Green Modifications

Suburban Wellness Center
Germantown, Maryland

Prepared by Cory J. Abramowicz
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Faculty Advisor: Dr. James Freihaut

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Executive Summary

The Suburban Wellness Community Center is a two story 58,200 square foot building which contains a variety of spaces. On the first level is a fitness center and on the second level are conference rooms, offices and private practicing doctor's offices. In the northwest corner of the first floor is the swimming pool area which consists of a large four lane lap pool, a therapy pool, public spa as well as a sauna and steam room. South of this room is the basketball court and racquetball courts which are two stories in height. In the center of the building are the men's and women's lockers rooms and a two story tall atrium with cardiovascular machines and the registration desk. The east side of the first floor holds the free weight rooms in the north and studio spaces for group exercise classes in the south. On the second story in the center of the north part of the building are restrooms and conference rooms. The southeast corner of the second story includes an imaging office which can perform X-Rays, MRIs and ultrasounds. The rest of the space on the second floor has yet to be leased out.

The focus of this report is to analyze sustainable design practices that could be used to save energy and provide superior indoor air quality to the patrons. Then the impacts these changes have on other disciplines will be discussed followed by a cost analysis of the proposed design.

The results suggest that a GreenGrid green roofing system may be applied to the roof of the Suburban Wellness Center. The green roof provides a significant drop in stormwater runoff reduces the mechanical loads on the building and cuts down on heat island effect. The addition of the GreenGrid green roofing system trays would not require a roof structural system redesign.

Indoor air quality is a very important issue in fitness centers and several measures were taken to improve the IAQ of the Suburban Wellness Center. 30% more ventilation, zero VOC paints and coatings, and a full system flush-out all contributed to provide the cleanest air possible. The changes to the indoor air quality consumed a lot of energy; however if the air that is being conditioned is not clean then there is no use conditioning it.

When comparing the existing and proposed system to a baseline building specified by ASHRAE Standard 90.1-2004 Appendix G, both systems failed to conserve any energy. The 30% increase in ventilation and inefficient rooftop units proved to have difficulty when being compared against a system with an electric heat pump. With the points earned in this report and a few more points gained in other categories of the LEED Checklist, a building that was once just suppose to be rented out as offices could become a building that helps the environment.

Building Summary

The Suburban Wellness Community Center is a two story 64,800 square foot building which contains a variety of spaces. On the first level is a fitness center and on the second level are conference rooms, offices and private practicing doctor's offices. In the northwest corner of the first floor is the swimming pool area which consists of a large four lane lap pool, a therapy pool, public spa as well as a sauna and steam room. South of this room is the basketball court and racquetball courts which are two stories in height. In the center of the building are the men's and women's lockers rooms and a two story tall atrium with cardiovascular machines and the registration desk. The east side of the first floor holds the free weight rooms in the north and studio spaces for group exercise classes in the south. On the second story in the center of the north part of the building are restrooms and conference rooms. The southeast corner of the second story includes an imaging office which can perform X-Rays, MRIs and ultrasounds. The rest of the space on the second floor has yet to be leased out.

Figure 1 Suburban Wellness Westside Entrance

Architecture

The prominent theme for the design of the Suburban Wellness Center was synergy. The first floor of the mixed-use medical facility includes racquetball and basketball courts, multiple exercise equipment rooms as well as an Olympic sized lap pool. The second floor houses medical offices, MRI Rooms, X-Ray rooms and physical therapy suites. Several of the areas on the second floor are open below so when customers visited the doctor's office, see the people below working out and become more inclined to work out. Visitors on the second floor are able to look down into the basketball courts and cardiovascular machine rooms. In the center of the building at the entrance is a large 2 story atrium. The purpose of the atrium was to promote communication between the fitness center and medical offices. To top it off, a clearstory skylight was also introduced. This gave natural sunlight to the fitness center patrons and made the spaces below more animated.

Building Envelope

The primary material used in the facade of the Suburban Wellness Center is brick and glass. The original design called for an office building design in case the use of the building was to change in the future. Steel members cover the structural component so the facade acts as a curtain wall and doesn't actually provide any structural support. Brick was used as not only because it was cost effective but also because it blended well with the residential area that surrounded the wellness center. Since the building is over 400 ft and only two stories high, ascent bricks were used to break up the building into sections.

The roofing system is made up of a metal decking with rooftop asphalt on top. A clearstory skylight pierces through the top to supply sunlight into the building.

Mechanical

Two single packaged combination heating and electric, air-cooled cooling units provide conditioned air to most of the building. RTU-1 which is located on the west side of the building supplies to the southwest corner while RTU-2 located on the east side of the building supplies to the east half of the building. A separate air handling unit is used to supply conditioned air strictly to the swimming pool facility. RTU-1 supplies to the basketball court, racquetball courts, group cycling room and the cardiovascular machine room. RTU-2 supplies to the locker rooms, weight training area, circuit training area, fitness center offices and group workout studios. Both supplies to the spaces using a VAV box system with electric reheat which ensures sufficient individual space conditioning control. A variable speed fan drive is also used to give even more control over the conditioning of the supply air.

The northwest corner of the building which holds the swimming pool facility is conditioned by a dehumidification unit and compressor unit. AHU-1 supplies to the swimming pool facility which has a four lane wide lap pool, public spa and a therapy pool. This space needed a separate unit because of the criterion that must be met for swimming pools. To avoid thermal discomfort and a high evaporation rate, the humidity ratio, air temperature and water temperature must all be kept around a certain range. The humidity ratio must be kept in a certain range, typically between 50% and 60%, and the air temperature must be kept between 80°F and 88°F or 2°F above the desired water temperature. Swimming pool water temperature is also an important factor because of the temperature ranges needed depending on what the swimming pool is used for. Aside from the rooftop units and air handling units, the building also utilizes unit heaters and electric ceiling heaters to heat the stairwells.

Figure 2 Current Swimming Pool Dehumidifier

Also located near the swimming pool facility is the main mechanical room of the Suburban Wellness Center. Two 800 MBH gas fired water heaters have been placed in the mechanical room to supply hot water throughout the building. To heat the three swimming pools, one 400 MBH and two 250 MBH gas fired pool heaters have been installed. Especially during the winter months when temperatures drop below freezing, these pool heaters take some of the loading off of the dehumidification unit.

Electrical

The Suburban Wellness Center electrical service is distributed from a 480/277V three phase switchboard. The main distribution panel is rated at 2000 amps. The electrical service is installed in the main electrical room located in the central west part of the building. From there, power is supplied from this room to 13 480V panels located throughout the building. Each distribution panel includes a 480 to 208/120V step-down transformer. 480/277V panels serve the main mechanical equipment and 120V or 277V panels serve the building lighting and basic power loads.
For emergency power, there is battery backup power supplied to all of the emergency lighting and critical equipment of the building.

Lighting

The Suburban Wellness Center uses a variety of lighting fixtures. The studio rooms, doctor's offices, weight rooms, swimming pool area, hallways, and locker rooms all have fluorescent lighting with between one and four T-8 lamps. The gymnasium includes thirty sports lighting fixtures with five compact fluorescent lamps each.

Structural

The structural system for the Suburban Wellness Center consists of steel columns, beams and girders supporting the roofing system. 20K3 and 30K11 steel joists provide ample support for the roof structural system. Steel floor beams support the composite desk of the second floor. These beams carry the load to the girders which connect to the steel columns. The floor slab is 5" slab on grade with 3500 psi concrete placed over a vapor barrier.

Construction

The Suburban Wellness Center had a design-bid-build project delivery method. The project started construction in December 2001 and completed construction in November 2002.

Fire Protection

The Suburban Wellness Center is protected from fire with a wet pipe sprinkler system. All areas where there is a ceiling have fully concealed pendant type sprinkler heads. Areas without ceilings use upright or side mounted sprinkler heads with a protective cage guard.

Telecommunications

The Telecommunication systems for the Suburban Wellness Center include telephone and data outlets installed throughout the building. Coaxial television outlets are also installed in the cardiovascular rooms.

Transportation

An elevator in the main lobby area transports building occupants between the first and second floor. Emergency stairwells are also provided on the north and south ends of the Suburban Wellness Center.

Proposed Redesign

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is the nationally accepted benchmark for the design, construction, and operation of energy conscience buildings. The main purpose of this building rating system is to improve public health and the environment as well as reduce operating costs for the building and potentially increase occupant productivity. The five main categories in which points can be attained are sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

The construction for the Suburban Wellness Center was completed in November 2002. Around that time, energy consumption wasn't a major issue in the building industry and so the LEED certification wasn't as popular as it is today. Many buildings were engineered to do one function and often time energy efficient technology originally implemented into the building was value engineered out because of the initial expenses. The Suburban Wellness Center didn't attempt any LEED credits and was never checked for a LEED certification. The proposed redesign is to implement green design techniques and strategies to gain a LEED certification. Energy consumption is a major issue in the building industry now and finding anyways to conserve energy would be very beneficial for the Suburban Wellness Center.

Americans spend about 90 percent of their time indoors where levels of pollutants can run two to five and up to 100 times higher than outdoor levels. Many of these pollutants can cause health reactions; specifically with the 17 million Americans who suffer from asthma and the 40 million who have allergies (1). Since the primary tenant is the Healthtrax Fitness and Wellness, an obvious category to attain several credits in is the Indoor Environmental Quality section. The IEQ category provides many opportunities to gain LEED accreditation and improve the quality of air for the occupants. Monitoring Outdoor Air coming into the building, using Low-Emitting Materials, and controlling the thermal comfort and the amount of daylight can all be implemented to achieve credits for IEQ.

A credit that is very important to the LEED Checklist is Credit 1: Optimize Energy Performance. This credit has a possible ten points which is quite a bit considering there are only 69 points on the LEED Checklist. Ways to go about doing this could be to redesign the rooftop units supplying conditioned air to the building or redesign the air handling unit and compressor used to supply conditioned air to the swimming pool space. Several manufacturers who design dehumidifying units are integrating heat recovery into their systems to utilize the energy being expelled into the atmosphere.

One HVAC manufacturer that engineers more efficient systems is Dectron Inc. Their DRY-O-TRON model maintains a constant humidity ratio in the pool area, but also recovers energy to provide free pool water heating. This is done using the hot gas that comes from the compressor. When the compressor is running, it expels hot gas which is normally expelled into the air, however with this technology; the hot gas is redirected into a heat exchanger which transfers the heat energy into the water which goes to the pool. The DRY-O-TRON also uses another process to recycle recovered heat. When warm humid air passes through the dehumidifying coil and cooled below its dew point, the air condenses and the heat captured can also be used to heat the water from the pool. These processes of heating the pool water using heat recovered from the unit can save the owner 80% on what it would normally cost to heat the pool using electricity or gas. Another technology Dectron Inc. has implemented into their dehumidifying units is Smart Saver Heat Recovery Coils. These coils extract the heat from the exhaust air stream and transfer it to the outdoor air stream using a passive refrigerant system loop. The heat recovered is determined by the temperature difference between indoor air and outdoor air. Below is a payback analysis of a system using the Smart Saver.

POOL LOCATION: Chicago Bin Data (see table at right)		
(T1)	O/A average temp:	51 °F (10.5°C)
(T2)	Winter design temp:	-8 °F (-22°C)
(T3)	Indoor design temp:	82 °F (27.7°C)
(V)	O/A volume:	4500 CFM
(N)	Occupied hours:	12 hours
	Energy cost:	0.55$/100,000 Btu
(n)	Energy efficiency:	80% (Efficiency of space heating system)
(hre)	Heat recovery efficiency:	50 %
Annual heat recovered:		Q = (T3-T1)*1.08*V*(8760*N/24)*hre = 329,945,400 Btu per year
Annual savings:		= (Q*$/100,000 Btu)/n = $2,268.37 per year
Reduction in space heating:		= (T3-T2)*1.08*V*hre = 218,700 Btu/h

Figure 3 DRY-O-TRON Smart Saver Heat Recovery Coils Payback Analysis

Other strategies proposed are CO_2 sensors in the workout spaces which supply more outdoor air when an increase in occupancy is detected. Motion sensor lighting controls can be used to control the lighting in the room depending if the room is occupied or not. Other methods of gaining certification are using recycled materials, using low-e glass glazing, and low VOC paints and sealants. The gas fired water heaters will also be considered and redesigned depending on their emissions levels. Another design method proposed is an extensive green roof which will be accessible to fitness center patrons. Green roofs have a number of benefits including the reduction of heating and cooling loads on the buildings, the filtration of pollutants and CO_2 in the air, as well as the filtration of pollutants and heavy metals in rainwater. This would also allow members to participate in group classes outside. Imagine doing yoga while still breathing in the fresh outdoor air and feeling the crisp grass blades against your bare feet. This redesign was chosen because LEED is not only changing our buildings but also the way we engineer. With this redesign, the LEED certification process will be further researched which will result in several benefits for the future.

Implementing an extensive green roof is structurally load intensive so a proposed breadth topic is to redesign the structural system on the roof to support this increased load. Currently the roof has composite steel decking which are supported by 20K3 and 30K11 steel joists spaced five feet on center and W18x35 and W16x31steel beams. When designed, the system originally was only suppose to support dead loads from the rooftop units and snow loads, but with the addition of a green roof, the steel member would need to be redesigned.

LEED points can also be gained by introducing more daylighting into the spaces. Studies report that 75 percent of employees surveyed prefer daylighting over electric lighting. Daylighting can increase worker productivity by up to 15 percent. Pacific Gas and Electric conducted a study which reflects this. In the study, some retail stores were fitted with daylighting and some were not. Of those retail stores that had daylighting, sales were 31 to 49 percent more than those that did not have daylighting. Keeping this in mind, I would like to add skylights and daylighting controls to the gymnasium to improve patron health.

LEED Review

The fact that green buildings are becoming more and more popular throughout the United States begs a question; are sustainable fitness centers important? The answer is yes. According to Advantage Fitness Products, "Green is the ultimate in customer service." Advantage Fitness Products is a company that promotes green through their "green clean" product maintenance which consists of cleaning products that are odorless and biodegradable. AFP stumbled upon the popularity of these products after numerous fitness center members would stay away from the vicinity the AFP technicians were working in.

Another stride fitness centers are taking towards energy reduction are taking is utilizing non-electric equipment. Precor and Life Fitness, two large manufacturers of exercise equipment, designed and produced exercise equipment that relies on the user to power the machine. Currently they are producing climbers, cycles and elliptical that doesn't require electricity. Another company that has designed eco-friendly equipment is SportsArt Fitness. Their new treadmill uses an Eco-Powr motor which consumes 32 percent less energy than a typical treadmill. Some fitness centers, such as Penn State's, are implementing machines that automatically turn the treadmill LCDs off after the user is done exercising.

While many fitness centers are increasingly using eco-friendly products and equipment, operating in a LEED certified building is the ultimate in sustainability. Environmental products and buildings are becoming more appealing to both business owners and gym patrons. Operating in a LEED certified building would allow the fitness center to reassure their members that they are exercising in a clean environment. The increased daylighting into the center would make patrons feel revitalized as if they were working outdoors without having to worry about inclement weather. Kara Burdick of L&T Health and Fitness says," Natural light is so much better. The impact it has on the feel and look of a fitness center is huge."

This report will go into detail three design options that were analyzed which could make the Suburban Wellness Center more sustainable. A green roof was implemented because it is one design option that offers numerous sustainable effects and LEED point. The Indoor Environmental Quality category of the LEED Checklist gives several options which can provide a better atmosphere for members to exercise in. The last design option is a building system simulation which shows the effects the changes from the green roof and IEQ have on the cooling and heating system.

Green Roof Systems

Green roofs systems have been around for several decades. Major research and development started in Germany during the 1960s where presently 10% of all flat roofs have green roof systems installed. Recently, popularity has exploded around the world with the market for green roof systems increasing by 10%-15% annually the past decade in Germany and 50% in the last four years in the United States (2) (3).

Green roof systems, or otherwise known as vegetated roof covers, eco-roofs and garden roofs, consist of a conventional flat or sloping roof with thin layers of living vegetation installed on top. These roof systems protect the conventional roof waterproofing system while adding many ecological and aesthetic benefits (4). According to the National Roofing Contractors Association, green roof systems are categorized three ways. Extensive green roof systems are shallow and consist of an engineered soil-based growth medium of approximately 2 to 6 inches deep. Semi-intensive are slightly deeper where the engineered soil-based medium is 6 to 10 inches deep. Finally, intensive green roof systems are very deep where the engineered soil-based growth medium is greater than 10 inches (5).

Figure 5 Modular GreenGrid System

Figure 4 Typical Green Roof System

Green roofs not only vary by the depth, but also by the layers involved in the construction and the plants that can grow. Green roofs are a very complex assembly and involve several layers which each play a big part to optimize the green roof. The typical layers follow: Protection Course, Root Barrier, Drainage Layer, Moisture-resistant Insulation, Aeration Layer, Moisture-retention Layer, Reservoir Layer, Filter Fabric and the Engineered Soil-based Growth Medium.

The Protection Course protects the waterproofing membrane from damage after installation. The waterproofing membrane is a crucial to keep the building from leaking and so it is important to keep this element from being damaged. Contractors will stand on the protection course to construct the rest of the green roof system. Extruded polystyrene boards, PVC sheets, or Asphaltic boards or sheets can all be used as a protection course layer.

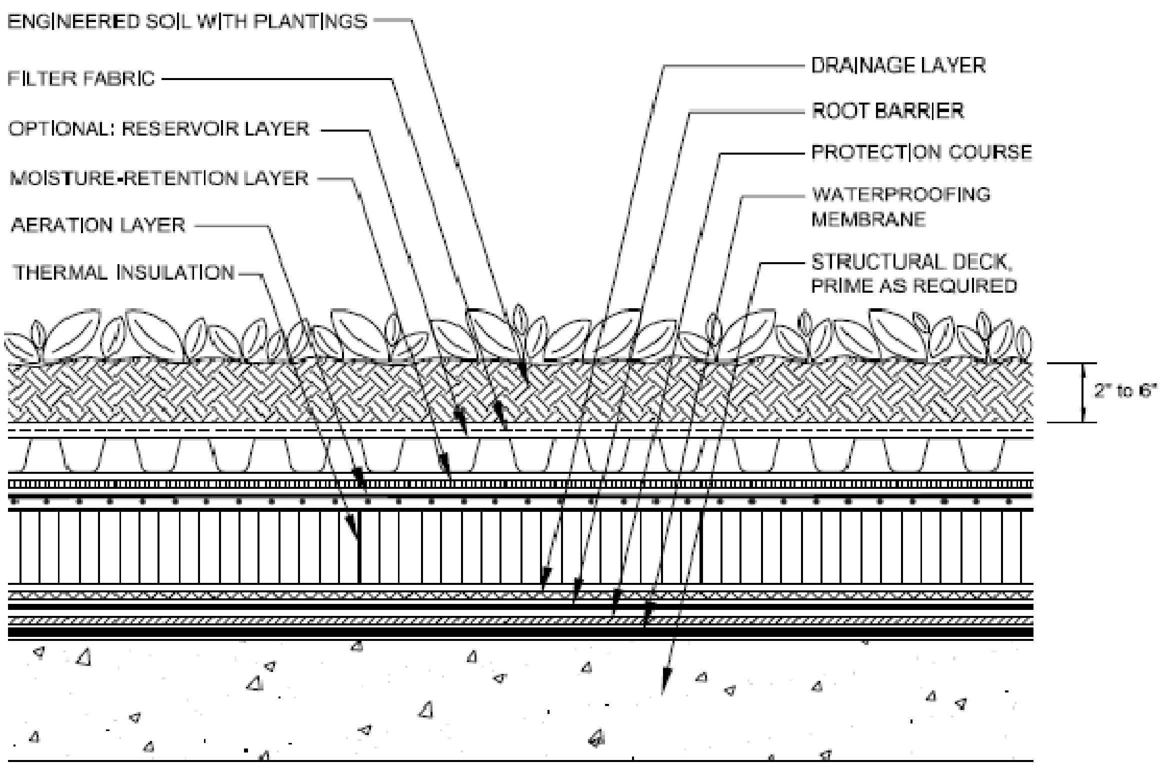

Figure 6 Construction of Green Roof

The Root Barrier is a material which prevents migration of plant roots from damaging the membrane. When the roots from the green roof plants grow, they will naturally sprawl out and try to penetrate the waterproofing membrane. This will cause leakage and so a root barrier is typically installed to prevent this. The layer is usually a separate material installed on top of the protection course; however it can also be combined with a protection course or drainage course. Materials that can be used as a root barrier are high-density polyethylene boards, granulated modified bitumen membranes with root-inhibiting additives, and polyethylene sheets.

The Drainage Layer allows for moisture to move laterally through the green roof system. Drainage layers most often used are drainage mats and insulating drainage panels. Drainage mats are a waffle like plastic material while insulating drainage panels are sheets of high density, moisture-resistant insulation boards that have grooved channels to direct the water.

The Moisture-Resistant Insulation reduces heat loss from the building which keeps the soil medium closer to the outdoor temperature. If the R-value is too small, heat loss from the building can keep the soil and roots warm which may tarnish plant life cycles.

The Aeration Layer is needed so the insulation will retain its R-value. The aeration layer allows for moisture to drain from the topside of the insulation. If an aeration layer is not used, the insulation will retain the moisture which will then decrease the R-value.

The Moisture-Retention Layer stores moisture for plant growth. This is typically made of recycled polypropylene fibers.

The Reservoir Layer stores moisture for overburden growth. They are used for additional moisture that the growth medium may need and are optional for extensive green roof systems.

The Filter Fabric restricts the flow of fine soil particles while allowing water to pass through. This protects the drainage layer from clogging.

The Engineered Soil-based Growth Medium is specifically formulated to help the green roof system grow. Types of growth medium vary depending on which kind of green roof system which uses different kinds of plants.

Yes	?	No			
			Sustainable Sites		**14** Points
1			Credit 6.1	**Stormwater Design,** Quantity Control	1
1			Credit 6.2	**Stormwater Design,** Quality Control	1
1			Credit 7.2	**Heat Island Effect,** Roof	1
			Energy & Atmosphere		**17** Points
10			Credit 1	**Optimize Energy Performance**	1 to 10
			Materials & Resources		**13** Points
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1

Table 1 Green Roof Point Association

Providing a green roof to a building can result in savings in energy as well as several points towards a LEED accreditation. Depending on which green roofing system is used, a total of 15 points can be achieved. This is over 20 percent of the maximum points that can be earned in LEED and over 50 percent of what is needed for a LEED certification. Although not all the points are guaranteed, with further engineering these points will be. Table 1 shows an overview of which credits may be obtained for a LEED certification. A detailed explanation of what each credit is and how it can be achieved is to follow in this report.

SS Credit 6.1 Stormwater Design, Quantity Control

The first point able to be earned is the Stormwater Design: Quantity Control credit. This credit can be achieved in a few ways. If the imperviousness is less than or equal to 50 percent of the entire site, the post-development peak discharge rate and quantity cannot exceed the pre-development peak discharge rate. Protecting receiving stream channels from excessive erosion can also be done to receive credit. If the imperviousness is greater than 50 percent of the entire site, the volume of pre-development stormwater runoff must be decreased by 25 percent. Since the Suburban Wellness Center has an impervious coverage of over 50 percent, the approach of decreasing the volume of pre-development stormwater runoff would be taken. Using the surface characteristics of the site and data on storm event frequency, intensity and duration, the pre-development discharge rate and quantity are typically determined by a civil engineer. These values are calculated for one-year, and two-year24-hour design storms. Once the post-development calculations are done in the same way that the pre-development calculations were done, if the post-development discharge rate and quantity are both25 percent less than the appropriate pre-development values, a credit is achieved.

Calculations were made to analyze the stormwater discharge rate for this credit; however a site plan to conduct the calculations for the entire site was not available. The green roof was analyzed and the results can be found in Table 2. A detailed description of the numbers and figures used in this calculation can be found in Appendix A.

Qp=qu*area*Qa		
Variables	1 Year 24 Hour Design Storm	2 Year 24 Hour Design Storm
Qp (cfs)	0.081	0.100

Table 2 Green Roof Stormwater Discharge Rates

SS Credit 6.2 Stormwater Design, Quality Control

The quality control stormwater design credit can be obtained by reducing impervious cover, promote infiltration, and capture and treat the stormwater runoff for 90 percent of the average annual rainfall. This credit is intended to reduce or eliminate water pollution. The annual rainfall for Germantown Maryland is approximately 41 inches so since this is above 40 inches, it is considered to be in a Humid Watershed. The green roof also proves to be helpful for this credit because with the green roof, it can be considered a non-structural measure. A non-structural measure denotes that the stormwater is being captured and treated by allowing it to naturally filter into the soil and vegetation. The pollutants are then broken down by microorganisms in the soil and plants. To gain this credit, the soil has to have the capacity to infiltrate water at a rate and quantity sufficient to absorb at least 90 percent of the annual rainfall volume.

