	33.50	16.85		50.35	64	
	6650	Residential, bath exhaust, grille, back draft damper										
	6660	50 CFM	Q-20	24	.833	Ea.	30	32.50		62.50	84	
	6670	110 CFM		22	.909		50	35		85	111	
	6680	Light combination, squirrel cage, 100 watt, 70 CFM	↓	24	.833	↓	63	32.50		95.50	120	
	6700	Light/heater combination, ceiling mounted										
	6710	70 CFM, 1450 watt	Q-20	24	.833	Ea.	74.50	32.50		107	133	
	6800	Heater combination, recessed, 70 CFM		24	.833		36	32.50		68.50	90.50	
	6820	With 2 infrared bulbs		23	.870		53.50	33.50		87	112	
	6900	Kitchen exhaust, grille, complete, 160 CFM		22	.909		63.50	35		98.50	126	
	6910	180 CFM		20	1		54	38.50		92.50	121	
	6920	270 CFM		18	1.111		97.50	43		140.50	175	
	6930	350 CFM	↓	16	1.250	↓	74.50	48.50		123	159	
	6940	Residential roof jacks and wall caps										
	6944	Wall cap with back draft damper										
	6946	3" & 4" dia. round duct	1 Shee	11	.727	Ea.	13.05	30.50		43.55	63.50	
	6948	6" dia. round duct	"	11	.727	"	31	30.50		61.50	83	
	6958	Roof jack with bird screen and back draft damper										
	6960	3" & 4" dia. round duct	1 Shee	11	.727	Ea.	12.55	30.50		43.05	63	
	6962	3-1/4" x 10" rectangular duct	"	10	.800	"	22.50	33.50		56	78.50	
	6980	Transition										
	6982	3-1/4" x 10" to 6" dia. round	1 Shee	20	.400	Ea.	13.85	16.85		30.70	42.50	
	7000	Roof exhauster, centrifugal, aluminum housing, 12" galvanized										
	7020	curb, bird screen, back draft damper, 1/4" S.P.										
	7100	Direct drive, 320 CFM, 11" sq. damper	Q-20	7	2.857	Ea.	360	111		471	570	
	7120	600 CFM, 11" sq. damper		6	3.333		365	129		494	605	
	7140	815 CFM, 13" sq. damper		5	4		365	155		520	645	
	7160	1450 CFM, 13" sq. damper		4.20	4.762		465	184		649	800	
	7180	2050 CFM, 16" sq. damper		4	5		465	194		659	815	
	7200	V-belt drive, 1650 CFM, 12" sq. damper		6	3.333		790	129		919	1,075	
	7220	2750 CFM, 21" sq. damper		5	4		890	155		1,045	1,225	
	7230	3500 CFM, 21" sq. damper		4.50	4.444		985	172		1,157	1,350	
	7240	4910 CFM, 23" sq. damper		4	5		1,225	194		1,419	1,650	
	7260	8525 CFM, 28" sq. damper		3	6.667		1,525	258		1,783	2,075	
	7280	13,760 CFM, 35" sq. damper		2	10		2,100	385		2,485	2,925	
	7300	20,558 CFM, 43" sq. damper	↓	1	20		4,475	775		5,250	6,150	
	7320	For 2 speed winding, add					15%					
	7340	For explosion-proof motor, add					330			330	360	
	7360	For belt driven, top discharge, add				↓	15%					
	7500	Utility set, steel construction, pedestal, 1/4" S.P.										
	7520	Direct drive, 150 CFM, 1/8 HP	Q-20	6.40	3.125	Ea.	660	121		781	915	
	7540	485 CFM, 1/6 HP		5.80	3.448		830	134		964	1,125	
	7560	1950 CFM, 1/2 HP		4.80	4.167		970	161		1,131	1,325	
	7580	2410 CFM, 3/4 HP		4.40	4.545		1,800	176		1,976	2,250	
	7600	3328 CFM, 1-1/2 HP	↓	3	6.667	↓	2,000	258		2,258	2,600	
	7680	V-belt drive, drive cover, 3 phase										
	7700	800 CFM, 1/4 HP	Q-20	6	3.333	Ea.	520	129		649	775	
	7720	1,300 CFM, 1/3 HP		5	4		545	155		700	840	
	7740	2,000 CFM, 1 HP		4.60	4.348		640	168		808	970	
	7760	2,900 CFM, 3/4 HP		4.20	4.762		865	184		1,049	1,250	
	7780	3,600 CFM, 3/4 HP		4	5		1,075	194		1,269	1,475	
	7800	4,800 CFM, 1 HP		3.50	5.714		1,250	221		1,471	1,725	
	7820	6,700 CFM, 1-1/2 HP		3	6.667		1,550	258		1,808	2,100	
	7830	7,500 CFM, 2 HP		2.50	8		2,100	310		2,410	2,825	
	7840	11,000 CFM, 3 HP	↓	2	10	↓	2,825	385		3,210	3,700	



16510 | Interior Luminaires

	Line	Description	Crew	Daily Output	Labor-Hours	Unit	2006 Bare Costs Mat.	2006 Bare Costs Labor	2006 Bare Costs Equip.	2006 Bare Costs Total	Total Incl O&P	
440	8270	24" diam. x 42" high, 6 light candle w/glass shade (R265113-40)	1 Elec	6	1.333	Ea.	230	56		286	340	440
	8280	17" diam. x 12" high, 8 light w/glass panels		8	1		261	42		303	350	
	8290	32" diam. x 48"H, 10 light bohemian lead crystal (R265723-05)		4	2		580	84		664	770	
	8300	27" diam. x 29"H, 10 light bohemian lead crystal		4	2		540	84		624	725	
	8310	21" diam. x 9" high 6 light sculptured ice crystal (R265723-20)	↓	8	1	↓	420	42		462	525	
	8500	Accent lights, on floor or edge, 0.5W low volt incand.										
	8520	incl. transformer & fastenings, based on 100' lengths										
	8550	Lights in clear tubing, 12" on center	1 Elec	230	.035	L.F.	7.70	1.46		9.16	10.70	
	8560	6" on center		160	.050		10	2.10		12.10	14.25	
	8570	4" on center		130	.062		15.30	2.58		17.88	21	
	8580	3" on center		125	.064		17	2.69		19.69	23	
	8590	2" on center		100	.080		24.50	3.36		27.86	32	
	8600	Carpet, lights both sides 6" OC, in alum. extrusion		270	.030		23	1.24		24.24	27.50	
	8610	In bronze extrusion		270	.030		26	1.24		27.24	31	
	8620	Carpet-bare floor, lights 18" OC, in alum. extrusion		270	.030		18.50	1.24		19.74	22.50	
	8630	In bronze extrusion		270	.030		21.50	1.24		22.74	26	
	8640	Carpet edge-wall, lights 6" OC in alum. extrusion		270	.030		23	1.24		24.24	27.50	
	8650	In bronze extrusion		270	.030		26	1.24		27.24	31	
	8660	Bare floor, lights 18" OC, in aluminum extrusion		300	.027		18.50	1.12		19.62	22	
	8670	In bronze extrusion		300	.027		21.50	1.12		22.62	25.50	
	8680	Bare floor conduit, aluminum extrusion		300	.027		6.10	1.12		7.22	8.50	
	8690	In bronze extrusion		300	.027	↓	12.25	1.12		13.37	15.20	
	8700	Step edge to 36", lights 6" OC, in alum. extrusion		100	.080	Ea.	61.50	3.36		64.86	73	
	8710	In bronze extrusion		100	.080		64	3.36		67.36	75.50	
	8720	Step edge to 54", lights 6" OC, in alum. extrusion		100	.080		92.50	3.36		95.86	107	
	8730	In bronze extrusion		100	.080		97.50	3.36		100.86	112	
	8740	Step edge to 72", lights 6" OC, in alum. extrusion		100	.080		123	3.36		126.36	141	
	8750	In bronze extrusion		100	.080		135	3.36		138.36	153	
	8760	Connector, male		32	.250		2.28	10.50		12.78	18.70	
	8770	Female with pigtail		32	.250		4.80	10.50		15.30	21.50	
	8780	Clamps		400	.020		.46	.84		1.30	1.80	
	8790	Transformers, 50 watt		8	1		65	42		107	136	
	8800	250 watt		4	2		222	84		306	375	
	8810	1000 watt		2.70	2.963	↓	410	124		534	640	
	9000	Minimum labor/equipment charge	↓	3	2.667	Job		112		112	173	
800	0010	**RESIDENTIAL FIXTURES**										800
	0400	Fluorescent, interior, surface, circline, 32 watt & 40 watt	1 Elec	20	.400	Ea.	77.50	16.80		94.30	112	
	0500	2' x 2', two U 40 watt		8	1		103	42		145	179	
	0700	Shallow under cabinet, two 20 watt		16	.500		44	21		65	81	
	0900	Wall mounted, 4'L, one 40 watt, with baffle		10	.800		119	33.50		152.50	183	
	2000	Incandescent, exterior lantern, wall mounted, 60 watt		16	.500		31.50	21		52.50	67.50	
	2100	Post light, 150W, with 7' post		4	2		110	84		194	250	
	2500	Lamp holder, weatherproof with 150W PAR		16	.500		19.50	21		40.50	54	
	2550	With reflector and guard		12	.667		54.50	28		82.50	103	
	2600	Interior pendent, globe with shade, 150 watt		20	.400	↓	128	16.80		144.80	167	
	9000	Minimum labor/equipment charge	↓	4	2	Job		84		84	129	

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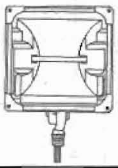

	Line	Description	Crew	Daily Output	Labor-Hours	Unit	Mat.	Labor	Equip.	Total	Total Incl O&P	
300	0010	**EXTERIOR FIXTURES** With lamps										300
	0200	Wall mounted, incandescent, 100 watt	1 Elec	8	1	Ea.	28	42		70	95.50	
	0400	Quartz, 500 watt		5.30	1.509		54	63.50		117.50	157	
	0420	1500 watt		4.20	1.905		102	80		182	236	
	1100	Wall pack, low pressure sodium, 35 watt		4	2		214	84		298	365	
	1150	55 watt	↓	4	2	↓	255	84		339	410	

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