SS Credit 7.2 Heat Island Effect, Roof

The Heat Island Effect credit for the roof can be obtained in three ways. The roofing material used must have a Solar Reflectance Index equal to or greater than the values in Table 2 for a minimum of 75 percent of the roof surface.

Roof Type	Slope	SRI
Low-Sloped Roof	≤ 2:12	78
Steep-Sloped Roof	> 2:12	29

Table 3 Roof Type and SRI Criterion

The second option is to install a vegetated roof for at least 50 percent of the roof area. The last possibly option to achieve this LEED credit if the combination of high albedo and vegetated roof surfaces are used. If this is the case, Equation 1 must be used.

$$\left(\frac{Area\ Of\ SRI\ Roof}{0.75}\right) + \left(\frac{Area\ of\ Vegetated\ Roof}{0.5}\right) \geq Total\ Roof\ Area$$

Equation 1 Option 3 Heat Island Effect, Roof

Since the Suburban Wellness Center will have a green roof or otherwise known as a vegetated roof, the second option may be used to achieve Credit 7.2.

EA Credit 1 Optimize Energy Performance

Quite possibly one of the most important credits in the LEED Certification Checklist is the Optimize Energy Performance credit. This credit can be obtained by improving on the total building efficiency. A green roof system can improve a building's performance because it cuts down on the absorptance from the sun, contributes to the thermal resistance of the roof, and utilizes evapotranspiration to cool the building. A detailed look at this credit will follow later in the Optimize Energy Performance section of this report.

MR Credit 4.1 & 4.2 Recycled Content, 10% or 20% (post-consumer + ½ pre-consumer)

A green roof system can also be counted toward the recycled content credit. Materials & Resources Credit 4 requires materials from the building can be made of recycled content so thereby reducing impacts resulting from extraction and processing of raw materials. One point is awarded for 10 percent recycled content of the whole project and another point is awarded for 20 percent. If using the modular system from GreenGrid, the modules, pavers, and some edge treatment options are all made from recycled materials (6). If using the non-modular construction of a green roof system, Hydrotech specifies their monolithic waterproofing contains a minimum of 25 percent post consumer recycled content. In addition, the retention and drainage layer installed are also post-consumer recycled content (7).

MR Credit 5.1 & 5.2 Regional Materials, 10% or 20% extracted, processed & manufactured regionally

The final credit a green roof has a possibility of achieving is the Materials and Resources Credit 5. The purpose of this credit is to increase demand for regional materials thereby supporting the use of local resources and reducing the environmental impact resulting from transportation. This credit is possibly using GreenGrid green roof modules because the green roof systems are assembled and pre-planted prior to installation at local nurseries.

eQuest Load Simulation

To gain the Optimize Energy Performance credit for the LEED certification, eQuest 3-6 was used to simulate and analyze the heating and cooling loads of the Suburban Wellness Center. EQuest was used to simulate the thermal loading because it is a program developed and funded by the Department of Energy, it is the preferred building systems simulation software for LEED certification and it is approved by the California Energy Commission.

The proposed design was to cover 66 percent of the roof leaving the other 34 percent to the two roof top units and the clearstory that pierces through the roof to bring light into the two story atrium located in the center of the building.

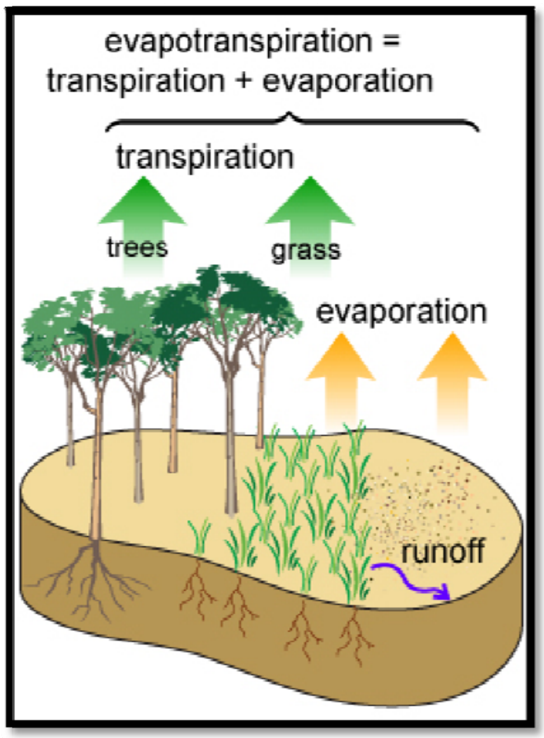

Figure 7 Evapotranspiration Process

There were three major concerns taken into account when the green roof was modeled in eQuest; Absorptance, R-value, and evapotranspiration. The absorptance factor specifies how much of the solar radiation the roof will absorb into the building and how much it will reflect. The lower the number, the more solar radiation the roof will reflect. In the eQuest model, an absorptance of 0.2 was used as advised by industry leaders. The conventional roof is made up of asphalt pavement and was assumed to have a solar absorptance of 0.70.

The R-value is a measure of thermal conductivity and relies on how heat transfer passes through the object. The higher the R-value, the less heat transfer occurs. The soil median of a green roof acts much like insulation used in walls and ceiling. When it gets wet, the moisture provides an easy path for heat transfer and thus decreases the R-value of the material. In a study conducted on several extensive and intensive green roofs, an extensive green roof was found to have an R-value of 2.4 ft^2 h °F/Btu. To be conservative, an R-value of 2 ft^2 h °F/Btu was used.

Evapotranspiration is also a major concern when the SWC's proposed green roof was modeled. Evapotranspiration is the loss of water by evaporation from the soil and plants during photosynthesis (3). In the summer, the thermal resistance increases because evapotranspiration takes place. Because of the limitations of eQuest, an analysis of this process could not be modeled however this is a very important process that occurs within a green roof system.

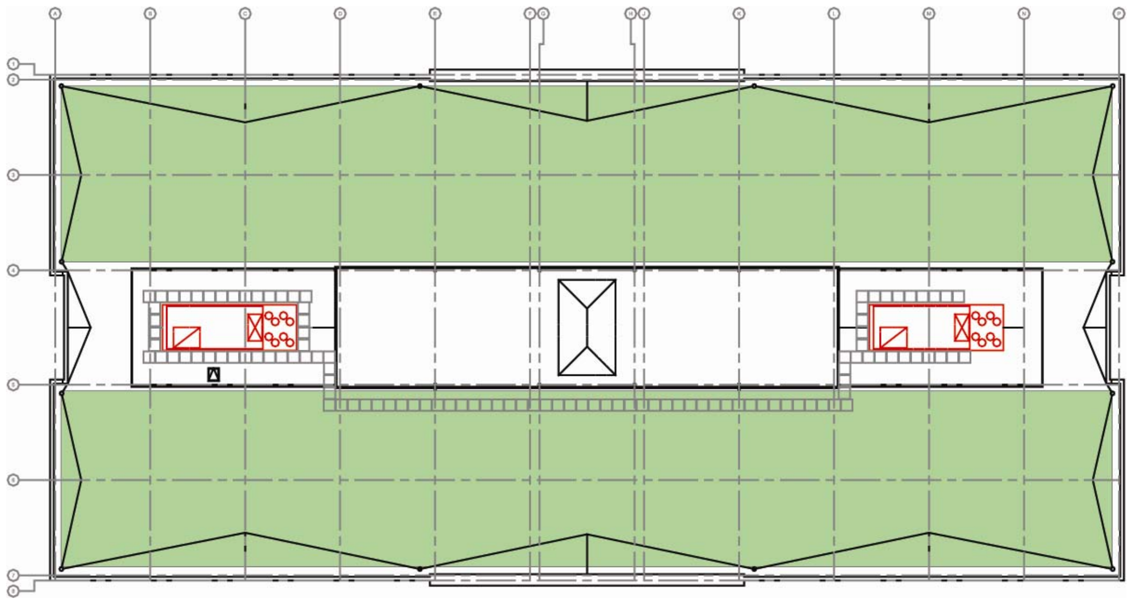

Figure 8 Proposed Green Roof Coverage

After the model simulation, the energy savings that were to be expected were not achieved. A study done on a green roof in Pennsylvania found the total air conditioning savings to be only 10 percent per cooling season. Overall, different studies found the reduction in heat flux to be anywhere from 10 percent to 75 percent depending on the roof performance (3). The low energy savings can be attributed to the low air conditioning demand for Maryland. Since green roofs work best during the summer and Maryland has a relatively short cooling season, this could be a reason the simulation only resulted in less than a 1 percent energy savings. Another possible reason for the low energy savings is the difficulty in modeling the effects of a green roof correctly because R-value of the green roof varies with respect to the weather and the inability of modeling software to model evapotranspiration.

When installing a green roof system there is two options available, modular and non-modular. Both offer several benefits however only one can be chosen. After discussing the modular system with a GreenGrid representative and the non-modular system with a Hydrotech Inc. representative, the modular system proved to be the best system to install. A comparison of the two options is shown in Table 4. The modular system has become a very efficient system to install and maintain. Plastic trays are sent from the warehouse to a local nursery where plants for the green roof are selected and planted. This can go toward MR Credit 5.1 and 5.2 which gives points for using regional materials for the building construction. After the trays are planted, they are delivered to the job site where a lul forklift can hoist the trays up to the roof. The trays are easily set in place and installed by the technician from GreenGrid. If a tray breaks, the tray can be replaced at a very little expense. The GreenGrid modular green roofing system was chosen because it's less expensive, easy to maintain, easy to repair and can be installed quickly.

Green Roofing System		
GreenGrid (modular)		Hydrotech (non-modular)
Materials Cost	$10.50-$11/SF	$15-$16/SF
Installation Cost	$2-$4/SF	$7-$9/SF
Includes Preplanted Trays, Delivery and Supervision of Installation		Includes Plants Materials, and Delivery. Technichian Installation Extra.
Installation Duration	5-8 Days	14-30 Days
Use Lul to lift trays to roof (max height 40 ft.)		Use Lul to lift materials to roof or blow engineered soil to roof
Weight	15 psf	28-30 psf
Disadvantages:		
Cannot be installed on sloped roof (max slope tolerance 3:12)		Expensive
		Long Installation Duration
		Heavy per square foot
		Extensive repair needed for leakage

Table 4 Green Roof System Comparison

Indoor Environmental Quality

Indoor air quality is a crucial element in the design phase of a mechanical system. In 2000, there were nearly 2 million visits to the emergency room and nearly half a million hospitalizations due to asthma. This resulted in an expense of $2 billion and 14 million missed school days (8). If more considerations were taken when designing for indoor air quality, these staggering numbers could improve. By establishing an Indoor Environmental Quality section in the LEED guidelines, the United State Green Building Council is assisting this. The IEQ category of LEED-NC Version 2.2 comprises of fifteen credits which is over 20% of the available LEED points. IAQ is not only an important design consideration for all buildings, but is especially important in a fitness center or office building. Clean and comfortable air can improve worker productivity and patron comfort. Since the IEQ category is an important section to fitness centers and offices, the credits available will be explained in detail followed by the credits which may be difficult. Since the SWC is mechanically ventilated, the details for each credit about natural ventilation will be omitted.

15	0			**Indoor Environmental Quality**	**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
1			Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
1			Credit 7.2	**Thermal Comfort**, Verification	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Figure 9 Indoor Environmental Quality Credit Checklist

Prerequisite 1 Minimum IAQ Performance

In most of the LEED checklist categories, prerequisite credits must be achieved before any other credits in that category may be achieved. One of the prerequisite credits for the IAQ section is to comply with ASHRAE Standard 62.1-2004. Specifically, the building must comply with sections 4 through 7. This is to ensure the comfort and well-being of the occupants. This analysis was done in the Technical Report 1: ASHRAE Standard 62.1 Compliance.

Prerequisite 2 Environmental Tobacco Smoke Control

This prerequisite can be achieved in three ways. The first is to ban smoking in the building and then offer smoking areas which much be 25 feet away from entries, outdoor air intakes and operable windows. This was the option which exists currently at the SWC because all of the buildings operated by Suburban Hospital are smoke-free. The second option is to designate smoking areas where if they are outside, they have to be 25 feet away from entries, outdoor air intakes, and operable windows. If the smoking area is inside, the ventilation must be designed to effectively capture, contain and remove the environmental tobacco smoke from the building. The final option is to prohibit smoking in all common areas and designate all exterior smoking areas 25 feet from entries, outdoor air intakes and operable windows. Additionally, all penetrations in walls, ceilings, and floors in the residential units must be sealed. Residential units leading to common hallways must also be weather-stripped to minimize air leakage into the hallway.

Credit 1 Outdoor Air Delivery Monitoring

The outdoor air delivery monitoring credit can be obtained by installing a permanent monitoring system which provides feedback on the ventilation system. This credit can be achieved with both mechanically ventilated and naturally ventilated spaces. For a mechanically ventilated space, such as the SWC, carbon dioxide concentrations must be monitored when the occupant density for the given space is greater than or equal to 25 people per 1000 ft^2. Also, for mechanically ventilated spaces serving non-densely occupied spaces, a direct outdoor airflow measurement device must be provided which is capable of measuring the minimum outdoor airflow rate with an accuracy of ±15% of the design minimum outdoor air rate.

Credit 2 Increased Ventilation

To achieve the increased ventilation credit, the outdoor air ventilation rates to all occupied spaces must be 30 percent above the minimum rates required by ASHRAE 62.1-2004. This is to provide additional outdoor air ventilation to improve indoor air quality. This is a very important credit for fitness centers and office buildings because it improves occupant comfort, well-being and productivity. A detailed calculation of this credit will be conducted in the equipment sizing section of this report.

Credit 3.1 Construction IAQ Management Plan, During Construction

The construction IAQ management plan that occurs during constructions involves a few precautions to ensure the materials don't become contaminated. The first is to meet or exceed the Control Measures of the Sheet Metal and Air Conditioning Contractors National Association IAQ Guidelines for Occupied Buildings under Construction, 1995 Chapter 3. The second is to protect any absorptive materials that may be stored on-site or installed from moisture damage. The final precaution is if permanently installed air handlers are used during construction, the return grille filtration media must have a Minimum Efficiency Reporting Value of 8 according to ASHRAE 55.2-1999. Prior to occupancy, all the filtration media must be replaced.

Credit 3.2 Construction IAQ Management Plan, Before Occupancy

Two options are available to gain the construction IAQ management plan before occupancy credit. Either a building flush-out or an air quality test can occur. The flush-out can either happen prior to the building being occupied or during. If a flush-out is done before occupancy, 14,000 ft^3 of outdoor air must be supplied per square foot while maintaining an internal temperature of at least 60°F and relative humidity of 60%. If a flush-out is done after occupancy, 3,500 ft^3 of outdoor air must be supplied per square foot before being occupied. Once occupied, 0.30 cfm/sq ft of outside air or the design minimum outside air rate from EQ Prerequisite 1 must be supplied, whichever is greater. During the flush-out period, ventilation shall begin a minimum of 3 hours before occupancy per day. These conditions will cease when 14,000 ft^3 of outdoor air are supplied to the building.

Flush-Out (No Occupancy)				
OA rate	14000 CF/SF			
Building Area	64800 SF			
Flush-out volume	907200000 CF			
OA Supply	91431 CFM			
System On	165.4 Hours			
	6.9 Days			
Date	1/1 - 1/7	4/1 - 4/7	7/1 - 7/7	10/1 - 10/7
Energy (MWh)	34.28	33.31	30.64	27.47

Table 5 Full Flush-Out

Flush-Out (Occupancy)				
OA rate	3500 CF/SF			
Building Area	64800 SF			
Flush-out volume	226800000 CF			
OA Supply	91431 CFM			
System On	41.3 Hours			
	1.7 Days			
Date	1/1 - 1/2	4/1 - 4/2	7/1 - 7/2	10/1 - 10/2
Energy (MWh)	10.04	11.03	11.62	10.01

Table 6 Partial Flush-Out

Table 5 and Table 6 are energy simulations which gauge how much energy the building would consume to obtain EQ Credit 3.2. The first method is a full flush-out before anyone occupies the building. This method is really good for the mechanical system because enough time is provided to get all the particles out however it is very energy intensive. The partial flush-out is brought on when occupant want to occupy the building soon after the building has completed construction. This method saves a lot of energy because it relies on part of the flushing out when the mechanical system isn't running at full load. The building is still getting flushed out, but while it's getting flushed out, the occupants of the building can still use it.

Low Emitting Materials

Credit 4 of the LEED Checklist is dedicated to decreasing the number of products which emit volatile organic compounds. VOCs are emitted as gases from certain solids and liquids. Examples of products that include VOCs are paints, lacquers, cleaning supplies, building materials and furnishings. All of these products can release organic compounds while being used or stored. VOCs have been linked to several health effects such as eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney and central nervous system. Some have even been found to cause cancer to both humans and animals (9). A detailed expense comparison is available in the Cost Analysis section of this report. The specific materials that must be utilized to gain credit and their VOC limit and guidelines are listed below:

- Credit 4.1 Low-Emitting Materials, Adhesives & Sealants
  - Adhesives, Sealants, and Sealant Primers – South Coast Air Quality Management District Rule #1168
  - Aerosol Adhesives – Green Seal Standard for Commercial Adhesives GS-36
- Credit 4.2 Low-Emitting Materials, Paints & Coatings
  - Architectural paints, coatings, and primers applied to interior walls and ceilings – Green Seal Standard GS-11
  - Anti-corrosive and anti-rust paints – Green Seal Standard GC-03 (VOC limit 250 g/L)
  - Clear wood finishes, floor coatings, stains, sealers and shellacs – SCAQMD rule 1113

Material	VOC Limit (g/L)
Clear wood finishes	
Varnish	350
Lacquer	550
Sealers	
Waterproofing sealers	250
Sanding sealers	275
Other	200

Material	VOC Limit (g/L)
Floor Coatings	100
Shellac	
Clear	730
Pigmented	550
Stains	250

Table 7 VOC Limit for Materials, Paints & Coatings

- Credit 4.3 Low-Emitting Materials, Carpet Systems
  - All carpet and carpet cushion must meet the requirements of the Carpet and Rug Institute Green Label program.
  - All carpet adhesive must meet the requirements from EQ Credit 4.1 (VOC limit 50 g/L)
- Credit 4.4 Low-Emitting Materials, Composite Wood & Agrifiber Products
  - Defined as: particleboard, medium density fiberboard, plywood, wheatboard, strawboard, panel substrates and door cores.

- Cannot contain any urea-formaldehyde resins

Credit 5 Indoor Chemical & Pollutant Sources Control

The indoor chemical and pollutant sources control credit is intended to minimize and control pollutant entry into the building and cross contamination. Grates, grilles or slotted systems must be installed in the entry to prevent dirt and particulars from entering the building. For those rooms which may have hazardous gases such as copying or printing rooms, exhaust must be sufficient to provide a negative pressure in the room. Self-closing doors and deck to deck partitions or hard lid ceilings must also be installed in these spaces. If a space is regularly occupied, the air filtration media must provide a Minimum Efficiency Reporting Value of at least 13. In the existing building, there is a grate located in the vestibule; however the air filtration media would need to be upgraded. A cost estimate of this will be located in the Cost Analysis section of this report.

Composite Average Particle Size Efficiency (%)			Minimum Final Resistance	
0.30 - 1.0 µm	1.0 - 3.0 µm	3.0 - 10.0 µm	(Pa)	(inch. Of Water)
< 75%	≥ 90%	≥ 90%	350	1.4

Table 8 Requirements for a MERV Value 13

Credit 6.1 Controllability of Systems, Lighting

Allowing for individual occupants to control the lighting systems improves their productivity, comfort and the general well-being. To achieve EQ Credit 6.1, individual lighting controls must be provided to 90 percent of the occupants to adjust for any task lighting. Additionally, a lighting control system must also be implemented for shared multi-occupant spaces to adjust for the groups' needs and preferences. Currently the building has dimming switches located at various points in the building, but a control system can also be implemented depending on the expenses.

Credit 6.2 Controllability of Systems, Thermal Comfort

Comparable to Credit 6.1, Credit 6.2 deals with the same conditions however with the mechanical systems instead of the lighting system. For individual controls, 50 percent of the building occupants must be able to control the thermal environment. Comfort system controls must also be installed in multi-occupant spaces to adjust for the groups' needs and preferences. To maximize this credit, thermostats must be placed at various locations of the building. Currently there thermostats located in different rooms throughout the building so this credit has a high probability of being achieved.

Credit 7.1 Thermal Comfort, Design

The design thermal comfort credit requires that the building be designed according to the requirements of ASHRAE Standard 55-2004. This standard provides a comfortable thermal environment that supports the productivity and well-being of the people occupying the building. The Suburban Wellness Center was not initially designed for the ASHRAE Standard however it will be in this report.

Credit 7.2 Thermal Comfort, Verification

EQ Credit 7.2 pertains to the verification of the mechanical system supplying adequate thermal comfort. A survey for the building occupants is required six to 18 months after initial occupancy. If there is more than 20 percent dissatisfaction, a plan must be created to correct the problem areas.

Credit 8.1 Daylight &Views, Daylight 75% of Spaces

The Daylight 75% of the Spaces credit for allows the designer three options to achieve this credit. The first is the Glazing Factor Calculation which requires a glazing factor of at least 2 percent in a minimum of 75 percent of the spaces. The glazing factor is calculated as follows:

$$Glazing\ Factor = \frac{Window\ Area\ [SF]}{Floor\ Area\ [SF]} * Window\ Geometry\ Factor * \frac{Actual\ Tvis}{Minimum\ Tvis} * Window\ Height\ Factor$$

Equation 2 Glazing Factor

The second option is to create a daylight simulation model. This requires that at 30" above the floor, a minimum of 75 percent of the spaces must have a daylight illumination level of 25 footcandles. The last option is to show through records of indoor light measurements that a minimum daylight illumination of 25 footcandles has been achieved in over 75 percent of the spaces. The second option of this credit was chosen as the path to achieve this credit because there are no records of daylighting available and it was the most accurate method of designing for daylighting. A detailed analysis of this credit can be found in the lighting analysis of this report.

Credit 8.2 Daylight & Views, Views for 90% of Spaces

The last credit available through the Indoor Environmental Quality category of the LEED checklist is to provide daylight views to over 90 percent of the spaces. For this credit, two calculations must be made; direct line of sight to perimeter vision glazing and horizontal view at 42 inches. The direct line of sight to perimeter vision glazing is the approach used to determine the calculated area of regularly occupied areas with direct line of sight to perimeter vision glazing. The horizontal view at 42 inches is the approach used to confirm that the direct line of sight to perimeter vision glazing remains available from a seated position. Both of these approaches will be checked accordingly and if the SWC does not comply, additional skylights and solartubes will be implemented.

Optimize Building Performance

Design Parameters

The EA Credit 1 is a beneficial credit to achieve provided the way of achieving it is done correctly. For this report, a model of the designed building was first created in eQuest. This model was then changed to comply with ASHRAE Standard 90.1-2004 since originally it only complied with ASHRAE Standard 90.1-1999. The power density of the building was changed from 1.40 W/ft^2 to 1.00 W/ft^2. When a model of the existing building was complete, a baseline building was created which was similar to the existing building, but followed ASHRAE Standard 90.1-2004 Appendix G. The major difference between the existing building and the baseline building was the mechanical system. Appendix G required an electric heat pump for the baseline building while a packaged rooftop unit with variable air volume and reheat was installed.

After the baseline building was created, the existing building model was modified to reflect the changes done with the green roof, indoor environmental quality and daylighting part of this report. The changes to the building model for the green roof included changing the roof absorptance from 0.70 which was used on the baseline model to 0.20. An R-value of 3 was also added onto the roof construction for the green roof. This gave the roof an overall R- value of 23 versus the R-value of 15 which was implemented for the baseline building. For the indoor environmental quality category of LEED, the outdoor air ventilation rates were increased 25% to 55%. This reflects the 30% increase required by EQ Credit 2.

eQuest Comparison

Through the building energy software eQuest3.6, several comparisons were made regarding the energy consumption of the proposed design changes. Below is a summary of the scenarios that were simulated in eQuest:

- Original Building
- Original Building + Daylighting Changes
- Original Building + Daylighting Changes + 30% ventilation increase
- Original Building + Daylighting Changes + Green Roof
- Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof
- Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof + Sensible Heat Exchanger
- 4 Baseline Building Simulations (Building Rotated at +0°, +90°, +180°, +270°)

Original Building

The original building's construction materials and design were found to meet and exceed ASHRAE Standard 90.1-2004 in a couple instances. The building is clad with low emissivity glazing which reduces the U-factor by suppressing radiative heat flow. Low-E glazing is transparent to visible light and opaque to infrared radiation. The original design of the building also fell below the maximum vertical fenestration allow by ASHRAE Standard 90.1-2004.

Original Building + Daylighting Changes

This scenario was similar to that of the original building except skylights were added to the roof in order to meet the criteria for LEED EQ Credit 8 Daylight 75% of Spaces. 14 skylights were added which pierce through the top of the building to bring sunlight into the core spaces in the second floor that don't have 25 footcandles. The addition of these skylightings also causes more loads to the building because the rate of heat transfer through windows is higher than through the roof. Comparing the building with extra skylights to the original building, the increase in electric consumption was not very high. The consumption increased 1400 kWh which is only 0.06 percent annually. Since space heating is also provided by the hot water heaters from the pool, there is also a change in load for gas consumption. A mere 200 Btu increase was due to the addition of the skylightings. A more detailed description of the building loads can be found in Appendix B.

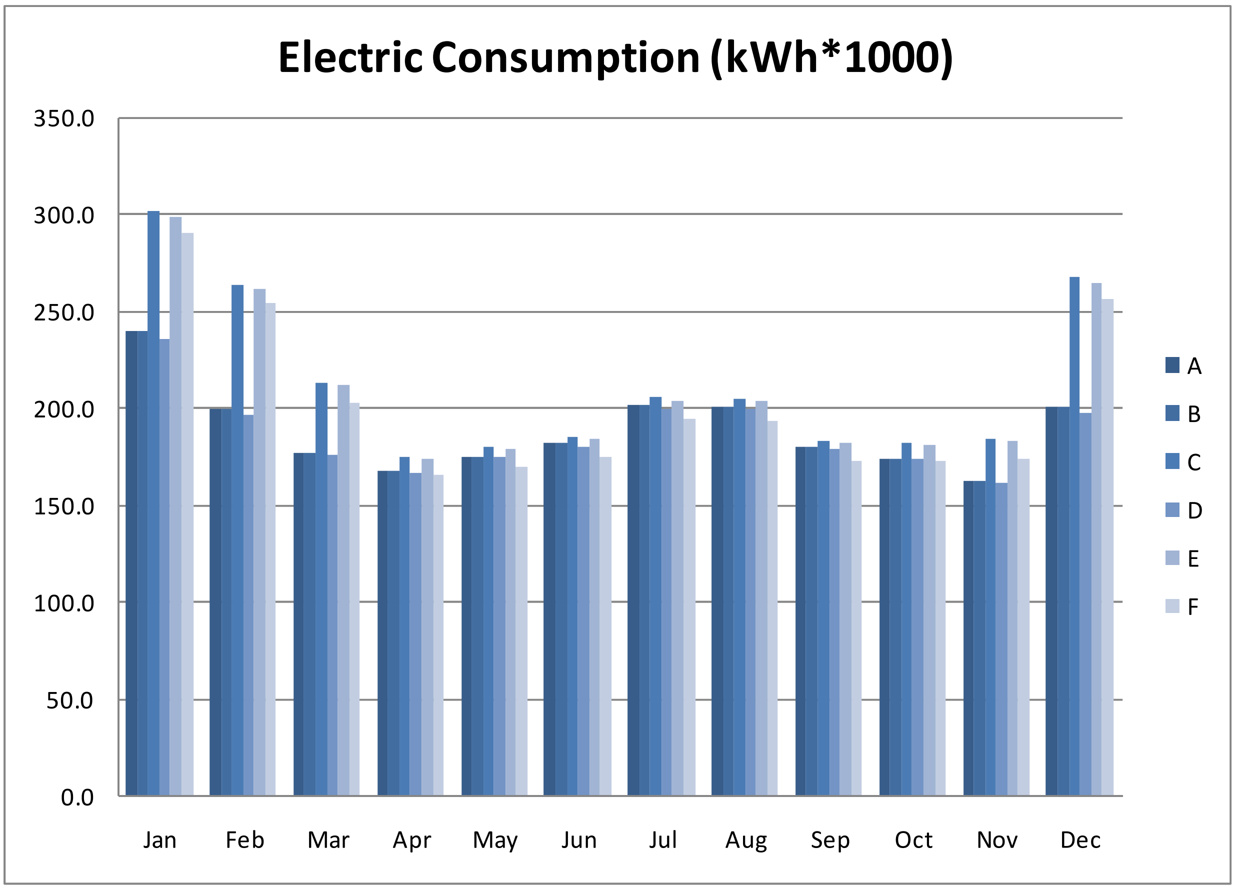

Figure 10 Electric Consumption of Proposed Redesigns

A. Original Building
B. Original Building + Daylighting Changes
C. Original Building + Daylighting Changes + 30% ventilation increase
D. Original Building + Daylighting Changes + Green Roof
E. Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof

F. Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof + Sensible Heat Exchanger

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A	239.6	199.5	176.9	167.7	175.4	181.8	201.8	201.1	179.7	174.3	162.3	200.4	2260.6
B	240.0	199.7	177.0	167.6	175.4	181.9	201.9	201.2	179.8	174.4	162.4	200.7	2262.0
C	301.7	264.0	212.9	174.6	179.7	185.7	205.9	205.3	183.6	181.9	184.0	267.5	2547.1
D	236.1	197.1	176.0	167.0	174.6	180.4	200.0	199.3	178.7	173.9	161.3	197.8	2242.1
E	298.6	261.8	212.0	174.1	179.0	184.4	204.2	203.6	182.6	181.5	182.9	264.9	2529.4
F	289.8	254.0	203.2	165.7	170.2	175.0	194.5	193.9	173.1	172.7	174.2	256.3	2422.5

Table 9 Annual Electric Consumption (kWh*1000)

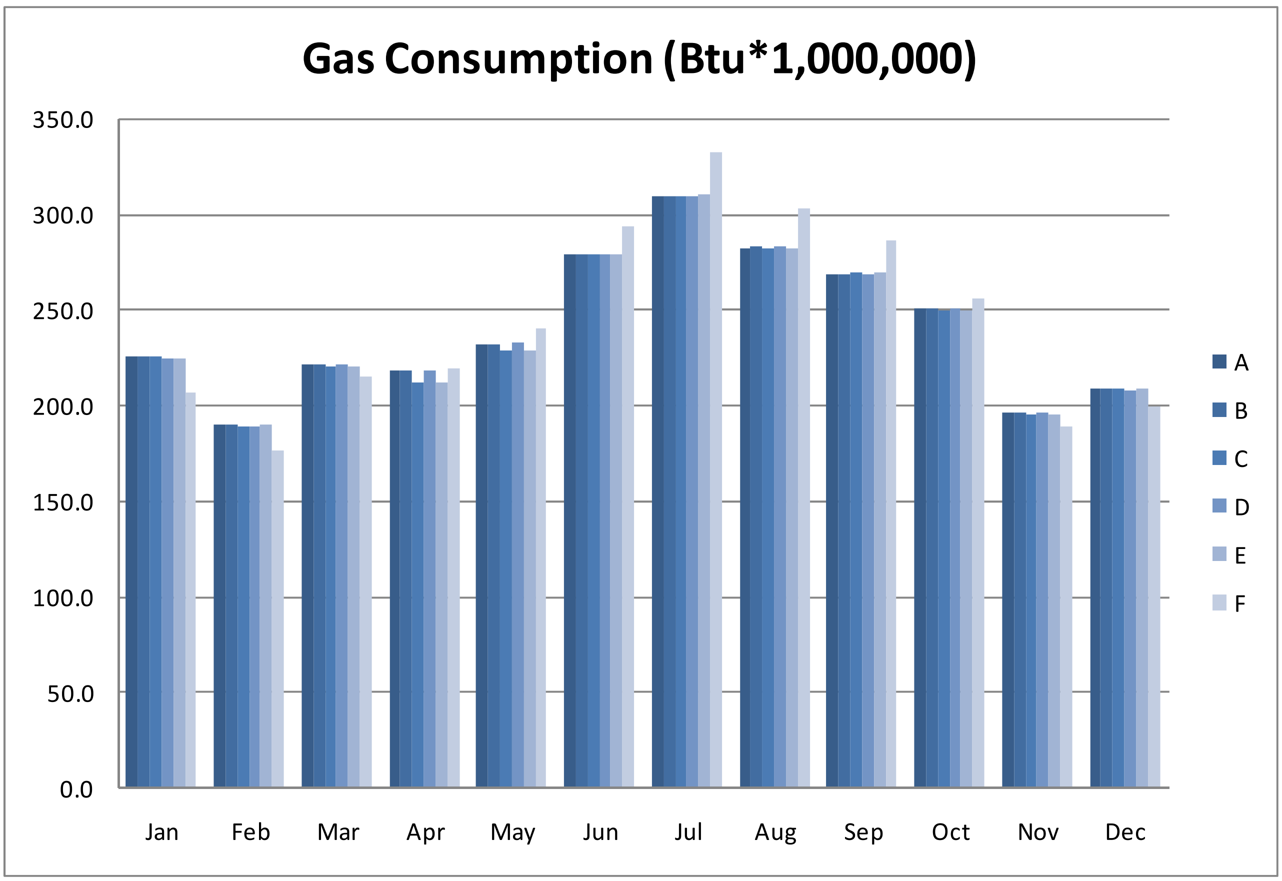

Figure 11 Gas Consumption (Btu * 1,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
A	225.4	190.1	221.9	217.9	232.4	278.7	309.3	282.6	268.4	250.6	196.2	209.2	2882.7
B	225.5	190.1	221.8	217.9	232.4	278.7	309.2	282.9	268.4	250.6	196.2	209.2	2882.9
C	225.3	189.4	220.6	212.4	228.4	278.9	309.4	281.9	269.1	249.9	194.9	209.4	2869.7
D	224.7	189.4	221.7	217.9	232.5	279.2	309.7	282.8	268.6	250.6	196.5	207.5	2881.2
E	225.0	190.6	220.0	212.5	228.5	279.4	309.9	282.4	269.8	249.9	194.9	208.6	2871.6
F	206.4	176.1	214.8	218.9	240.5	293.2	331.8	302.7	286.4	256.3	189.5	199.1	2915.8

Table 10 Gas Consumption (Btu * 1,000,000)

	Cooling Loads		Heating Loads		Elec. Consumption		Gas Consumption	
	Mbtu	% Diff.	Mbtu	% Diff.	kWhx1000	% Diff.	Btu	% Diff.
A	9088		1886		2260.6		2882.7	
B	9093	-0.06%	1889	-0.16%	2262.0	-0.06%	2882.9	-0.01%
C	9747	-7.25%	2556	-35.52%	2547.1	-12.67%	2869.7	0.45%
D	9006	0.90%	1859	1.43%	2242.1	0.82%	2881.2	0.05%
E	9644	-6.12%	2534	-34.36%	2529.4	-11.89%	2871.6	0.39%
F	9560	-5.19%	2554	-35.42%	2423.0	-7.18%	2916.0	-1.16%

Table 11 Cooling & Heating Loads, Electric and Gas Consumption Comparison

Original Building + Daylighting Changes + 30% ventilation increase

This scenario included all the changes done involving the daylighting changes, but also added extra ventilation. EQ Credit 1 requires the building ventilation system to increase the minimum outdoor air supply 30 percent from what it was originally designed for after ASHRAE Standard 62.1-2004. The existing outdoor air ratio to follow Standard 62.1 for the SWC was 25 percent, but after the 30 percent ventilation increase, the overall minimum outdoor air ratio is now 55 percent. This increases the loads for both heating and cooling because instead of using mostly recirculated air to supply to the spaces, this must be exhausted and more outside air is used instead. The outdoor air then takes more energy to heat or cool the air to an appropriate condition to supply to the spaces. Through eQuest, these increases for heating and cooling were found. When the building was simulated for this specific scenario, the cooling electric consumption increased 83,400 kWh (10 percent). On the opposite end, the heating electric consumption also increased 197,300 kWh (85 percent). Compared to the original design, the total electric consumption of the building increased by 285,100 kWh (13 percent). A more detailed description of the building loads can be found in Appendix B.

Original Building + Daylighting Changes + Green Roof

The eQuest building simulation results for the original building including a green roof did not prove to have the results expected. Aside from cutting down on stormwater runoff, green roofs have shown to lower heat flux through a building's roof extensively. Green roofs can be modeled by tweaking three characteristics; roof absorptance, roof R-value and evapotranspiration. Because of the limitations of eQuest, evapotranspiration was not able to be simulated however research is being done to model this in the future. The roof absorptance was assumed to have a value of 0.2 which is dramatically lower than the conventional roof absorptance of 0.7. Since the R-value of a green roof changes depending on if it is wet or dry and eQuest doesn't include precipitation in its simulation, an R-value of 3 was assumed. The reason for this is because a study done on several extensive roofs found to have an R-value between 2.4-2.7 ft^2 h °F/Btu. Although the results from this simulation did not provide the results expected, there was still an improvement. The annual cooling and heating electric consumption from this change were cut by 10,800 kWh (1.3 percent) and 8,400 kWh (3.6 percent) respectively. The proposed green roof was simulated to cover 24,000 of the 36,400 total square feet. The result is 66 percent of the roof being coved by the green roof and the rest being the area for the roof top units and skylights. A more detailed description of the building loads can be found in Appendix B.

Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof

This simulation involved all the changes done to the building. The electric and gas consumption increased for the daylighting changes and ventilation increase but decreased for the addition of the green roof. This simulation was the final model and was compared to the baseline model to be reviewed for LEED points. A comparison between four of the design scenarios can be found in Figure 12 and Table 12. A more detailed description of the building loads can be found in Appendix B.

Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof + Sensible Heat Exchanger

This simulation was very similar to the others that were conducted except there was a sensible heat exchanger added. For this situation, the heat exchanger is air-to-air. When air is being rejected into the atmosphere through the exhaust, the heat from this air is being captured and transferred to the outside air that's coming into the system. Most heat exchanger efficiencies range from 70% to 75% so for this simulation, the sensible effectiveness was assumed to be 0.75. The cooling loads and electric consumption were reduced significantly while the heating loads and gas consumption increased slightly. These numbers are reflected in

4 Baseline Building Simulations (Building Rotated at +0°, +90°, +180°, +270°)

To obtain any points through EA Credit 1, a baseline building was created that had most of the same qualities of the SWC and followed ASHRAE Standard 90.1-2004 Appendix G. Aside from being designed to meet and not exceed ASHRAE Standard 90.1, the other major difference from the baseline building and the SWC was the mechanical system. In the SWC, two rooftop units and one air handling unit supply conditioned air to the spaces whereas for the baseline building, an electric heat pump was to be modeled. Additionally, the baseline building is to be simulated when positioned four different ways. This is to properly gauge which position in reference to the sun is best for the building loads. A comparison between four of the design scenarios can be found in Figure 12 and Table 12. Also, comparison of the baseline building along with the three rotations can be found in Figure 13 and Table 14. A more detailed description of the building loads for the baseline building can be found in Appendix B.

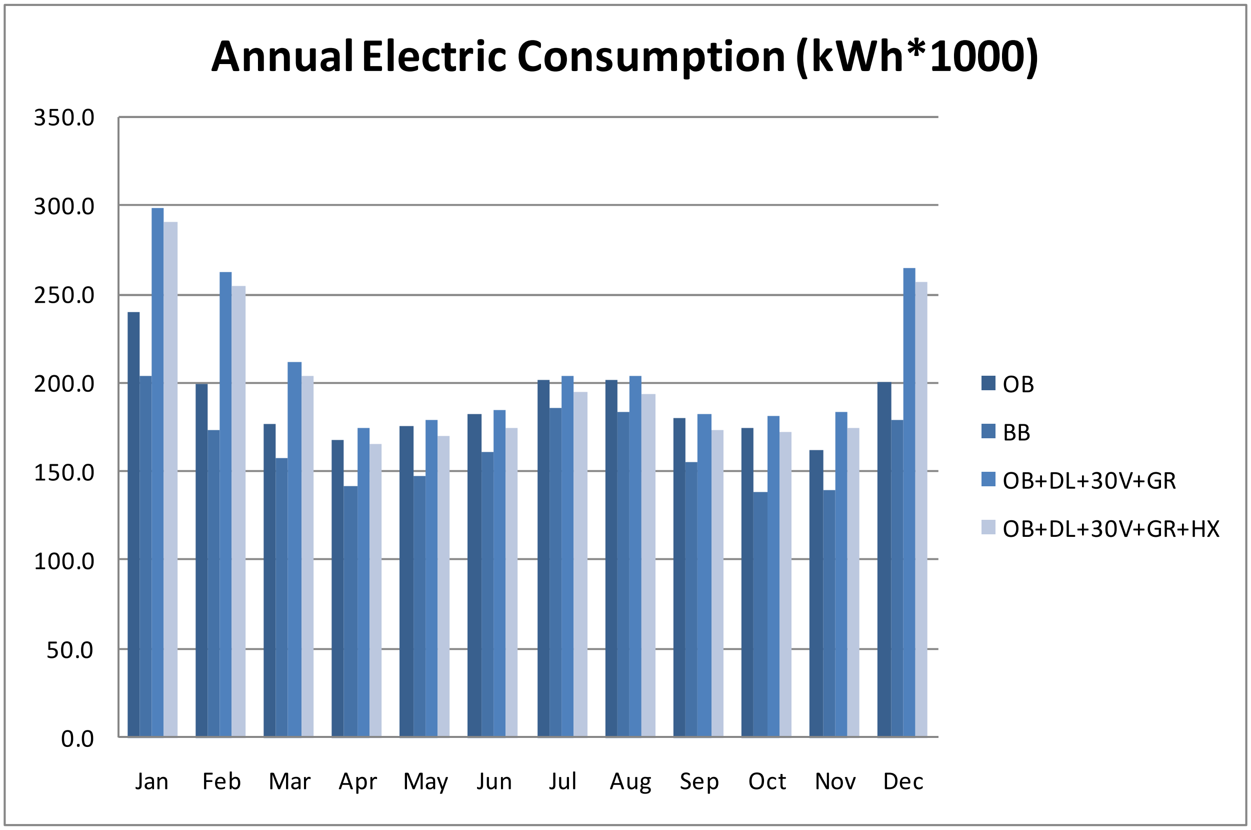

Figure 12 Electric Consumption (kWh*1000)

- OB - Original Building
- BB - Baseline Building (0° Rotation)
- OB+DL+30V+GR - Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof
- OB+DL+30V+GR+HX - Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof + Sensible Heat Exchanger

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
OB	239.6	199.5	176.9	167.7	175.4	181.8	201.8	201.1	179.7	174.3	162.3	200.4	2260.6
BB	203.7	173.1	157.9	141.3	147.0	160.5	186.1	183.9	155.1	138.9	139.2	179.5	1966.3
OB+DL+30V+GR	298.6	261.8	212.0	174.1	179.0	184.4	204.2	203.6	182.6	181.5	182.9	264.9	2529.4
OB+DL+30V+GR+HX	289.8	254.0	203.2	165.7	170.2	175.0	194.5	193.9	173.1	172.7	174.2	256.3	2422.5

Table 12 Electric Consumption (kWh*1000)

	Cooling Loads		Heating Loads		Elec. Consumption		Gas Consumption	
	Mbtu	% Diff.	Mbtu	% Diff.	kWhx1000	% Diff.	Btu	% Diff.
OB	9088		1886		2,260.60		2,882.70	
BB	3379	62.82%	1825	3.23%	1,966.30	13.02%	2,126.50	26.23%
OB+DL+30V +GR	9644	-6.12%	2534	-34.36%	2,529.40	-11.89%	2,871.60	0.39%
OB+DL+30V +GR+HX	9560	-5.19%	2554	-35.42%	2,423.00	-7.18%	2,916.00	-1.16%

Table 13 Cooling & Heating Loads, Electric and Gas Consumption Comparison

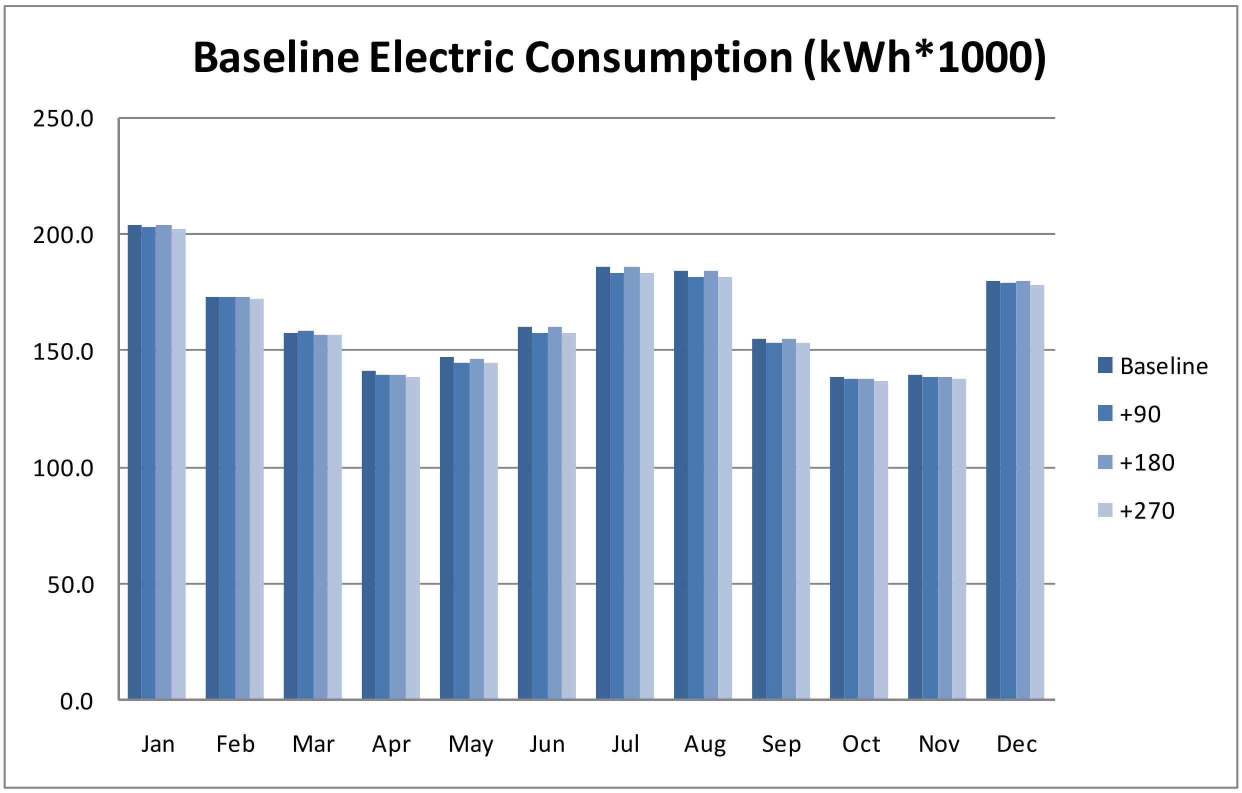

Figure 13 Baseline Electric Consumption (kWh*1000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Baseline	203.7	173.1	157.9	141.3	147.0	160.5	186.1	183.9	155.1	138.9	139.2	179.5	1966.3
+90	203.1	173.2	158.1	139.7	144.5	157.9	183.5	181.3	153.4	138.0	138.8	178.7	1950.2
+180	203.9	172.9	157.1	139.9	146.5	160.4	186.0	183.7	154.7	137.8	138.3	179.6	1960.9
+270	202.4	172.3	156.5	138.9	144.3	157.8	183.3	181.1	153.1	137.2	137.8	178.0	1942.8

Table 14 Annual Electric Consumption (kWh*1000)

	Cooling Loads		Heating Loads		Elec. Consumption		Gas Consumption	
	Mbtu	% Diff.	Mbtu	% Diff.	kWhx1000	% Diff.	Btu	% Diff.
Baseline	3379		1825		1,966.30		2,126.50	
+90	3312	1.98%	1819	0.33%	1,950.20	0.82%	2,107.80	0.88%
+180	3359	0.59%	1806	1.04%	1,960.90	0.27%	2,100.70	1.21%
+270	3305	2.19%	1826	-0.05%	1,942.80	1.20%	2,139.70	-0.62%

Table 15 Cooling & Heating Loads, Electric & Gas Consumption for Baseline Building

Energy Usage

The Suburban Wellness Center completed construction in November 2002 so therefore energy bills and usage were obtainable. From the monthly electric and gas bills gathered, electric and gas consumption follow a trend that is comparable to the trend shown by eQuest. The consumption of both utilities rises to a high during the winter and summer months and then drops to a low during the spring and fall months. The Btuh/SF that is compared with the existing data is based on only 44046 ft^2 being occupied. Currently not all the space is rented out to tenants, however for this building simulation, the unoccupied areas are assumed to be office space because it was originally designed as an office building.

Figure 14 shows a comparison of the electric consumption for existing data, data from the original design, data after the proposed design and data from the baseline building. The data from the original building and from the redesign are very similar except during the winter seasons. The btuh/ft^2 rate for the redesign peaks at over 20 while the original design simulation stays just below. This is because with the additional outside air being introduced into the building, the system is working harder than it did before to compensate for the cold weather. The existing data follows both the original design simulation and proposed design simulation lines but not quite as closely as they follow each other. The rate stayed consistent with both of the simulations until October 2006 where the existing data jumped and then never came back to the rate of the original design simulation and proposed design simulation. The baseline building simulation proves to be the most efficient because the usage per square feet ratio consistently stays below the other three options.

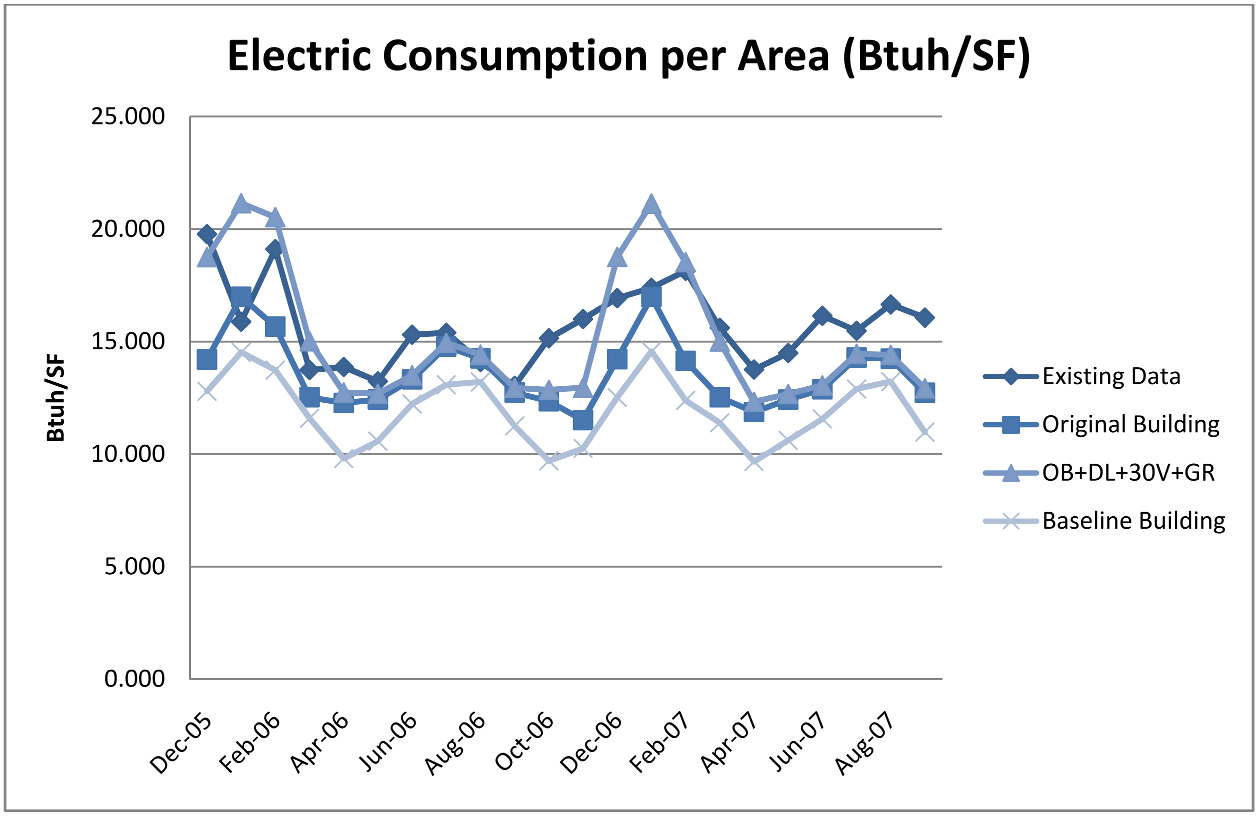

Figure 14 Comparison of Electric Consumption per Area

Figure 15 shows the gas consumption per area for the SWC. Initially, the data from the simulation compared well with the numbers from all simulation cases. More information was provided when the scenarios were plotted with respect to time. The curve for the existing data and the baseline building reach a high during the winter and decrease to a low during the summer however for the original design and redesign, this is opposite. During the summer, the gas consumption for the original design and redesign increased to the maximum value for the year and then decrease down to the minimum value for the year during the winter. This should not be the case because the gas consumption is based on when the water heaters for the building are used most. During the year, the outside temperature increases from the winter to the summer and then decreases from the summer to the winter. The gas fired hot water heaters are used to heat the water in the building and also indirectly heat the air in the swimming pool room as a result of heating the water. More heat is being lost in the winter to the outdoors because of the drop in temperature so therefore the maximum gas consumption should be in the winter. Because of the limitations of the user’s knowledge of eQuest, the gas consumption due to the domestic water heater was not accurately modeled. Among other things, an ample amount of information about the domestic hot water system was not provided to the designer upon research and analysis.

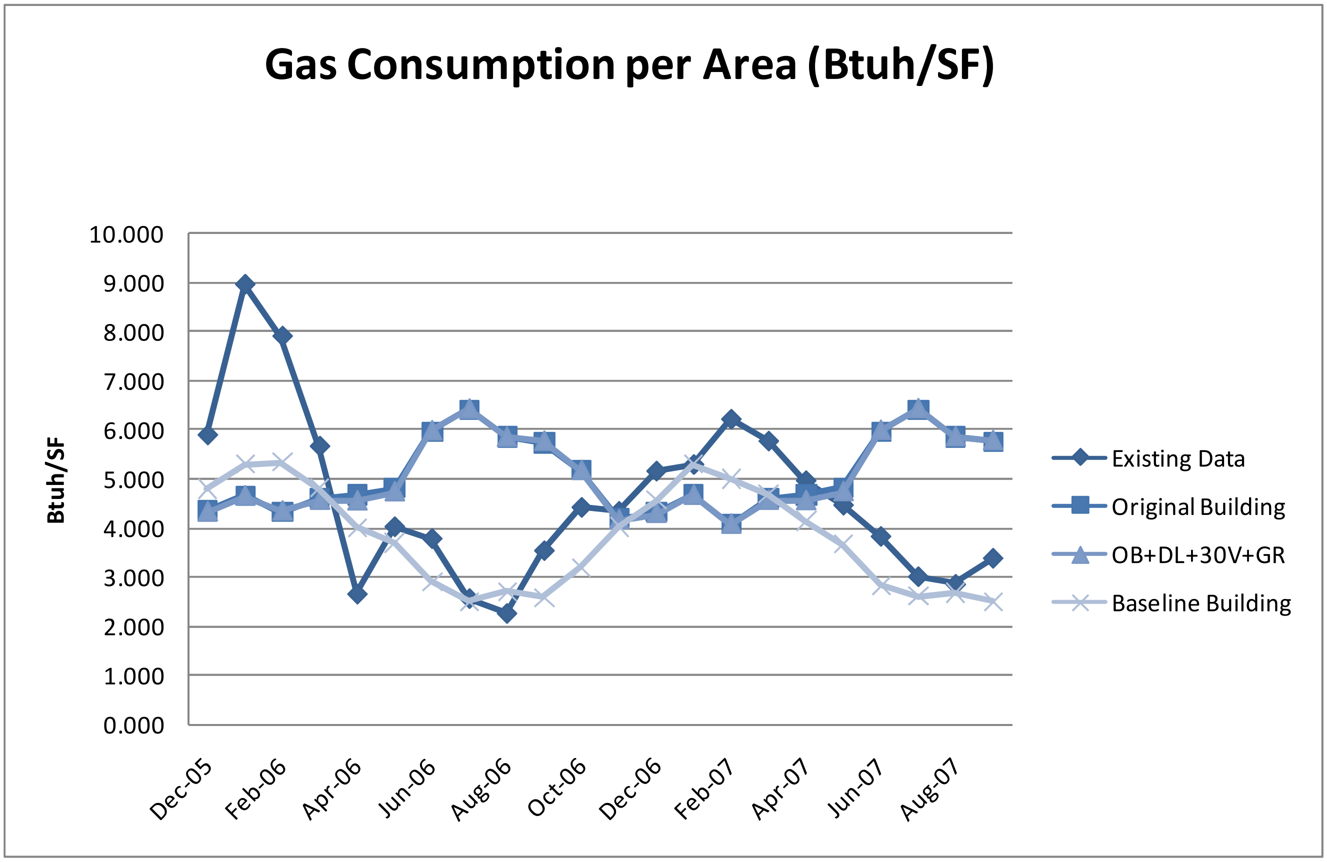

Figure 15 Comparison of Gas Consumption per Area

Mechanical Redesign

The existing mechanical system is comprised of two 90 ton rooftop units which supplies conditioned air to all the spaces except the swimming pool room. A 25 ton air cooled condensing unit and air handling unit supply up to 10,500 CFM to the swimming pool area via constant volume. The loads on the build fluctuated dramatically and because of that, the mechanical system will have to be redesigned. The modification with the daylighting and green roof provided minimal changes in the building loads, however the 30 percent increase in ventilation proved to have a significant change. To counter the additional loads brought on by the increase in ventilation, a heat exchanger was designed to recovery some of the energy expelled from the exhaust. Currently one rooftop unit is placed at the drawing north end of the building and the drawing south end of the building. This setup will remain intact because it allows for one RTU to supply one half of the building while the other RTU supplies to the other side of the building.

Typical Natatorium Design Conditions			
Type of Pool	Air Temp	Water Temp	Relative Humidity, %
Recreational	75-85	75-85	50-60
Therapeutic	80-85	85-95	50-60
Competitive	78-85	76-82	50-60
Diving	80-85	80-90	50-60
Whirlpool/spa	80-85	97-104	50-60

Table 16 Design Consideration for a Natatorium

Type of Pool	Typical Activity Factor (Fa)
Residential Pool	0.50
Condominium	0.65
Therapy	0.65
Hotel	0.80
Public, schools	1.00
Whirlpools, spas	1.00
Wavepools, water slides	1.50

Table 17 Pool Activity Levels

After simulating all the proposed design changes, a cooling load of 240 tons was needed. This made the two RTUs each rated at 120 ton. After the sensible heat exchanger was added to the system, the cooling load dropped by eight tons which brought the total cooling load for the building down to 232 tons. Since the designer was most comfortable with Trane products and Trane RTUs were used in the original design, the Trane IntelliPak 2 Rooftops were used. For the redesign, the ductwork and variable air volume boxes location and types stayed the same except they should be resized as needed. The heat exchanger is an option that is now offered in the Trane IntelliPack 2 Rooftops that were not offered when the building was originally designed and constructed.

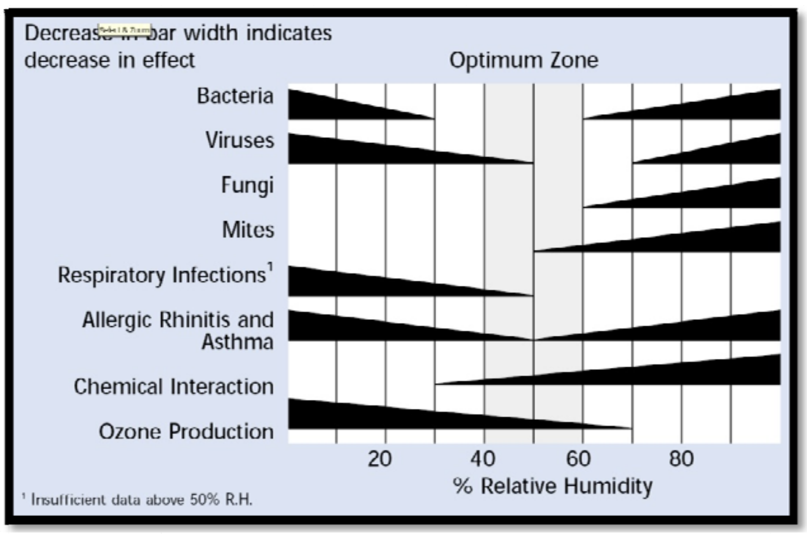

Figure 16 Health Factor Impacts

The northwest corner of the building which holds the swimming pool facility is conditioned by a dehumidification unit and compressor unit. AHU-1 supplies to the swimming pool facility which has a four lane wide lap pool, public spa and a therapy pool. This space needed a separate unit because of the criterion that must be met for swimming pools. To avoid thermal discomfort and a high evaporation rate, the humidity ratio, air temperature and water temperature must all be kept around a certain range. The humidity ratio must be kept in a certain range, typically between 50% and 60%, and the air temperature must be kept between 80°F and 88°F or 2°F above the desired water temperature. **Error! Reference source not found.** shows the appropriate temperatures and humidity levels for the given type of swimming pool. Swimming pool water temperature is also an important factor because of the temperature ranges needed depending on what the swimming pool is used for.

The redesign conducted assumed the different water temperatures for each of the three pools, but designed the system to condition air at 82°F and 50% relative humidity. From this, the evaporation of the water was found using the area of the pools and the activity levels of each pool. The activity level is dependent on the movement in the pool. Table 17 shows the different factors used for each type of pool. Residential pools are the lowest because it is assumed that only a few people are using them every so often while a wavepools are the highest because there is constant motion in the water which encourages water to evaporate. The details of the calculated evaporation rates can be found in **Error! Reference source not found.**. The evaporation rates for each pool were calculated separately and then combined at the end. With this information, a dehumidification system was able to be sized. Figure 16 shows the impact of certain health factors which may become a problem if the natatorium is not conditioned properly. There are several manufactures who manufacture dehumidification units for natatoriums and pools of all sizes however Dectron Inc. proved to be the most environmentally friendly. They've installed units in many LEED certified buildings including a natatorium located in New York City. The company's innovative designs allowed them to provide an earth friendly atmosphere to the patrons.

ER=0.1*A*AF*(Pw-Pdp)			
ER	Evaporation Rate of Water, lb/h		
A	Area of Pool Water Surface, ft2		
AF	Activity Factor		
Pw	Saturation Vapor Pressure at Water Surface, in. Hg		
Pdp	Partial Vapor Pressure at Room Air Dew Point, in. Hg		
For air velocity over water between 10-30 fpm			
	Lap Pool	Therapy	Whirl
Area	1800	323	115
AF	0.65	0.65	1
Air Temp	82	82	82
RH	50%	50%	50%
Water Temp	82	85	100
Pw	1.116	1.3052	1.95488
Pdp	0.57288	0.57288	0.57288
Evap Rate	63.55	15.38	15.89
ER Total			94.81

Table 18 Water Evaporation Rate Calculations

Finally, the last pieces of equipment to be sized due to the redesign are the domestic hot water heaters. The original design hot water system called for two 800 gallon natural gas water heaters. According to the simulation model, the domestic hot water heater needed to supply a load of about 1,210,000 Btu/h. After the changes done through the proposed design modifications this increased to 1,280,000 Btu/h. From the calculations, the hot water heaters that were in the original design are adequate to support the additional hot water load brought on by the new design. The rated input for the two units combined is 1,600,000 Btu/h but after the 80% efficiency the rated output for these units is 1,280,000 Btu/h. This is exactly the load which needs to be supplied to the system; however the existing units will not change because during the design phase the hot water heaters were oversized. The manufacturer and model will remain the same. To reduce emissions, a low-NOx burner will also be installed.

Improved Carbon Footprint

The amounts and types of emissions changes every year. These changes are caused by changes in the economy, industrial activity, traffic, technology improvements and server other factors. As the United States is becoming more conscience about the environmental problems that are plaguing the world due to emissions, several states have put regulations into effect. Many states make it mandatory for automobiles to pass an inspection to drive on the roads and some have put stringent restrictions on the emissions of buildings.

A major factor for how successful a building is environmentally designed is its carbon footprint. Cars, buildings and anything that uses coal and natural gas emit substances into the air due to the combustion of these fuels. With the introduction of alternative fuels and hybrid vehicles, cars are becoming more efficient and emitting fewer emissions. Buildings have followed the same path and are now being expected to operate more efficient and cleaner. The emissions of the Suburban Wellness Center were studied to compare the effects on the emissions of the redesigned system. Many people have used the carbon footprint as a basis of how sustainable a building is. The pounds of emission particles released into the air were calculated using the annual natural gas and electricity consumption as well as the rate at which these particles were released. The original data from electric and gas bills were used for this comparison; however this did not prove to be the best comparison. The SWC is not fully rented out which gives slightly skewed results. Only the first floor and part of the second floor is currently rented out to tenants; the rest is still open for other businesses. As a result, the calculations for the original data only cover part of the square footage of the building while the redesign and baseline building cover the entire building. The detailed calculations can be found in Appendix C.

Another comparison was used to decide if there was any change in the emissions of the mechanical system. The ratio of pounds of emission particles per square foot was used to evaluate the success of the mechanical system redesign on the overall building carbon footprint.

	Nox		SOx		CO2			
Natural Gas	lbm/SF	% Diff.	lbm/SF	% Diff.	lbm/SF	% Diff.	Hg lbm/SF	% Diff.
Original Data	0.00146		0		4.613		-	-
Redesign	0.00166	14%	0	0%	5.265	14%	-	-
Baseline	0.00122	-17%	0	0%	3.843	-17%	-	-
Electricity								
Original Data	0.146		0.715		88.566		0.0025	
Redesign	0.131	-11%	0.639	-11%	79.172	-11%	0.0022	-11%
Baseline	0.107	-27%	0.520	-27%	64.452	-27%	0.0018	-27%

Table 19 Emissions per SF & % Difference

Table 19 shows a significant improvement on the building carbon footprint. The redesign NOx and CO_2 for natural gas emissions increased while the baseline emission decreased. This seems accurate because the natural gas consumption increased for the redesign but decreased for the baseline building simulation. Allegheny Energy supplies power to the SWC and as a result, emissions are given off at the power plant to create electricity. Emission rates per MWh are released yearly and these rates were taken from a report done on the top 100 electricity generation companies in the United States. For the electricity emissions, both the redesign and baseline building design decreased the emissions compared to the original data. The overall design proved to be very efficient and had the overall effect of taking 73 cars of the roads.

After further reviewing the results, a discrepancy was found among data and calculations. The gas and electric consumption for the original data and original design model have a significant difference. This was overlooked after realizing the original data for the building received from the electric and gas bills covered only part of the building while the original design model results covered the entire building. The energy per square foot was then calculated which proved to have disappointing results. The energy per square foot for the original data is higher than the energy per square foot for the original design by nearly 8 percent. Table 20 shows a comparison of the original design simulation, redesign simulation and the baseline building simulation results. The pounds of emission per SF were calculated and compared to conclude if there was an improvement of building emissions. The detailed calculations of the comparison to the original design and the comparison to the original data can both be found in Appendix C.

Natural Gas	Nox lbm/SF	% Diff.	SOx lbm/SF	% Diff.	CO2 lbm/SF	% Diff.	Hg lbm/SF	% Diff.
Original Design	0.00165		0		5.205		-	-
Redesign	0.00166	1%	0	0%	5.265	1%	-	-
Baseline	0.00122	-26%	0	0%	3.843	-26%	-	-
Electricity								
Original Design	0.122		0.597		73.894		0.0021	
Redesign	0.131	7%	0.639	7%	79.172	7%	0.0022	7%
Baseline	0.107	-13%	0.520	-13%	64.452	-13%	0.0018	-13%

Table 20 Emissions Comparing Original Design, Redesign, and Baseline Building

Green Roof Structural Analysis

The proposed green roof has several mechanical system effects; however the weight of green roof also increases the structural loading. To analyze the impact of the green roof, a gravity analysis was conducted. The roof loading that was used for each material is as follows:

- ½ Inch. Roof Decking – 3 PSF
- 4 Inch. Polystyrene Insulation – 1.5 PSF
- Waterproofing Membrane – 0.7 PSF
- GreenGrid Green Roof System Trays – 15 PSF

The configuration of each bay throughout the roof structure does not change dramatically and so a typical bay was assumed and analyzed. An image of the typical bay can be seen in Figure 17. The bay is a 25′ by 25′ square with 20K3 steel joists that are offset 5′ o.c. The dead load with superimposed dead load totaled to 25.2 PSF.

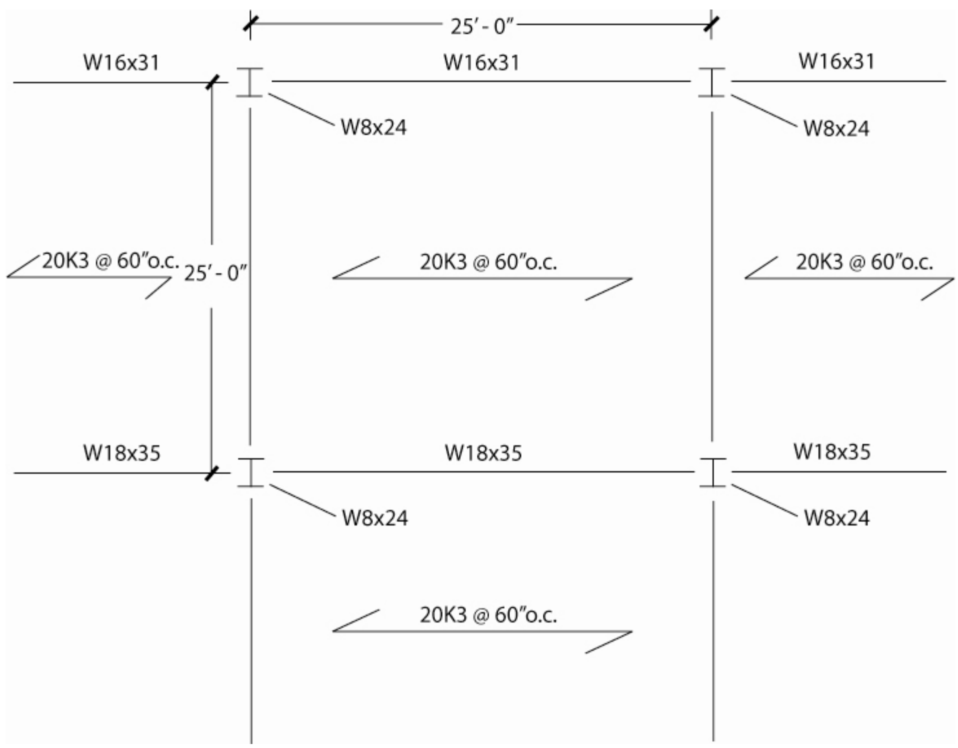

Figure 17 Typical Bay

The live loads and snow loads were also considered in the gravity analysis. A snow load of 30 PSF was assumed for the Suburban Wellness Center and since it has an ordinary, flat pitched roof, a live load of 20 PSF was assumed. Prescribed Load Combinations were used to determine the worst case scenario the proposed green roof would have on the building. Once the prescribed load combinations were calculated, this was checked with against the maximum total loading on the

20K3 and 30K11 steel joists. The 30K11 steel joist bays are set up similar to the 20K3 steel joist bay however extended twice the length. This gives the typical bay for a 30K11 steel joist bay a dimension of 25' by 50'. Steel girders support the steel joists and vary in two ways by size. All steel joist calculation figures came from the 42 edition of Standard Specification (10). W16x31 and W18x35 were both used the design of the roof structural system and were also analyzed. Both beams were checked and passed for deflection. Details of the calculations can be seen in Appendix D.

Daylighting Analysis

Daylighting Redesign

Natural sunlight has a huge impact on the way people feel. Although there have been many advancements in the lighting industry to try to trick the mind into thinking a fixture is sunlight, there is no substitute for natural daylighting. To achieve EQ Credit 8.1, 75 percent of the spaces must have a daylight measurement of 25 footcandles 30 inches off the floor. The main concern for this was not the perimeter but rather the core. Getting direct sunlight into the core of any two story building with a 2:1 aspect ratio can be very difficult.

One space that was studied particularly was the gymnasium located in the northwest part of the building. The space is two stories tall which allows for ample amount of daylight to travel to the corners of the room. AGI32 proved to be the best software to simulate the daylighting in the gymnasium and with the outputs, an analysis was done. Figure 18 shows a diagram of the areas of the gymnasium that have adequate daylighting.

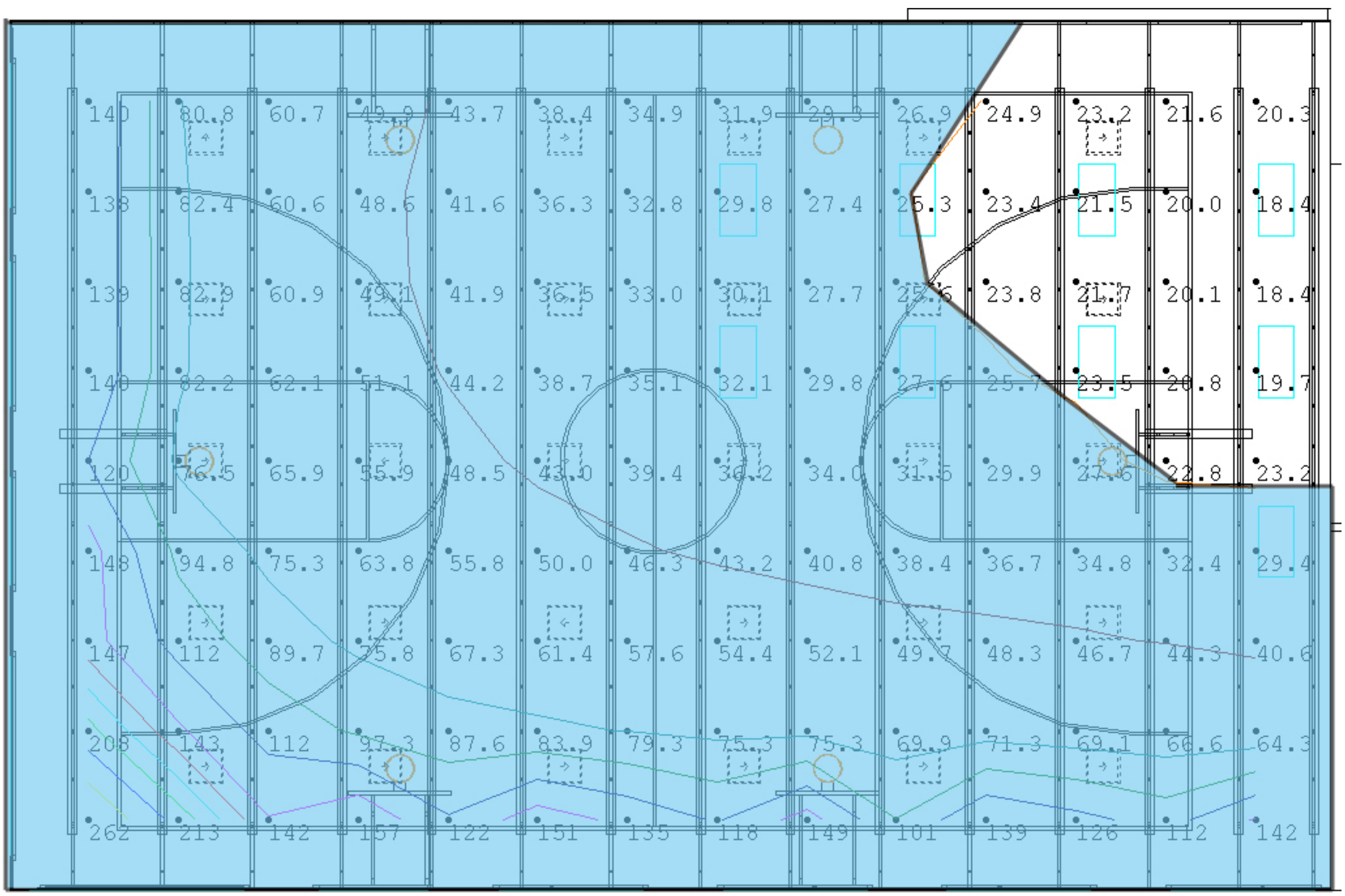

Figure 18 Gymnasium Adequate Daylighting

The area in blue has a minimum of 25 footcandles from 30 inches off the 2nd floor level. This scenario was used to analyze the impact of the skylights on the floors and to find out how far into the building the perimeter daylighting travels. With this, designing the location of each skylight will be possible. Another simulation was done where a single skylight was turned out thus allow sunlight into the area that didn't have a 25 fc measurement. Figure 19 shows the impact on the gymnasium the skylight has. The blue eclipse signifies the area that the skylight adds 25 fc. This was important when placing on the revised roof plan where each skylight would go to achieve 75 percent daylighting to the building.

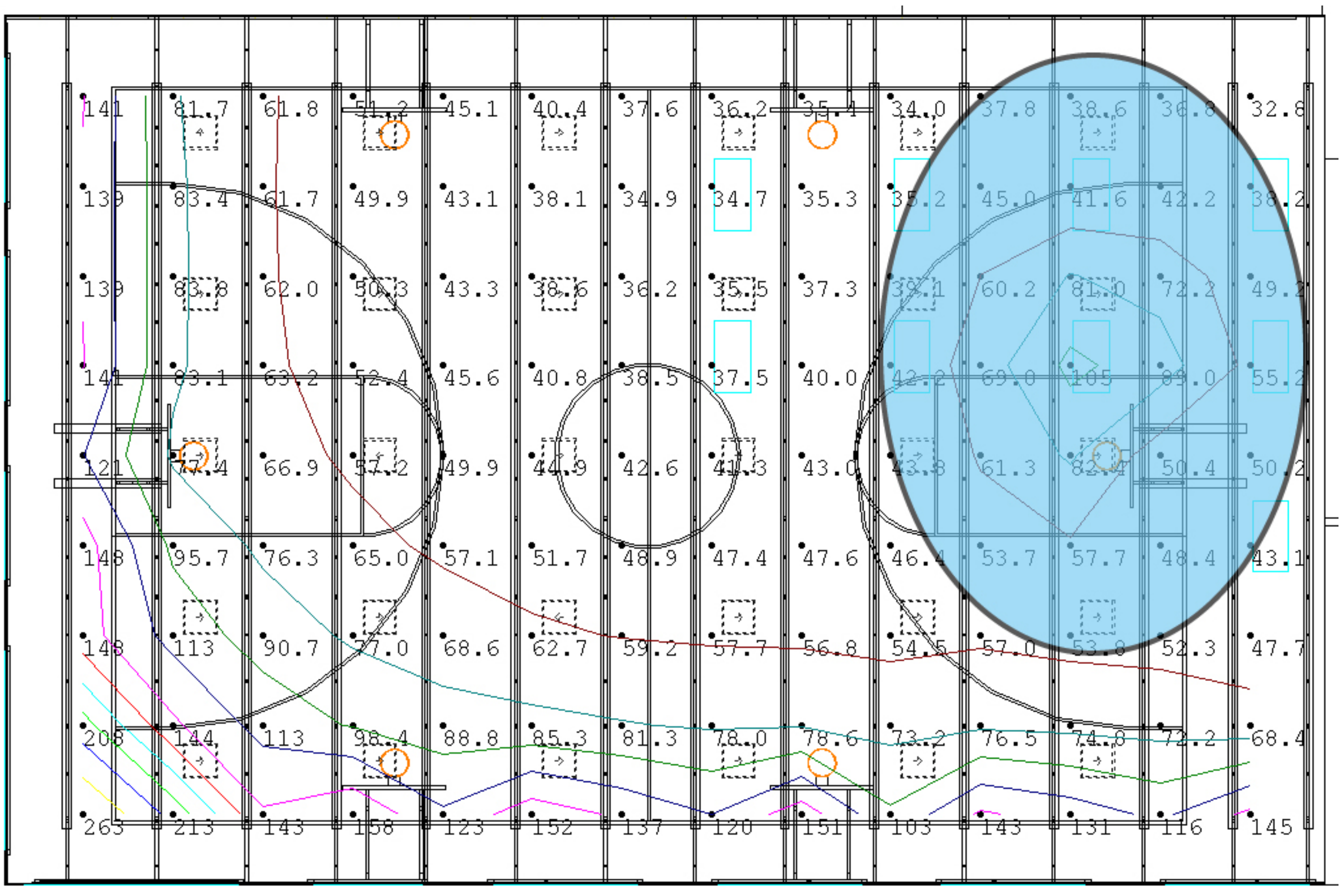

Figure 19 Skylight Daylighting Impact

With the area of that the skylight lit up the surface to 25fc, a roof plan was created where skylights were strategically placed to bring daylight into the core of the second floor where 25 fc was not met. Figure 20 shows a roof plan of the proposed skylight design. The red box in the center represents the area in the core which does not receive 25 fc of daylight based on the AGI32 calculations. 16 daylights were designed to correctly raise the daylighting levels to 25 fc in the interior spaces.

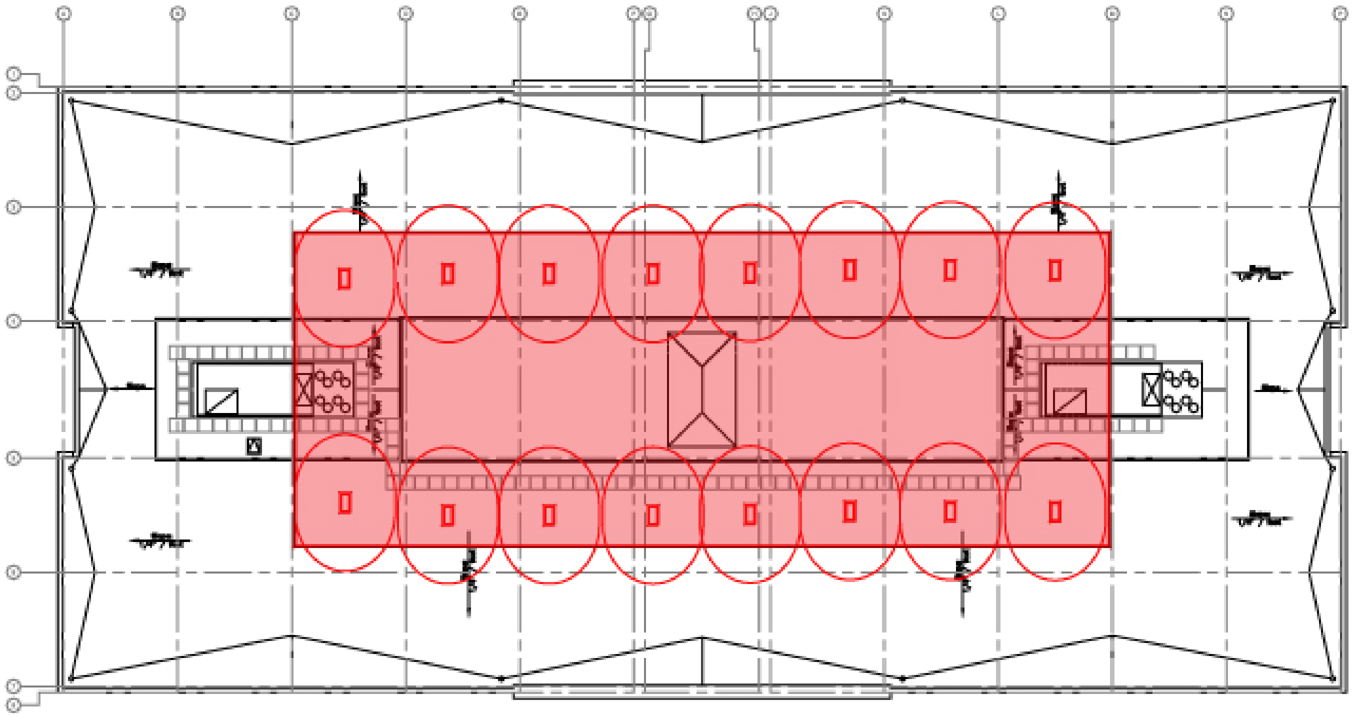

Figure 20 Proposed Skylight Roof Plan

The next problem was getting daylight into the core of the first floor. Skylights would not be a possibility because they cannot travel through an entire floor. Upon researching different alternatives, the best option decided was solartubes. Solartubes are tubes that pierce the roof, but collect sunlight and shine it down. They are much different than skylights because unlike skylights, the daylight that transfers through the solartube is much more concentrated. Solatube, a leading manufacturer of solartubes has several sizes to choose from and can be used for both residential and commercial use. Solatube daylighting systems are very efficient. A 21 inch open daylighting system has an average light output of 13,900 lumens whereas a typical 40W 48" fluorescent tube only produces 2300 lumens. The solatube daylighting system also doubles as a lighting fixture at night.

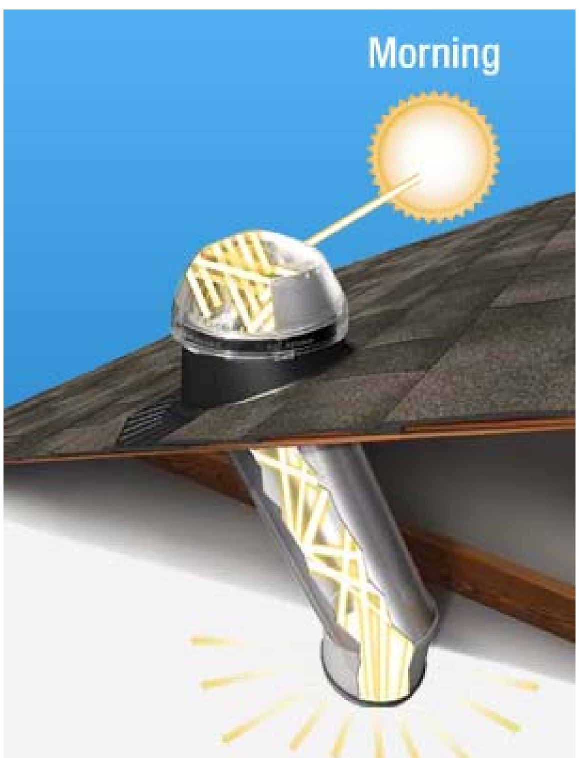

Figure 21 Solatube Diagram

Figure 22 Gymnasium Rendering Without Skylight

Figure 23 Gymnasium With Skylight

Figure 24 Gymnasium with Skylight and Lights On

Cost Analysis

There were several different changes done to the Suburban Wellness Center and cost can be an important aspect in the design process. The original design and the proposed design were calculated to analyze at what expense the proposed design would offer better services. Table 21 gives a detailed breakdown of the expense differences between the proposed design and original design. Included in the proposed design is pricing for the larger rooftop units, pool dehumidification unit, water heaters, commissioning for the mechanical equipment, skylights, zero-VOC paint and green roof system. The commissioning for mechanical equipment was included because to gain EA Credit 3, commissioning must be done on the building after building completion.

Proposed Design			Original Design		
Qty.	Item	Expense	Qty.	Item	Expense
2	120 Ton Rooftop Units	$ 469,956.20	2	90 Ton Rooftop Units	$ 367,320.00
1	Dehumidifier; 120-155 lb/hr	$ 65,971.17	1	Dehumidifier; 120-155 lb/hr	$ 65,971.17
2	300 gal. Gas Water Heaters	$ 12,649.16	2	300 gal. Gas Water Heaters	$ 12,649.16
	Commissioning for Mechanical Equipment	$ 4,018.00			
14	2x4 Skylights	$ 4,060.00			
200	1 Gal. Zero-VOC Paint	$ 9,406.00			
	Green Roof System	$ 360,000.00			
	Total	$ 926,060.53		Total	$ 445,940.33

Table 21 Detailed Cost Analysis

EQ Credit 4.2 requires the use of low-emitting VOC paints and coatings. Many paint and coating manufactures are offering products that emit low amounts of VOC and some that even emit no VOCs. Sherwin-William's Harmony line of paints and primers emit zero VOCs after application. Although the cost was expected to be much more than average VOC paints, it was not. For a flat finish, a one gallon pale of Harmony paint is only $2.50 more expensive.

Sherwin-Williams (per 1 gal. container)			
Finish	Classic 99 w/ VOC	Harmony Zero-VOC	$ Difference
Flat	$ 32.99	$ 35.49	$ 2.50
Semi-gloss	$ 34.99	$ 39.99	$ 5.00

Table 22 Paint Expense Comparison

The type of green roof was also an important expense to analyze. As discussed, there are two options for green roofing systems, modular or non-modular. The advantages and costs for the modular outweighed the non-modular so the green roof was designed for a modular system. Table 23 shows a detailed breakdown of the cost for each option per square foot. A more detailed cost analysis can be found in Appendix F.

Expenses	GreenGrid Green Roofing System	Hydrotech Green Roofing System
Materials Cost	$10.50-$11/SF	$15-$16/SF
Installation Cost	$2-$4/SF	$7-$9/SF
Total	$12.50-$15/SF	$22-$25/SF

Table 23 GreenGrid vs. Hydrotech Price Comparison

Conclusions and Recommendations

Green Roof System

The green roof system has several positive characteristics and if maintained correctly can benefit the building and owner immensely. A green roof cuts down on stormwater runoff, reduces the loads in a building, and preserves the roof membrane. The calculations and analysis proved to have good results; however because a green roof cannot be properly simulated in energy modeling software, its full benefit was not seen. Numerous studies and tests have been done to predict the effects on the building loads, but nothing has been implemented. The GreenGrid green roof system specifically is perfect for the Suburban Wellness Center because the materials and installation is not expensive and maintenance is minimal.

Indoor Environmental Quality

Clean air is a valuable asset to fitness centers and office building which makes the IAQ category of LEED particularly important. Several of the credits were shown to have a dramatic impact on the system and the patrons of the SWC will be able to tell a difference. 30% increased ventilation, zero-VOC paints and coatings, and a mechanical system flush-out all contribute a lot to providing the members with the cleanest air possible. The increased mechanical loads were high however after a sensible heat exchanger was installed; the loads weren't quite as excessive. The additional daylights are a good design, but the Solatube is a better design. The Solatube daylighting system is a compact, easy to install, cost effective way of bringing daylight into spaces.

Optimize Energy Performance

An important credit for any building going for a LEED rating, EA Credit 1Optimize Energy Performance is a credit that offers several points. After numerous simulations, the proposed design was not able to achieve any points from this credit. The existing and proposed system was a rooftop unit with variable air volume. These systems are not efficient and are used because of their low cost and easy installation. The baseline building consisted of an electric heat pump which in the end proved to be more efficient than the existing system. Although the rooftop units were chosen by the owner, a different system could be used for better efficiency.

Green Roof Structural Analysis

Since a green roof was added to the building, a gravity analysis was done on the roofing system. The system was checked against dead loads, live loads, snow loads and the additional load from the green roof. The GreenGrid trays carry a load of 15 psf which the existing roof structure was able to hold. If another green roof system was chosen, the roof structure might not have been able to hold the proposed design which would have resulted in the roof structure being redesigned. Since the existing roof system was able to support the green roof, both the green roof and the current roof system are recommended.

Daylighting Analysis

Getting daylight into the core of the first and second floor proved to be a difficult task, but it can be done. The initial design was for sixteen skylights to pierce the green roof to bring natural light into the spaces below. The Solatube Daylighting System is more appealing because the cross section through the roof isn't as large, more daylight comes through and there aren't quite as many losses due to heat transfer as there are for regular daylights. The Solatube Daylighting System was researched toward the end of this report so there isn't a lot of substantial data; however with further research, the Solatube Daylighting System could prove to be very beneficial to the SWC.

Yes	?	No			
3			**Sustainable Sites**		**14** Points
1			Credit 6.1	**Stormwater Design,** Quantity Control	1
1			Credit 6.2	**Stormwater Design,** Quality Control	1
1			Credit 7.2	**Heat Island Effect,** Roof	1
		0	**Energy & Atmosphere**		**17** Points
		0	Credit 1	**Optimize Energy Performance**	1 to 10
2			**Materials & Resources**		**13** Points
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
15	0		**Indoor Environmental Quality**		**15** Points
Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
1			Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
1			Credit 7.2	**Thermal Comfort**, Verification	1
1			Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1			Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No			
20	0	39	**Project Totals** (pre-certification estimates)		**69** Points

Table 24 LEED Proposed Design Checklist

Table 24 displays the LEED points that the proposed design for the Suburban Wellness Center would achieve. Zero points were awarded for the Optimize Energy Performance Credit because there wasn't a net savings in energy.

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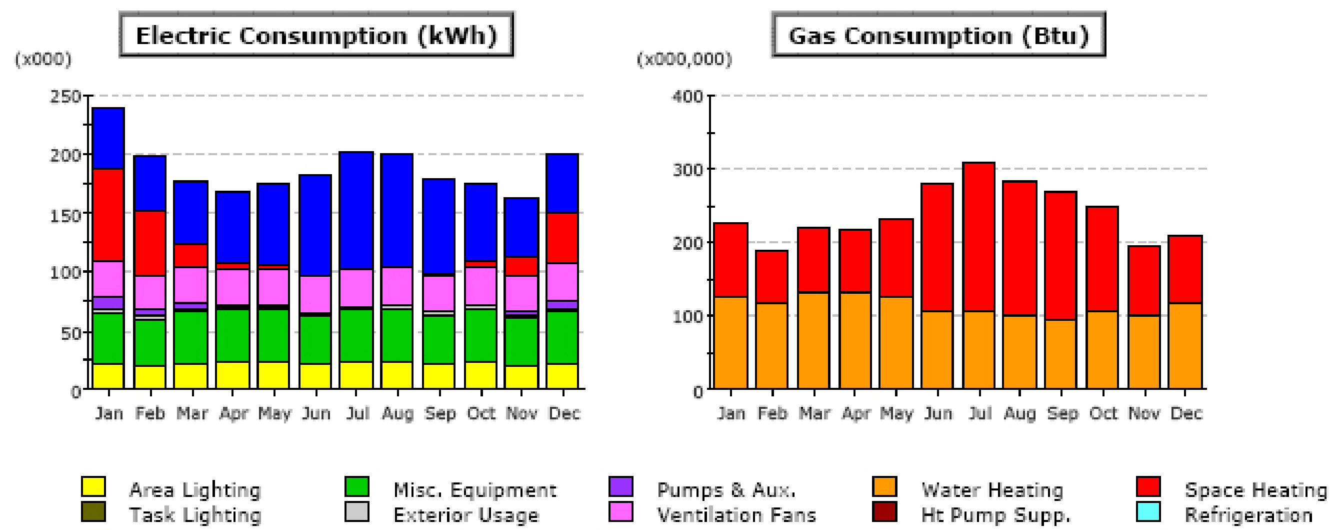
Appendix A | Green Roof Stormwater Discharge Rate Calculations

Variables	1 Year 24 Hour Design Storm	2 Year 24 Hour Design Storm	
I	0.34	0.34	Rv- Volumetric Runoff Coefficient
Rv	0.05	0.05	I- Percent Imperviousness
			Rv=0.05 + (0.009*I)
P (in)	2.6	3.2	Vr=(P*Rv*A)/12'
A (sq ft)	36380	36380	Vr- Water Quality Volume
WQv (CF)	418.24	514.75	P-Rainfall in inches
Qa	0.14	0.17	Montgomery County
CN	57.00	51.86	1 Year 24 Hour Design Storm = 2.6 in
			2 Year 24 Hour Design Storm = 3.2 in
			Qa- Runoff Volume
			Qa=P*Rv
Tt	0.14	0.14	Tt=((0.007*(n*L)^0.8)/((P2)^0.5*s^0.4))
n	0.022	0.022	Tt- Travel time (hr)
L	200	200	n-Manning's Roughness Coefficient
P2	3.2	3.2	L-Flow Length (ft)
s	0.0025	0.0025	P2- 2year, 24 hour rainfall (in)
			s- slope of hydraulic grade line
Ia	1.509	1.857	Ia=(200/CN)-2
Ia/P	0.580	0.580	
qu (csm/in)	450	450	qu(from TR-55 Exhibit 4II)
Area (sq mi)	0.001305	0.001305	
Qp (cfs)	0.081	0.100	Qp=qu*area*Qa

Appendix B | eQuest Building Simulation Outputs

Original Design



Electric Consumption (kWh x000)

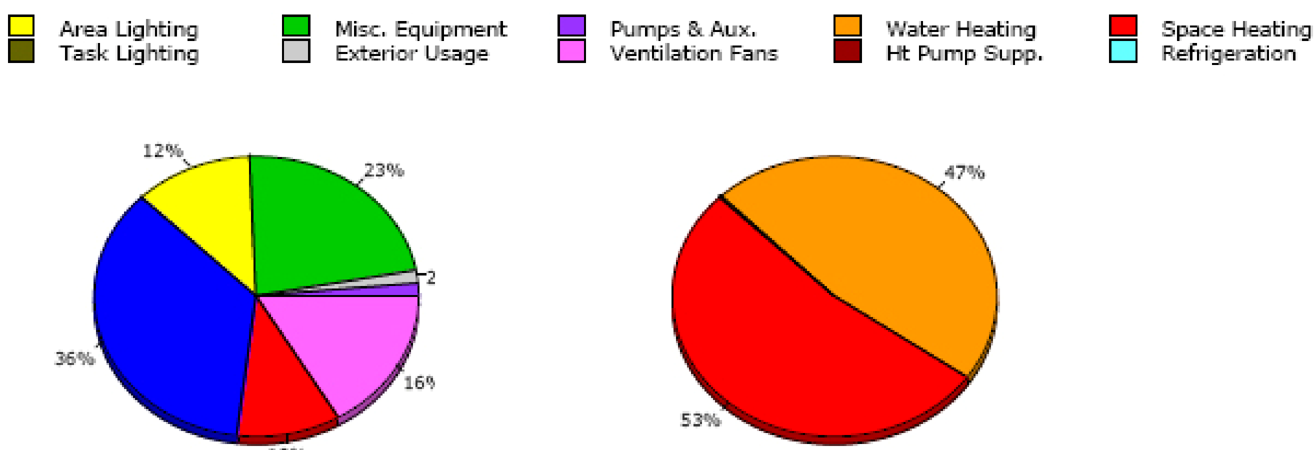
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	52.0	46.7	53.5	59.5	70.1	84.4	99.0	96.4	80.4	64.5	50.3	50.9	807.8
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	78.0	55.5	19.2	5.7	2.4	1.1	0.8	0.9	2.2	6.1	15.6	43.2	230.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	31.7	28.4	30.7	30.5	31.8	31.0	31.9	32.1	30.8	31.5	29.5	30.7	370.6
Pumps & Aux.	8.8	6.8	4.4	1.5	1.1	0.1	0.1	0.1	0.1	0.9	3.0	6.2	33.0
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	239.6	199.5	176.9	167.7	175.4	181.8	201.8	201.1	179.7	174.3	162.3	200.4	2,260.6

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.7	71.8	90.4	84.0	107.8	172.9	202.4	180.7	175.5	145.1	96.8	91.2	1,518.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.4	1,358.4
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	225.4	190.1	221.9	217.9	232.4	278.7	309.3	282.6	268.4	250.6	196.2	209.2	2,882.7

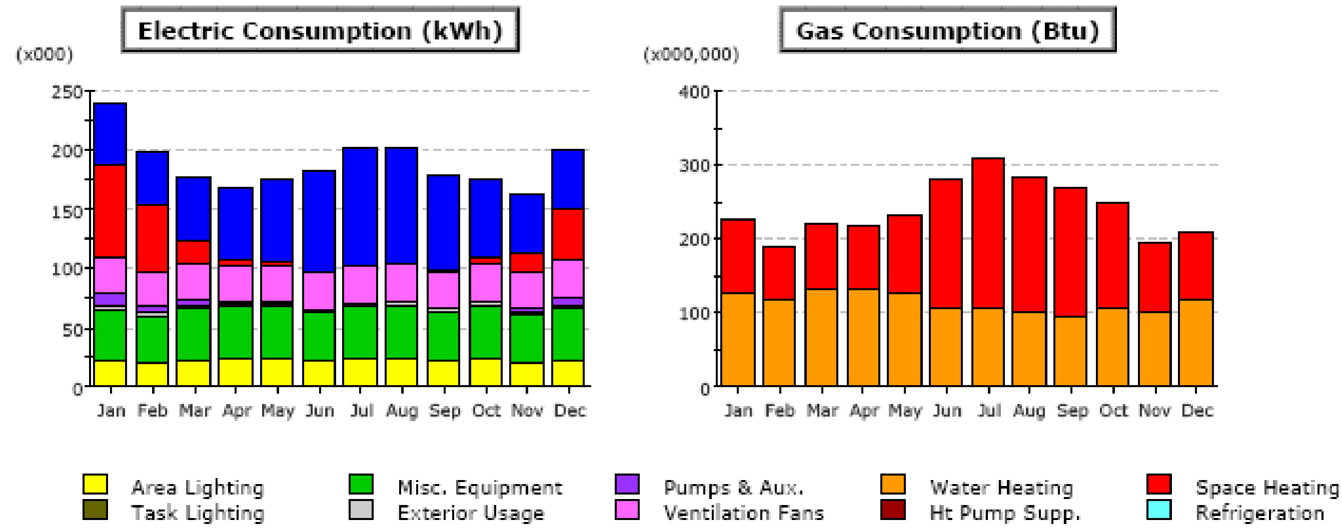
Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	807.8	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	230.8	1,518.3	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.4	-	-
Vent. Fans	370.6	-	-	-
Pumps & Aux.	33.0	5.9	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,260.6	2,882.7	-	-



Electricity **Natural Gas**

Original Design + Daylighting Changes



Electric Consumption (kWh x000)

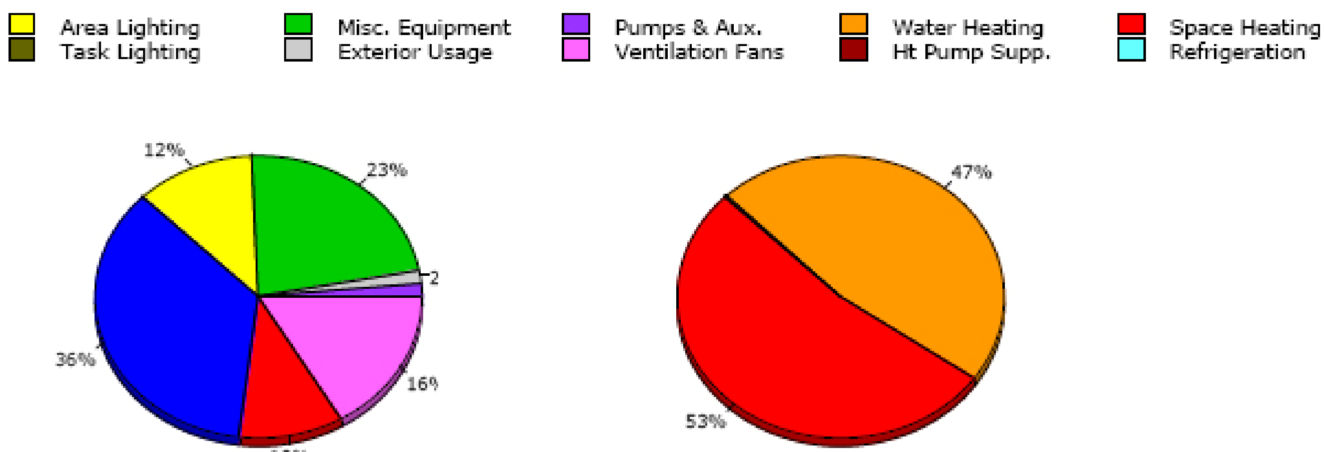
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	52.0	46.7	53.5	59.6	70.1	84.5	99.1	96.5	80.5	64.5	50.3	50.9	808.3
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	78.4	55.7	19.3	5.7	2.4	1.1	0.8	0.9	2.2	6.1	15.7	43.5	231.6
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	31.7	28.4	30.7	30.5	31.8	31.0	31.9	32.1	30.8	31.5	29.5	30.7	370.6
Pumps & Aux.	8.8	6.8	4.4	1.5	1.1	0.1	0.1	0.1	0.1	0.9	3.0	6.3	33.0
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	240.0	199.7	177.0	167.6	175.4	181.9	201.9	201.2	179.8	174.4	162.4	200.7	2,262.0

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.8	71.8	90.3	83.9	107.8	172.9	202.4	180.9	175.5	145.1	96.9	91.2	1,518.6
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.4	1,358.4
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	225.5	190.1	221.8	217.9	232.4	278.7	309.2	282.9	268.4	250.6	196.2	209.2	2,882.9

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	808.3	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	231.6	1,518.6	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.4	-	-
Vent. Fans	370.6	-	-	-
Pumps & Aux.	33.0	5.9	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,262.0	2,882.9	-	-



Electricity

Natural Gas

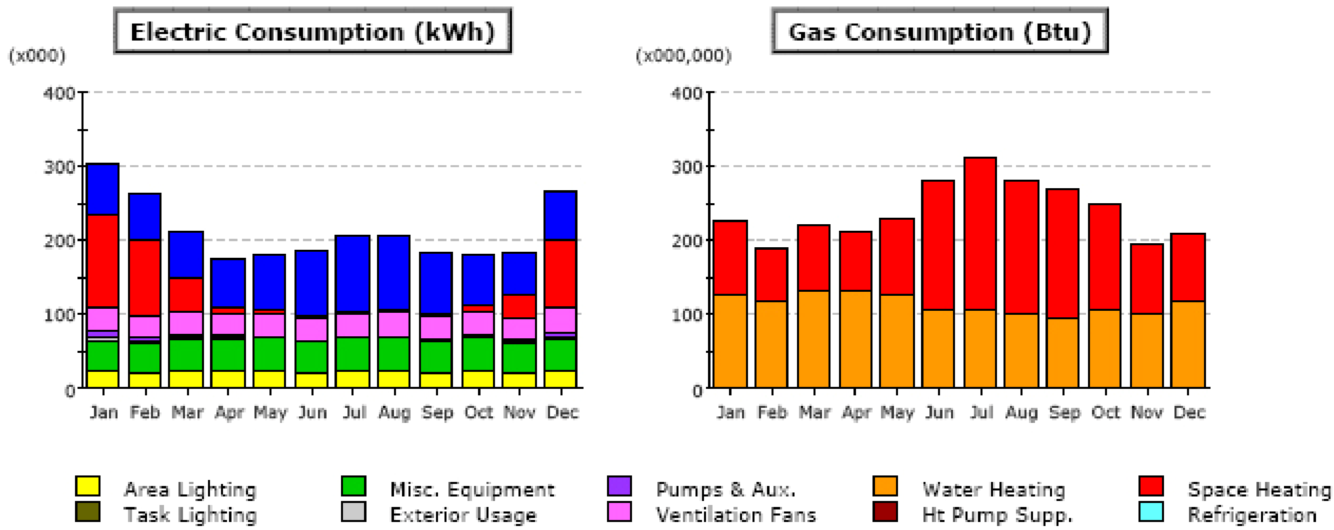
Suburban Wellness Centerswp DOE-2.2-44d3 4/02/2008 23:30:10 BDL RUN 1

REPORT- SS-D Building HVAC Load Summary WEATHER FILE- WASHINGTON, DC

MONTH	COOLING ENERGY (MBTU)	COOLING TIME OF MAX DY	COOLING TIME OF MAX HR	COOLING DRY-BULB TEMP	COOLING WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	HEATING TIME OF MAX DY	HEATING TIME OF MAX HR	HEATING DRY-BULB TEMP	HEATING WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	635.45593	17	19	3.F	2.F	2560.012	-358.626	17	19	3.F	2.F	-1713.437	236403.	766.958
FEB	544.24463	27	7	14.F	13.F	2198.408	-256.939	4	6	8.F	6.F	-2041.232	197018.	818.030
MAR	586.90216	13	7	24.F	23.F	1906.832	-137.982	18	6	24.F	20.F	-1212.568	173934.	583.550
APR	662.38177	2	17	82.F	63.F	2081.786	-78.645	12	7	32.F	27.F	-670.536	164726.	444.031
MAY	791.74634	31	19	92.F	77.F	2574.139	-82.760	30	22	70.F	68.F	-422.628	173326.	459.040
JUN	952.71112	26	10	84.F	74.F	2593.013	-118.407	27	10	71.F	70.F	-376.423	179904.	445.981
JUL	1095.20593	26	17	87.F	77.F	2597.101	-137.324	31	21	76.F	74.F	-362.263	199819.	456.224
AUG	1063.28516	16	17	96.F	77.F	2631.919	-123.219	1	21	71.F	68.F	-335.472	197777.	477.919
SEP	908.73700	3	17	91.F	77.F	2638.296	-124.011	22	9	61.F	60.F	-408.256	176506.	463.514
OCT	741.40900	15	17	81.F	65.F	2158.878	-119.026	31	7	23.F	22.F	-1003.163	170953.	545.315
NOV	546.96692	12	7	23.F	23.F	1959.315	-125.382	12	6	25.F	25.F	-1444.564	158958.	658.178
DEC	563.95972	30	7	20.F	18.F	2082.273	-226.510	30	7	20.F	18.F	-1465.730	197142.	676.863
TOTAL	9093.005						-1888.833						2226467.	
MAX						2638.296						-2041.232		818.030

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY) 0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE) 0.000 (KBTU)

Original Building + Daylighting Changes + 30% Ventilation Increase



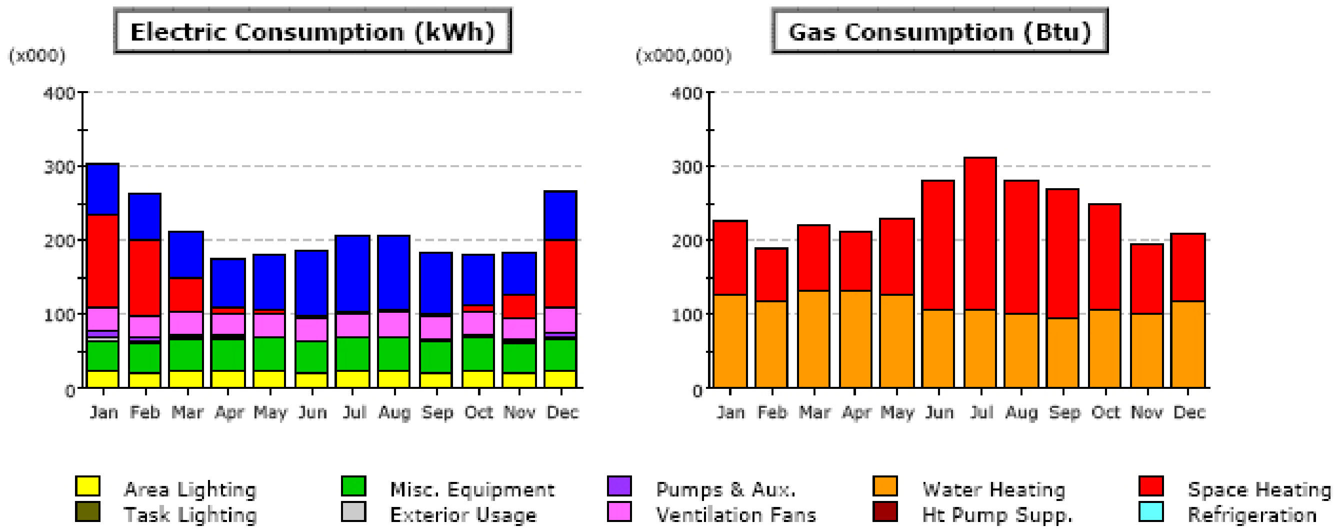
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	66.2	61.2	63.2	63.3	73.1	87.4	102.0	99.4	83.4	68.6	57.0	66.8	891.7
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	124.7	104.0	44.9	9.3	3.6	2.2	2.0	2.2	3.3	9.9	30.4	92.6	428.9
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	33.0	29.9	31.4	30.0	31.5	30.8	31.8	32.0	30.6	31.1	29.7	32.5	374.4
Pumps & Aux.	8.7	6.7	4.4	1.6	1.5	0.1	0.1	0.1	0.1	0.9	2.9	6.3	33.6
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	301.7	264.0	212.9	174.6	179.7	185.7	205.9	205.3	183.6	181.9	184.0	267.5	2,547.1

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.6	71.1	89.1	78.5	103.8	173.1	202.5	180.0	176.3	144.4	95.5	91.5	1,505.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.5	1,358.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	225.3	189.4	220.6	212.4	228.4	278.9	309.4	281.9	269.1	249.9	194.9	209.4	2,869.7

Original Building + Daylighting Changes + 30% Ventilation Increase



Electric Consumption (kWh x000)

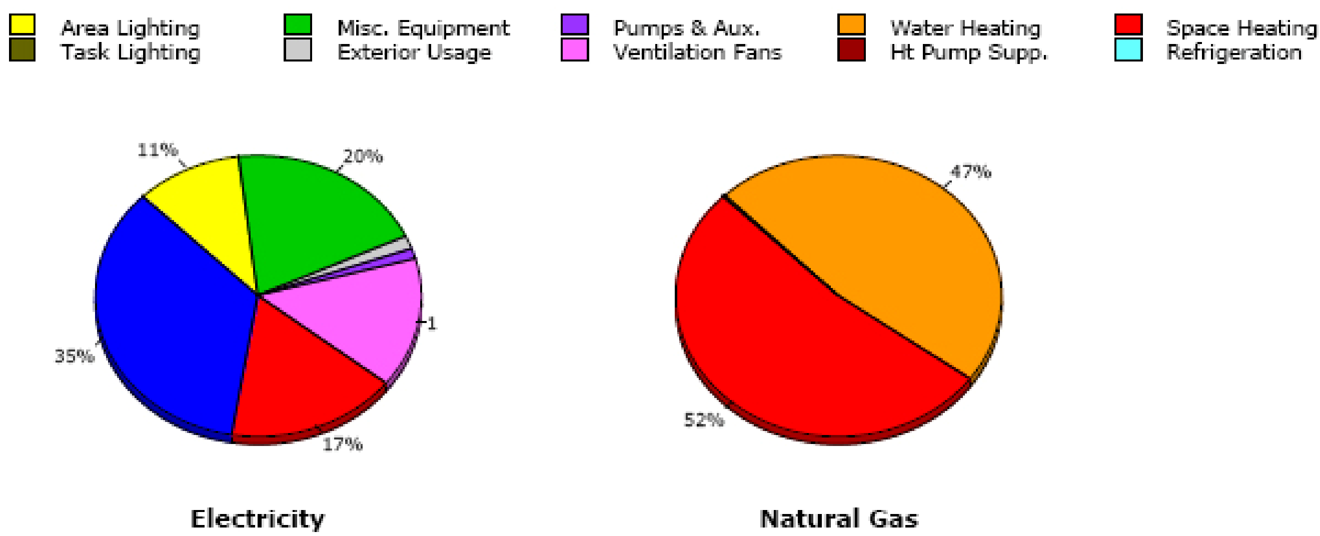
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	66.2	61.2	63.2	63.3	73.1	87.4	102.0	99.4	83.4	68.6	57.0	66.8	891.7
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	124.7	104.0	44.9	9.3	3.6	2.2	2.0	2.2	3.3	9.9	30.4	92.6	428.9
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	33.0	29.9	31.4	30.0	31.5	30.8	31.8	32.0	30.6	31.1	29.7	32.5	374.4
Pumps & Aux.	8.7	6.7	4.4	1.6	1.5	0.1	0.1	0.1	0.1	0.9	2.9	6.3	33.6
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	301.7	264.0	212.9	174.6	179.7	185.7	205.9	205.3	183.6	181.9	184.0	267.5	2,547.1

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.6	71.1	89.1	78.5	103.8	173.1	202.5	180.0	176.3	144.4	95.5	91.5	1,505.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.5	1,358.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	225.3	189.4	220.6	212.4	228.4	278.9	309.4	281.9	269.1	249.9	194.9	209.4	2,869.7

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	891.7	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	428.9	1,505.3	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.5	-	-
Vent. Fans	374.4	-	-	-
Pumps & Aux.	33.6	6.0	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,547.1	2,869.7	-	-



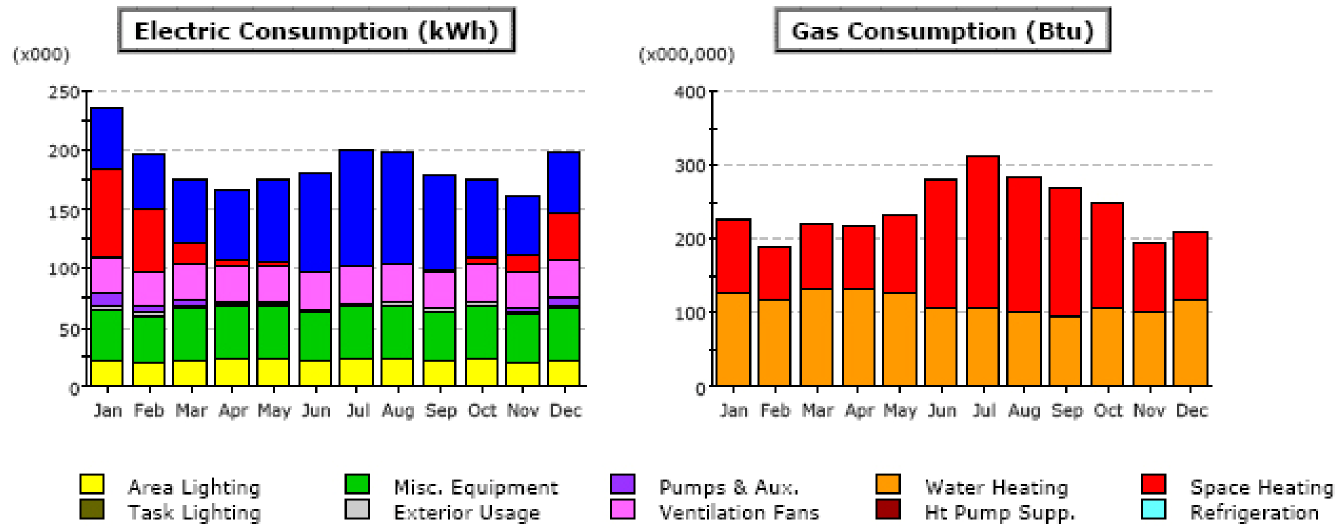
Suburban Wellness Centerswp DOE-2.2-44d3 4/02/2008 23:30:56 BDL RUN 1

REPORT- SS-D Building HVAC Load Summary WEATHER FILE- WASHINGTON, DC

	C O O L I N G						H E A T I N G						E L E C	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	798.71149	17	19	3.F	2.F	2882.713	-516.447	22	6	20.F	19.F	-2015.597	298168.	879.274
FEB	715.72668	27	7	14.F	13.F	2632.742	-421.071	4	6	8.F	6.F	-2281.179	261301.	908.819
MAR	668.38049	13	7	24.F	23.F	2387.754	-224.609	18	6	24.F	20.F	-1678.728	209879.	761.579
APR	663.16364	2	17	82.F	63.F	2066.292	-87.985	12	7	32.F	27.F	-996.090	171675.	574.964
MAY	788.06628	31	19	92.F	77.F	2552.847	-85.611	30	22	70.F	68.F	-422.885	177630.	459.270
JUN	954.53766	26	10	84.F	74.F	2590.210	-122.376	27	10	71.F	70.F	-376.884	183701.	450.478
JUL	1101.00049	26	17	87.F	77.F	2592.386	-141.609	31	21	76.F	74.F	-362.486	203855.	462.121
AUG	1067.68567	16	17	96.F	77.F	2629.469	-126.996	1	21	71.F	68.F	-336.061	201874.	480.143
SEP	910.63190	3	16	91.F	77.F	2653.527	-128.226	22	9	61.F	60.F	-420.761	180355.	472.516
OCT	749.27338	31	7	23.F	22.F	2406.970	-131.810	31	7	23.F	22.F	-1451.444	178527.	711.028
NOV	589.44659	18	7	21.F	21.F	2524.522	-174.561	12	6	25.F	25.F	-1831.587	180586.	806.213
DEC	740.87366	16	8	21.F	18.F	2508.791	-394.447	30	7	20.F	18.F	-1840.241	263993.	816.882
TOTAL	9747.492						-2555.748						2511541.	
MAX						2882.713						-2281.179		908.819

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY) 0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE) 0.000 (KBTU)

Original Building + Daylighting Changes + Green Roof



Electric Consumption (kWh x000)

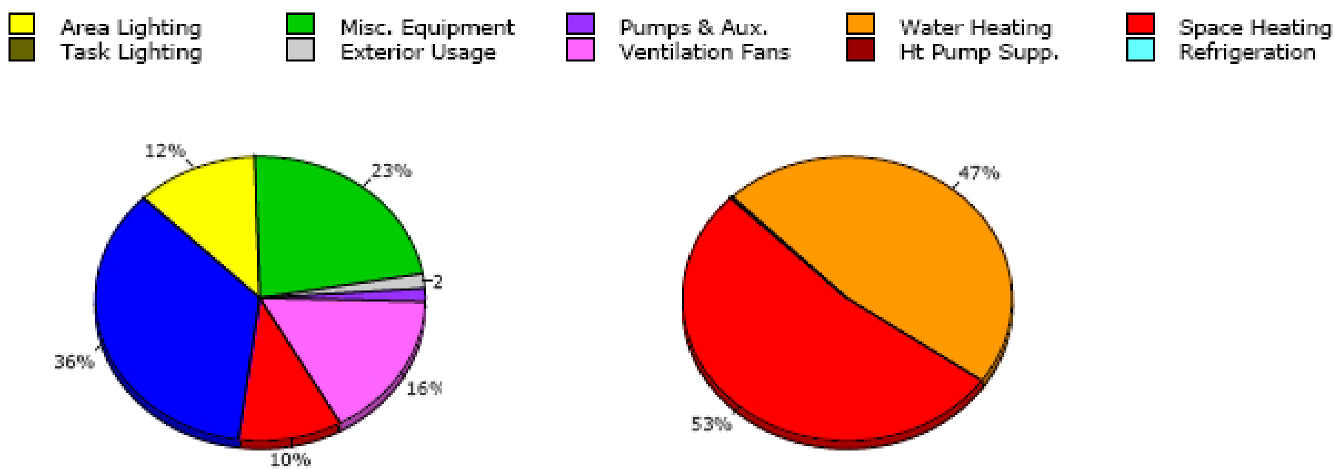
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	51.6	46.4	53.2	58.8	69.1	82.8	97.2	94.5	79.2	63.9	50.1	50.6	797.5
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	75.0	53.4	18.7	5.8	2.6	1.4	1.0	1.2	2.4	6.2	14.7	40.9	223.2
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	31.7	28.4	30.7	30.5	31.7	30.8	31.8	31.9	30.6	31.5	29.5	30.7	369.9
Pumps & Aux.	8.7	6.8	4.4	1.5	1.1	0.1	0.1	0.1	0.1	0.9	2.9	6.3	33.0
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	236.1	197.1	176.0	167.0	174.6	180.4	200.0	199.3	178.7	173.9	161.3	197.8	2,242.1

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.0	71.1	90.2	84.0	107.9	173.4	202.9	180.9	175.7	145.1	97.1	89.5	1,516.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.4	1,358.4
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	224.7	189.4	221.7	217.9	232.5	279.2	309.7	282.8	268.6	250.6	196.5	207.5	2,881.2

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	797.5	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	223.2	1,516.8	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.4	-	-
Vent. Fans	369.9	-	-	-
Pumps & Aux.	33.0	5.9	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,242.1	2,881.2	-	-



Electricity **Natural Gas**

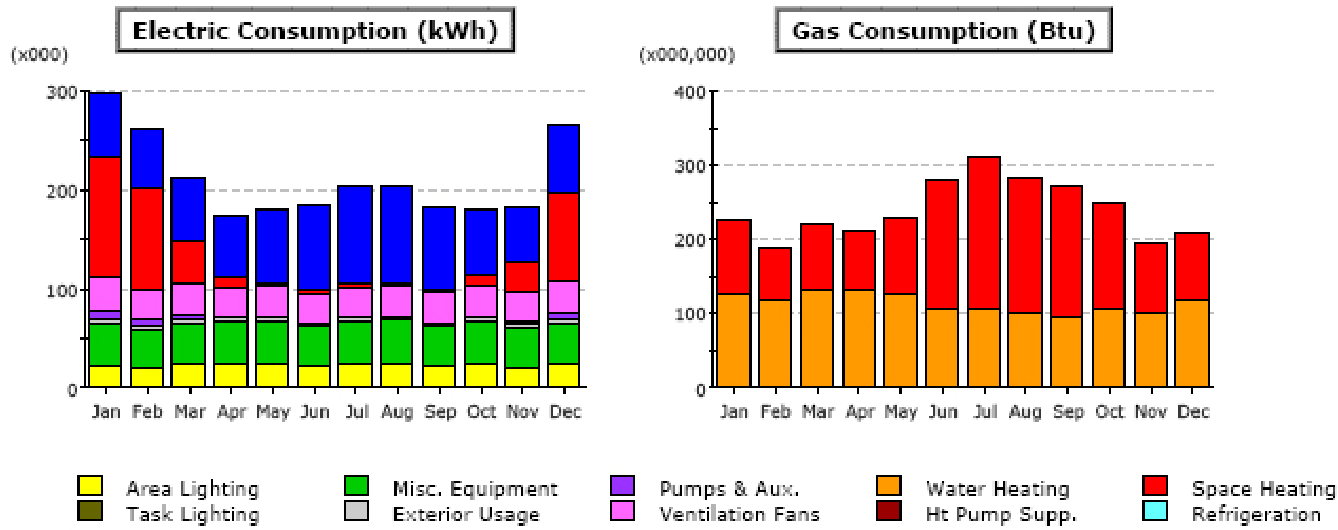
Suburban Wellness Centerswp   DOE-2.2-44d3   4/02/2008   23:32:23 BDL RUN 2

REPORT- SS-D Building HVAC Load Summary   WEATHER FILE- WASHINGTON, DC

MONTH	COOLING: COOLING ENERGY (MBTU)	COOLING: TIME OF MAX DY	COOLING: TIME OF MAX HR	COOLING: DRY-BULB TEMP	COOLING: WET-BULB TEMP	COOLING: MAXIMUM COOLING LOAD (KBTU/HR)	HEATING: HEATING ENERGY (MBTU)	HEATING: TIME OF MAX DY	HEATING: TIME OF MAX HR	HEATING: DRY-BULB TEMP	HEATING: WET-BULB TEMP	HEATING: MAXIMUM HEATING LOAD (KBTU/HR)	ELEC: ELEC-TRICAL ENERGY (KWH)	ELEC: MAXIMUM ELEC LOAD (KW)
JAN	638.54553	17	19	3.F	2.F	2538.483	-346.506	22	6	20.F	19.F	-1669.386	232591.	748.916
FEB	547.47845	27	7	14.F	13.F	2202.089	-248.525	4	6	8.F	6.F	-2000.088	194370.	804.692
MAR	589.05664	13	7	24.F	23.F	1912.914	-135.811	18	6	24.F	20.F	-1201.630	172974.	579.402
APR	656.18115	2	17	82.F	63.F	2031.317	-79.188	12	7	32.F	27.F	-669.840	164109.	443.630
MAY	781.22827	31	19	92.F	77.F	2530.072	-83.546	30	22	70.F	68.F	-423.777	172467.	454.552
JUN	931.90643	26	10	84.F	74.F	2542.975	-119.926	27	10	71.F	70.F	-377.184	178385.	439.434
JUL	1072.01965	26	17	87.F	77.F	2542.275	-138.415	31	21	76.F	74.F	-362.575	197928.	448.390
AUG	1039.62598	16	17	96.F	77.F	2546.585	-124.084	1	21	71.F	68.F	-336.422	195891.	468.757
SEP	893.55060	3	17	91.F	77.F	2543.380	-125.062	22	9	61.F	60.F	-409.975	175361.	453.789
OCT	738.12488	15	17	81.F	65.F	2117.459	-119.246	31	7	23.F	22.F	-995.359	170455.	543.015
NOV	550.30475	12	7	23.F	23.F	1962.710	-122.334	12	6	25.F	25.F	-1396.068	157841.	643.115
DEC	568.02063	30	7	20.F	18.F	2084.912	-216.415	30	7	20.F	18.F	-1430.483	194203.	665.748
TOTAL	9006.059						-1859.059						2206575.	
MAX						2546.585						-2000.088		804.692

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY)   0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE)   0.000 (KBTU)

Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof



Electric Consumption (kWh x000)

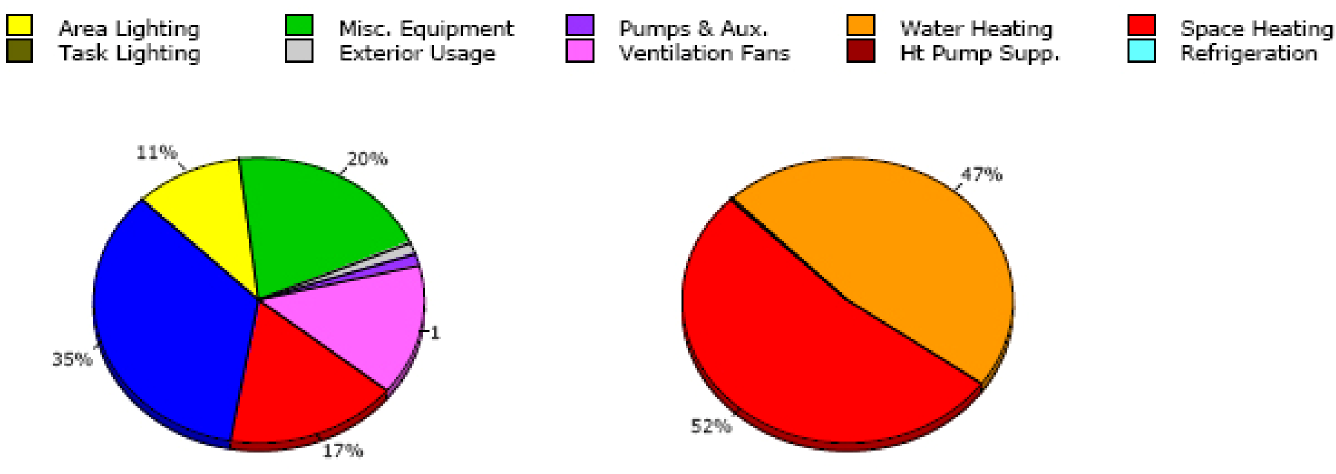
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	66.0	61.0	62.8	62.6	72.2	85.7	100.2	97.6	82.2	68.1	56.8	66.6	881.7
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	121.8	102.0	44.3	9.5	3.9	2.6	2.3	2.5	3.6	10.0	29.4	90.2	422.1
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	33.0	29.9	31.4	29.9	31.4	30.7	31.7	31.8	30.5	31.1	29.7	32.5	373.5
Pumps & Aux.	8.7	6.8	4.4	1.6	1.5	0.1	0.1	0.1	0.1	0.9	2.9	6.2	33.5
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	298.6	261.8	212.0	174.1	179.0	184.4	204.2	203.6	182.6	181.5	182.9	264.9	2,529.4

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	99.3	72.3	88.5	78.6	103.8	173.6	203.1	180.5	177.0	144.4	95.5	90.6	1,507.1
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.5	1,358.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	6.0
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	225.0	190.6	220.0	212.5	228.5	279.4	309.9	282.4	269.8	249.9	194.9	208.6	2,871.6

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	881.7	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	422.1	1,507.1	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.5	-	-
Vent. Fans	373.5	-	-	-
Pumps & Aux.	33.5	6.0	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,529.4	2,871.6	-	-



Electricity

Natural Gas

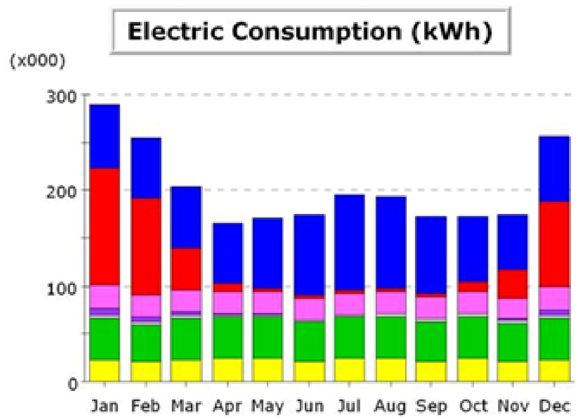
Suburban Wellness Centerswp DOE-2.2-44d3 4/02/2008 23:31:01 BDL RUN 3

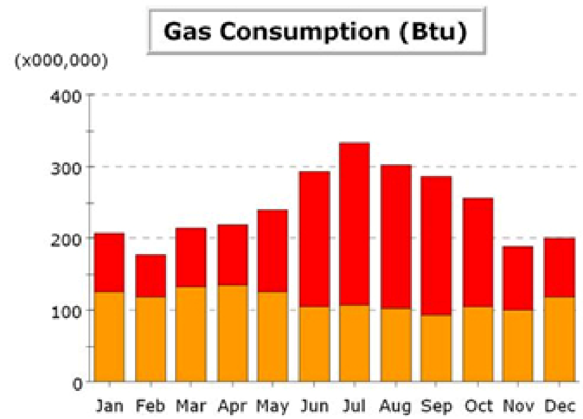
REPORT- SS-D Building HVAC Load Summary WEATHER FILE- WASHINGTON, DC

	C O O L I N G						H E A T I N G						E L E C	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	802.36835	17	19	3.F	2.F	2836.896	-506.539	22	6	20.F	19.F	-1977.584	295035.	864.442
FEB	718.49323	27	7	14.F	13.F	2635.130	-415.080	4	6	8.F	6.F	-2247.924	259055.	898.374
MAR	669.06836	13	7	24.F	23.F	2393.177	-222.285	18	6	24.F	20.F	-1671.393	208974.	758.580
APR	655.12628	2	17	82.F	63.F	2007.060	-88.707	12	7	32.F	27.F	-996.307	171137.	573.051
MAY	775.58093	31	19	92.F	77.F	2502.378	-86.658	30	22	70.F	68.F	-424.275	176888.	454.425
JUN	931.34766	26	10	84.F	74.F	2535.691	-124.135	2	18	65.F	63.F	-379.006	182338.	441.323
JUL	1075.61694	26	17	87.F	77.F	2532.594	-142.980	31	21	76.F	74.F	-362.838	202119.	455.286
AUG	1041.93445	16	17	96.F	77.F	2536.103	-128.504	1	21	71.F	68.F	-337.131	200167.	470.682
SEP	893.79529	3	17	91.F	77.F	2526.342	-129.697	22	9	61.F	60.F	-422.845	179308.	454.383
OCT	744.60944	31	7	23.F	22.F	2363.622	-132.092	31	7	23.F	22.F	-1405.949	178066.	694.726
NOV	591.16193	18	7	21.F	21.F	2527.820	-171.371	12	6	25.F	25.F	-1796.644	179438.	795.633
DEC	744.86426	16	8	21.F	18.F	2520.929	-385.624	30	7	20.F	18.F	-1809.614	261346.	806.758
TOTAL	9643.965						-2533.675						2493872.	
MAX						2836.896						-2247.924		898.374

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY) 0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE) 0.000 (KBTU)

Original Building + Daylighting Changes + 30% Ventilation Increase + Green Roof + Sensible Heat Exchanger





Area Lighting · Task Lighting · Misc. Equipment · Exterior Usage · Pumps & Aux. · Ventilation Fans · Water Heating · Ht Pump Supp. · Space Heating · Refrigeration

Electric Consumption (kWh x000)

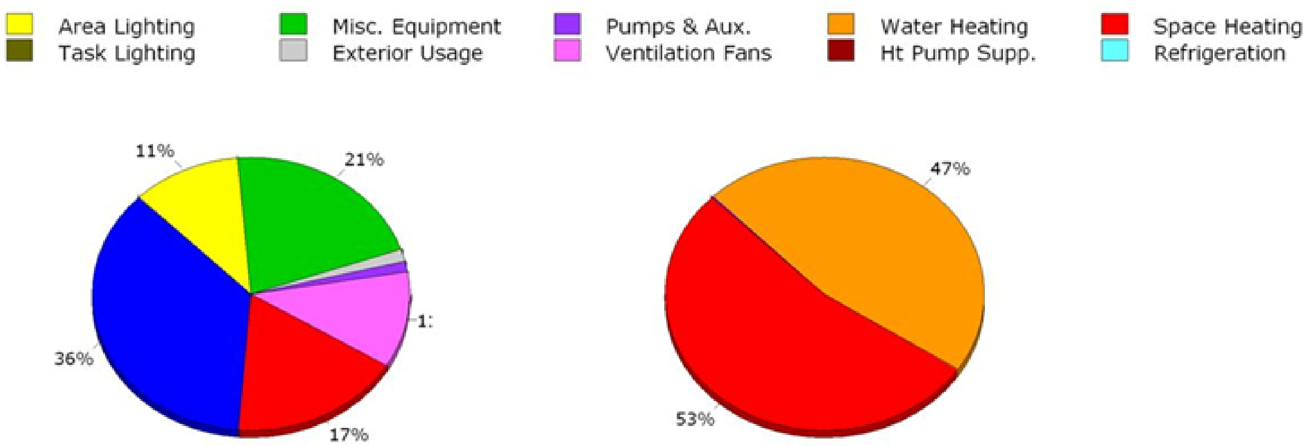
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	66.7	61.8	62.9	62.4	71.9	84.6	99.0	96.3	80.8	67.8	56.9	67.5	878.7
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	121.6	101.8	44.2	9.5	3.9	2.6	2.3	2.5	3.6	10.0	29.4	90.1	421.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	24.5	22.2	22.9	21.7	22.9	22.5	23.2	23.3	22.3	22.6	21.5	24.0	273.8
Pumps & Aux.	7.8	6.0	4.1	1.7	1.5	0.1	0.0	0.1	0.1	0.9	2.3	5.3	30.0
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	289.8	254.0	203.2	165.7	170.2	175.0	194.5	193.9	173.1	172.7	174.2	256.3	2,422.5

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	80.6	57.8	83.3	85.0	115.8	187.4	225.0	200.8	193.6	150.8	90.1	81.1	1,551.4
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.8	131.0	133.4	124.1	105.4	106.4	101.5	92.4	105.0	98.9	117.5	1,358.5
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.5	0.5	0.5	5.9
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	206.4	176.1	214.8	218.9	240.5	293.2	331.8	302.7	286.4	256.3	189.5	199.1	2,915.8

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	878.7	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	421.5	1,551.4	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.5	-	-
Vent. Fans	273.8	-	-	-
Pumps & Aux.	30.0	5.9	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	2,422.5	2,915.8	-	-



Electricity **Natural Gas**

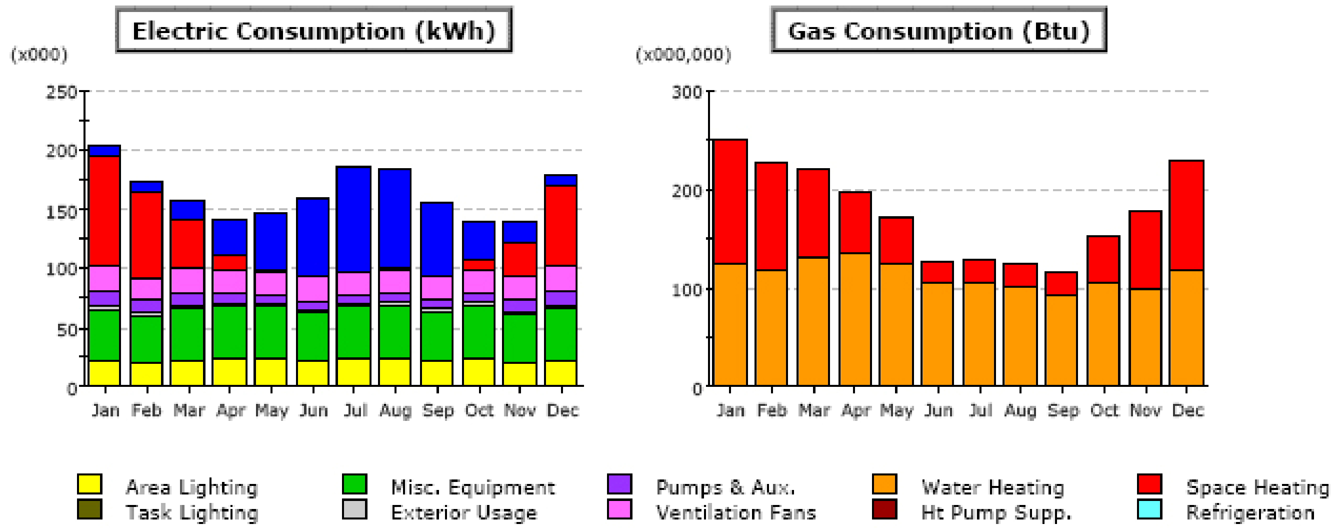
Suburban Wellness Centerswp   DOE-2.2-44d3   4/04/2008   15:48:52   BDL RUN 11

REPORT- SS-D Building HVAC Load Summary   WEATHER FILE- WASHINGTON, DC

MONTH	COOLING ENERGY (MBTU)	COOLING TIME OF MAX DY	COOLING TIME OF MAX HR	COOLING DRY-BULB TEMP	COOLING WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	HEATING TIME OF MAX DY	HEATING TIME OF MAX HR	HEATING DRY-BULB TEMP	HEATING WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	797.33276	30	19	10.F	9.F	2786.823	-490.838	13	9	21.F	20.F	-1896.870	286216.	851.988
FEB	713.42584	27	7	14.F	13.F	2658.472	-402.738	4	6	8.F	6.F	-2194.682	251232.	886.829
MAR	663.05121	13	7	24.F	23.F	2380.798	-217.740	18	6	24.F	20.F	-1642.743	200204.	747.085
APR	650.81488	2	17	82.F	63.F	1977.074	-93.128	29	6	38.F	33.F	-762.803	162758.	561.075
MAY	770.06586	31	19	92.F	77.F	2460.002	-94.947	30	22	70.F	68.F	-423.251	168130.	439.956
JUN	920.58398	26	10	84.F	74.F	2479.814	-133.868	27	10	71.F	70.F	-389.967	173011.	429.998
JUL	1062.58130	26	17	87.F	77.F	2495.641	-158.062	31	21	76.F	74.F	-375.439	192424.	440.641
AUG	1028.92554	16	17	96.F	77.F	2492.473	-142.461	25	19	78.F	70.F	-356.475	190472.	455.452
SEP	885.20825	3	16	91.F	77.F	2501.641	-141.207	22	9	61.F	60.F	-430.322	169790.	447.151
OCT	740.14001	31	7	23.F	22.F	2371.940	-136.513	31	7	23.F	22.F	-1382.562	169261.	684.220
NOV	587.14648	18	7	21.F	21.F	2523.481	-165.980	12	7	23.F	23.F	-1707.931	170731.	782.537
DEC	740.39642	16	8	21.F	18.F	2512.971	-376.162	26	7	25.F	23.F	-1684.810	252733.	795.599
TOTAL	9559.672						-2553.649						2386961.	
MAX						2786.823						-2194.682		886.829

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY)   0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE)   0.000 (KBTU)

4 Baseline Building Simulations (Building Rotated at +0°, +90°, +180°, +270°)
Baseline Building



Electric Consumption (kWh x000)

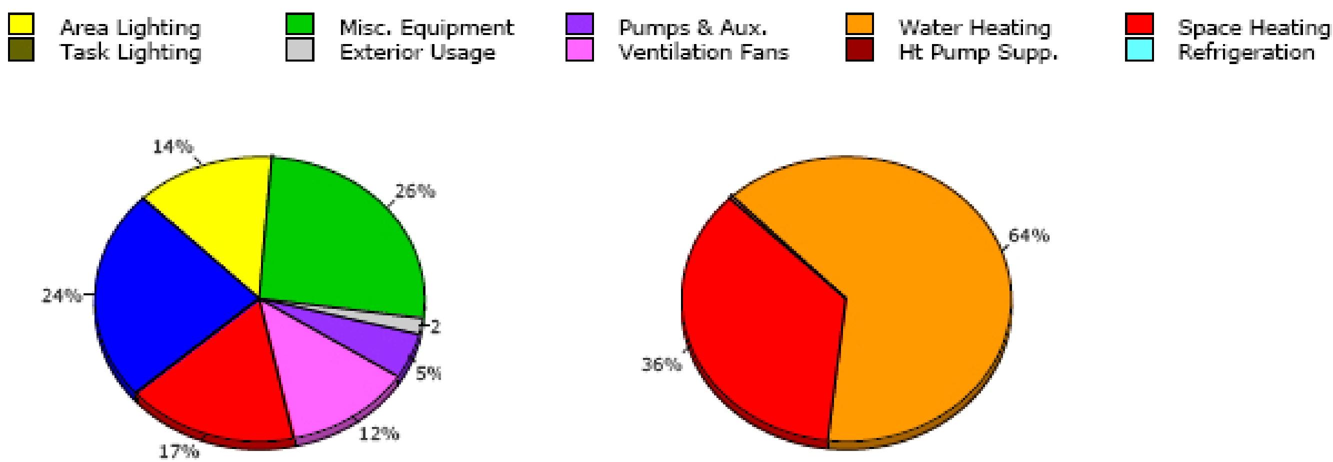
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	8.3	8.2	17.0	30.8	47.9	68.4	88.5	84.2	62.3	31.7	17.6	9.6	474.4
Heat Reject.	-	-	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.0	0.0	-	1.2
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	94.4	74.1	40.7	11.8	1.5	0.1	-	0.0	0.2	8.3	29.5	68.8	329.4
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	20.1	18.5	20.9	20.4	20.6	20.2	20.6	21.0	19.8	20.6	19.2	20.5	242.5
Pumps & Aux.	11.8	10.1	10.3	7.9	6.9	6.5	6.6	6.8	6.3	7.0	8.9	11.3	100.3
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	203.7	173.1	157.9	141.3	147.0	160.5	186.1	183.9	155.1	138.9	139.2	179.5	1,966.3

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	124.7	109.4	89.0	64.9	46.7	20.6	23.0	23.5	23.2	46.8	77.9	111.6	761.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.9	131.0	133.5	124.1	105.3	106.4	101.4	92.4	105.1	99.0	117.5	1,358.8
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.2
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	250.5	227.7	220.6	198.9	171.4	126.5	129.9	125.6	116.2	152.4	177.4	229.6	2,126.5

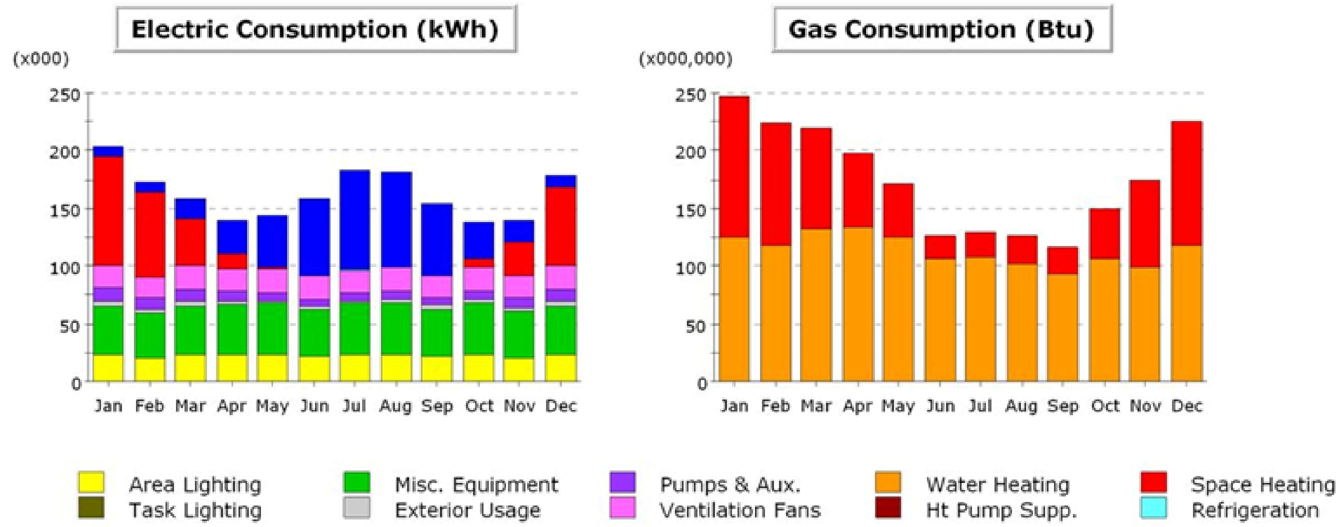
Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	474.4	-	-	-
Heat Reject.	1.2	-	-	-
Refrigeration	-	-	-	-
Space Heat	329.4	761.5	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,358.8	-	-
Vent. Fans	242.5	-	-	-
Pumps & Aux.	100.3	6.2	-	-
Ext. Usage	35.5	-	-	-
Misc. Equip.	512.1	-	-	-
Task Lights	-	-	-	-
Area Lights	270.9	-	-	-
Total	1,966.3	2,126.5	-	-



Electricity **Natural Gas**

Baseline Building +90° Rotation



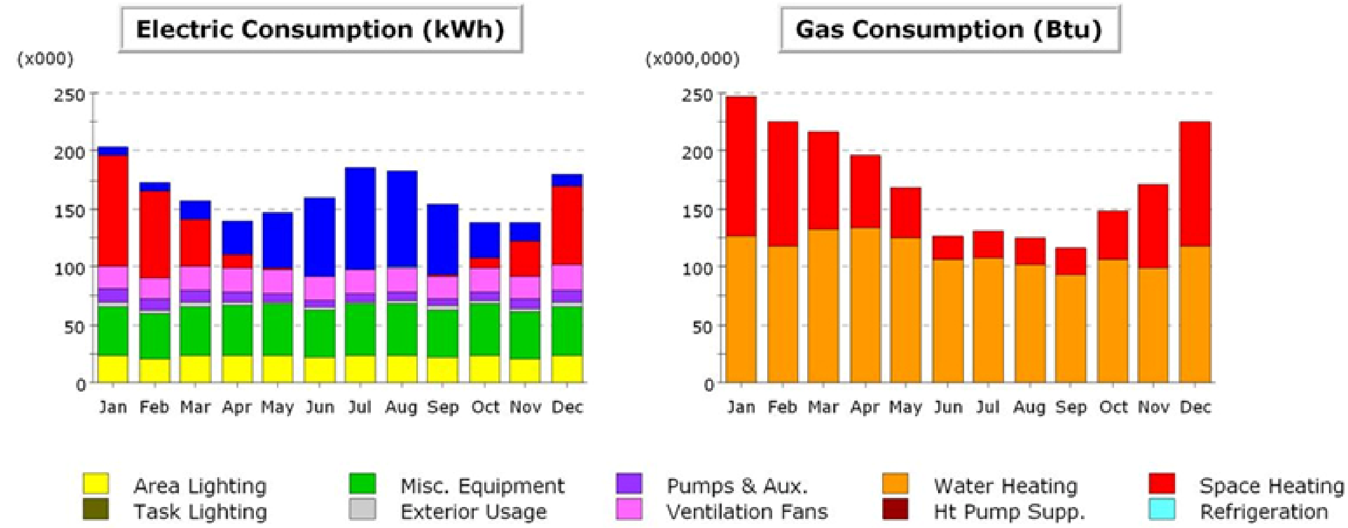
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	8.4	8.4	16.8	29.7	45.9	66.3	86.5	82.2	61.2	31.3	17.6	9.9	464.2
Heat Reject.	-	-	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.0	0.0	-	1.2
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	94.3	74.5	41.6	12.0	1.6	0.1	-	0.0	0.2	8.4	29.8	68.2	330.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	19.7	18.1	20.4	20.0	20.2	19.7	20.2	20.5	19.3	20.2	18.8	20.0	237.0
Pumps & Aux.	11.7	10.0	10.2	7.6	6.8	6.3	6.4	6.6	6.2	6.8	8.6	11.3	98.6
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	203.1	173.2	158.1	139.7	144.5	157.9	183.5	181.3	153.4	138.0	138.8	178.7	1,950.2

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	120.8	105.8	88.0	63.8	46.6	20.7	23.0	23.9	23.8	44.4	75.0	106.7	742.7
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.2	117.9	131.0	133.5	124.1	105.4	106.4	101.4	92.4	105.1	99.0	117.5	1,358.9
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	246.6	224.1	219.5	197.8	171.3	126.6	130.0	125.9	116.8	150.0	174.5	224.7	2,107.8

Baseline Building +180° Rotation



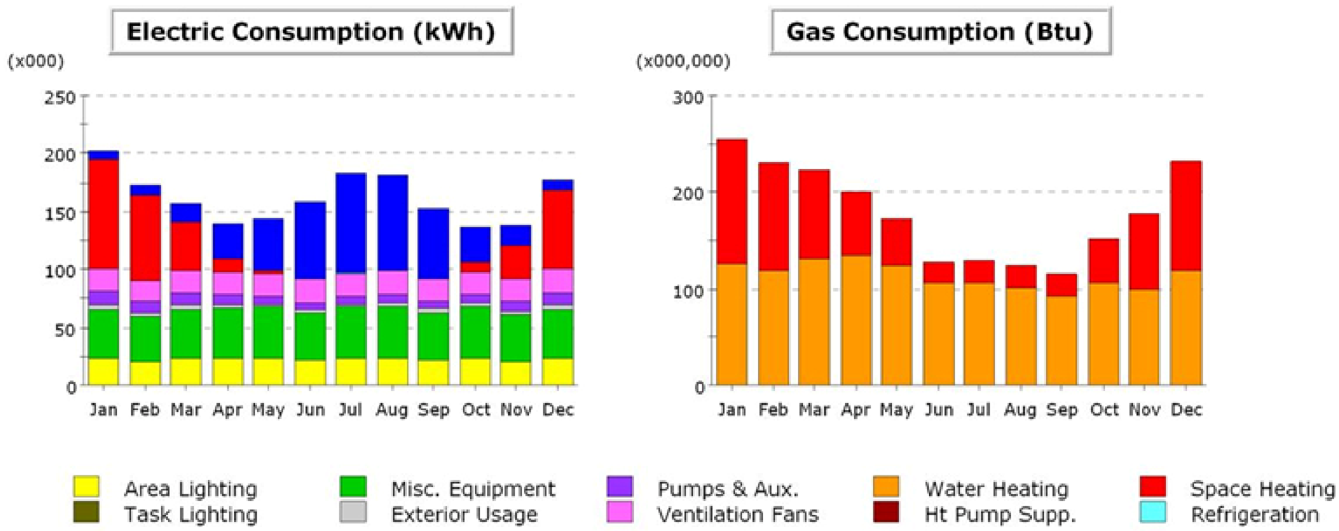
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	8.1	7.8	16.5	30.1	47.5	68.3	88.5	84.1	62.1	30.8	16.9	9.5	470.3
Heat Reject.	-	-	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.0	0.0	-	1.2
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	94.8	74.3	40.5	11.3	1.5	0.1	-	0.0	0.2	8.1	29.4	69.0	329.2
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	20.1	18.5	20.9	20.4	20.6	20.1	20.6	21.0	19.8	20.6	19.2	20.5	242.2
Pumps & Aux.	11.7	10.0	10.2	7.8	6.8	6.4	6.5	6.7	6.2	6.9	8.8	11.2	99.5
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	203.9	172.9	157.1	139.9	146.5	160.4	186.0	183.7	154.7	137.8	138.3	179.6	1,960.9

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	121.6	107.1	85.6	62.8	44.6	20.9	24.0	23.5	22.6	43.3	72.6	106.9	735.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.3	117.9	131.1	133.5	124.1	105.4	106.4	101.5	92.4	105.1	99.0	117.5	1,359.0
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	247.3	225.4	217.2	196.8	169.2	126.8	130.9	125.5	115.6	149.0	172.0	224.9	2,100.7

Baseline Building +270° Rotation



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	8.0	7.9	16.1	29.2	46.0	66.6	86.6	82.3	61.2	31.0	17.1	9.5	461.6
Heat Reject.	-	-	0.0	0.0	0.1	0.2	0.4	0.3	0.2	0.0	0.0	-	1.2
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	94.3	74.4	41.0	11.7	1.6	0.1	-	0.0	0.2	8.1	29.4	68.3	329.1
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	19.4	17.8	20.1	19.7	19.9	19.4	19.9	20.3	19.1	19.9	18.6	19.8	233.9
Pumps & Aux.	11.6	10.0	10.2	7.8	6.7	6.3	6.4	6.6	6.1	6.9	8.7	11.1	98.4
Ext. Usage	3.6	2.7	3.0	2.9	2.1	2.0	2.1	3.4	3.3	3.4	3.4	3.6	35.5
Misc. Equip.	42.9	38.9	43.3	43.8	44.3	41.5	44.3	44.4	41.3	44.3	40.0	43.1	512.1
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	22.6	20.5	22.7	23.6	23.7	21.7	23.7	23.7	21.6	23.7	20.6	22.7	270.9
Total	202.4	172.3	156.5	138.9	144.3	157.8	183.3	181.1	153.1	137.2	137.8	178.0	1,942.8

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	129.0	112.3	90.9	66.8	47.7	20.6	22.3	22.6	23.0	46.6	79.2	113.6	774.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	125.3	117.9	131.1	133.5	124.1	105.4	106.4	101.5	92.4	105.1	99.0	117.5	1,358.9
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.5	0.5	6.2
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	254.7	230.6	222.5	200.7	172.3	126.5	129.3	124.6	116.0	152.3	178.6	231.6	2,139.7

Appendix C | Equipment Selection Information

TRANE

General Data

Table 3 General Data (All dimensions in inches)

	90/100 Tons[1]	105/118 Tons[1]	120/128 Tons[1]	130/140 Tons[1]	150/162 Tons[1]
Compressor Data					
Number/Size (Nominal)	4/20 Ton	2/20 Ton 2/25 Ton	4/25 Ton	2/25 Ton 2/32 Ton	4/32 Ton
Type	Scroll	Scroll	Scroll	Scroll	Scroll
Unit Capacity Steps	100/75/50/25	100/72/44/22	100/75/50/25	100/72/44/22	100/75/50/25
RPM	3450	3450	3450	3450	3450
No. of Circuits	2	2	2	2	2
Air-Cooled Condenser Fans					
Number/Size/Type	6/30/Prop	6/30/Prop	8/30/Prop	8 /30/Prop	8/30/Prop
Hp (each)	1.5	1.5	1.5	1.5	1.5
CFM	58500	58500	87750	87750	87750
Evaporator Coil Std.					
Dimensions	118 x 90	118 x 90	170 x 90	170 x 90	170 x 90
Size (Ft^2)	73.75	73.75	106.25	106.25	106.25
Rows/Fin Series	3/168	4/168	3/168	4/168	6/168
Tube Diameter	1/2	1/2	1/2	1/2	1/2
Surface	Enhanced	Enhanced	Enhanced	Enhanced	Enhanced
Evaporator Coil Hi Cap.					
Dimensions	118 x 90	118 x 90	170 x 90	170 x 90	N/A
Size (Ft^2)	73.75	73.75	106.25	106.25	
Rows/Fin Series	5/168	6/168	6/168	6/168	
Tube Diameter	1/2	1/2	1/2	1/2	
Surface	Enhanced	Enhanced	Enhanced	Enhanced	
Condenser Coil					
Size (Ft^2)	134	162	176	176	176
Rows/Fin Series	3/156	3/156	3/156	3/156	4/156
Tube Diameter	3/8	3/8	3/8	3/8	3/8
Evaporative-Cooled Condenser Fans					
Number/Size/Type	2/30/Prop	2/30/Prop	2/30/Prop	2/30/Prop	2/30/Prop
HP (each)	3	5	5	5	5
RPM/CFM	1165/22000	1165/22000	1165/22000	1165/22000	1165/22000
Cycle/Phase	60/3	60/3	60/3	60/3	60/3
Evaporative-Cooled Condenser Pump					
Number/Type	1 / Submersible	1 / Submersible	1 / Submersible	1 / Submersible	1 / Submersible
HP	1	1	1	1	1
RPM	1725	1725	1725	1725	1725
Cycle/Phase	60/3	60/3	60/3	60/3	60/3
Sump Volume GPM	90	90	90	90	90
Supply Fans Std CFM					
Number/Size/Type	1 /36 DW AF	1 / 36 DW AF	1 /40 DW AF	1 /40 DW AF	1 /40 DW AF
Number of Motors	1	1	1	1	1
HP Range	15 - 60	20 - 75	20 - 75	20 - 100	20 - 100
CFM Range	20000 - 40000	23000 - 45000	27000 - 54000	29000 - 58000	29000 - 58000
Total SP Range-(In. WG)	7.5	7.5	7.5	7.5	7.5
Supply Fans Low CFM					
Number/Size/Type	1/25 DW AF	1/32/ DW AF	1/32/ DW AF	1/32/ DW AF	1/32/ DW AF
Number of Motors	1	1	1	1	1
HP Range	15 - 50	15 - 60	15 - 60	20 - 60	20 - 60
CFM Range	16000 - 31000	19000 - 36000	21000 - 42000	23000 - 45000	23000 - 45000
ESP Range-(In. WG)	7.5	7.5	7.5	7.5	7.5
Exhaust Fans Std CFM					
Number/Size/Type	1/28 DW FC	1/32 DW FC	1/32 DW FC	1/32 DW FC	1/32/ DW FC
Number of Motors	1	1	1	1	1
HP Range	10 - 25 hp	15 - 50 hp	15 - 60 hp	15 - 60 hp	15 - 60 hp
CFM Range	20000 - 36000	23000 - 40000	27000 - 48000	29000 - 52000	29000 - 52000
ESP Range-(In. WG)	2.5	2.5	2.5	2.5	2.5
Exhaust Fans Low CFM					
Number/Size/Type	1/25/ DW FC	1/28/ DW FC	1/28/ DW FC	1/28/ DW FC	1/28 DW FC
Number of Motors	1	1	1	1	1
HP Range	7.5 - 25 hp	7.5 - 25 hp	7.5 - 30 hp	7.5 - 50 hp	7.5 - 50 hp
CFM Range	10000 - 28000	12000 - 33000	14000-37000	15000 - 41000	15000 - 41000
ESP Range-(In. WG)	2.5	2.5	2.5	2.5	2.5

Table 3 General Data (All dimensions in inches)

	90/100 Tons(i)	105/118 Tons[1]	120/128 Tons[1]	130/140 Tons[1]	150/162 Tons[1]
Return Fans Std CFM					
Number/Size/Type	1 /40 Plenum AF	1 / 40 Plenum AF	1 /44 Plenum AF	1 /44 Plenum AF	1 /44 Plenum AF
Number of Motors	1	1	1	1	1
HP Range	10 - 30 hp	15 - 40 hp	15 - 40 hp	20 - 50 hp	20 - 50 hp
CFM Range	20000 - 40000	24000 - 44000	27000 - 51000	29000 - 54000	29000 - 54000
ESP Range-(In. WG)	2.5	2.5	2.5	2.5	2.5
Return Fans Low CFM					
Number/Size/Type	1/36.5/ Plenum	1/36.5/ Plenum	1/36.5/ Plenum	1/36.5/ Plenum	1/36.5/ Plenum
Number of Motors	1	1	1	1	1
HP Range	7.5 - 20 hp	10 - 25 hp	10 - 40 hp	15 - 40 hp	15 - 40 hp
CFM Range	16000 - 28000	19000 - 33000	21000 - 36000	23000 - 36000	23000 - 36000
ESP Range-(In. WG)	2.5	2.5	2.5	2.5	2.5
Energy Recovery Std CFM					
Cassette Dimensions (LxWxH)	104x104x10	108x108x14	115x115x14	115x115x14	115x115x14
Wheel Segments	16	16	16	16	16
Motor (V/ph/Hz)	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60
HP	0.33	0.33	0.33	0.33	0.33
Galv. Steel RA Filters (number/size)	10/24x24x1	10/24x24x1	10/24x24x1	10/24x24x1	10/24x24x1
Galv. Steel FA Filters (number/size)	8/24x24x1	8/24x24x1	8/24x24x1	8/24x24x1	8/24x24x1
CFM Range	8500 - 18000	9000 - 21000	10000 - 24000	13000 - 29000	13000 - 29000
Energy Recovery Low CFM					
Cassette Dimensions (LxWxH)	85x85x7.07	85x85 x7.07	91x91 x10	96x96x10	96x96x10
Wheel Segments	8	8	8	16	16
Motor Information (V/ph/Hz)	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60	460/3/60 575/3/60
HP	0.25	0.25	0.25	0.33	0.33
Galv. Steel RA Filters Size/Number	10-24x24x1	10-24x24x1	10-24x24x1	10-24x24x1	10-24x24x1
Galv. Steel FA Filters (number/size)	8/24x24x1	8/24x24x1	6/24x24x1 2/12x24x1	6/24x24x1 2/12x24x1	6/24x24x1 2/12x24x1
CFM Range	8500 - 14000	9000 - 14000	9000 - 15000	9000 - 16000	9000 - 16000
Electric Heat (60 Hz)					
KW	90-265	90-265	140-300	140-300	140-300
Circuit Capacity Steps	30 - 37.5 KW	30 - 37.5 KW	35 - 37.5 KW	35 - 37.5 KW	35 - 37.5 KW
Electric Heat (50 Hz)					
KW	56-166	56-166	88-188	88-188	88-188
Circuit Capacity Steps	18.8 - 23.5 KW	18.8 - 23.5 KW	21.9 - 23.5 KW	21.9 - 23.5 KW	21.9 - 23.5 KW
Natural Gas Heat					
2-Stage Gas Heat					
Low Heat Input (MBH)	850	850	1100	1100	1100
Mid Heat Input (MBH)	1100	1100	1800	1800	1800
High Heat Input (MBH)	1800	1800	2500	2500	2500
Fully Modulating Steps					
Low Heat Input (MBH)	10:1	10:1	20:1	20:1	20:1
Mid Heat Input (MBH)	20:1	20:1	20:1	20:1	20:1
High Heat Input (MBH)	20:1	20:1	20:1	20:1	20:1
Heat Exchanger Material	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel
Hot Water Coil					
Size	33 x 88 x 2 rows	33 x 88 x 2 rows	33 x 110 x 2 rows	33 x 110 x 2 rows	33 x 110 x 2 rows
Quantity	2	2	2	2	2
Type	5W, PrimaFlo	5W, PrimaFlo	5W, PrimaFlo	5W, PrimaFlo	5W, PrimaFlo
High Heat (fins/ft)	122	122	122	122	122
Low Heat (fins/ft)	88	88	88	88	88
Steam Coil					
Size	33 x 88 x 1 row	33 x 88 x 1 row	33 x 110 x 1 row	33 x 110 x 1 row	33 x 110 x 1 row
Quantity	2	2	2	2	2
Type	NS, SigmaFlo	NS, SigmaFlo	NS, SigmaFlo	NS, SigmaFlo	NS, SigmaFlo
High Heat (fins/ft)	112	112	112	112	112
Low Heat (fins/ft)	62	62	62	62	62

Dectron Model 100/102

Moisture Removal and Sensible Cooling Tables

Model 100/102 - Moisture Removal Capacity in lb./h

Return Air Temperature	Relative Humidity 70%	60%	50%	40%
74 °F	124.0	103.9	83.8	46.9
75 °F	125.6	105.5	85.4	51.9
76 °F	127.3	107.2	87.1	57.0
77°F	129.0	108.9	88.8	60.3
78 °F	130.7	110.6	90.5	63.7
79 °F	132.3	112.2	92.1	65.3
80 °F	134.0	113.9	93.8	67.0
81 °F	135.7	115.6	95.5	68.7
82 °F	137.4	117.3	97.2	70.4
83 °F	139.0	118.9	98.8	72.0
84 °F	140.7	120.6	100.5	73.7
85 °F	142.4	122.3	102.2	75.4
86 °F	144.1	124.0	103.9	77.1

Model 100/102 - DX Coil Sensible Cooling in Btu/h

Return Air Temperature	Relative Humidity 70%	60%	50%	40%
74 °F	145,060	159,560	172,220	177,280
75 °F	143,260	158,420	174,750	181,330
76 °F	141,460	157,290	176,120	184,880
77 °F	139,650	156,140	175,650	187,410
78 °F	137,850	155,000	175,180	192,470
79 °F	136,030	153,860	174,720	192,360
80 °F	134,210	152,710	174,260	192,240
81 °F	132,690	151,570	173,780	192,150
82 °F	131,170	150,440	173,300	192,060
84 °F	129,650	149,290	172,840	191,950
84 °F	128,130	148,140	172,380	191,850
85 °F	126,610	146,890	171,900	191,740
86 °F	125,090	145,880	171,430	191,630

ER=0.1*A*AF*(Pw-Pdp)

ER	Evaporation Rate of Water, lb/h
A	Area of Pool Water Surface, ft2
AF	Activity Factor
Pw	Saturation Vapor Pressure at Water Surface, in. Hg
Pdp	Partial Vapor Pressure at Room Air Dew Point, in. Hg

For air velocity over water between 10-30 fpm

	Lap Pool	Therapy	Whirl
Area	1800	323	115
AF	0.65	0.65	1
Air Temp	82	82	82
RH	50%	50%	50%
Water Temp	82	85	100
Pw	1.116	1.3052	1.95488
Pdp	0.57288	0.57288	0.57288
Evap Rate	63.55	15.38	15.89
ER Total			94.81

A.O. Smith BTP-300-800 Low-NOx Water Heater

A. O. Smith *Commercial Gas Water Heaters*

Conservationist®
LOW-NOx POWERED-BURNER MODELS

Conservationist® (BTP and BTPV) commercial water heaters offer precise powered-burner performance for medium-demand commercial applications, plus the flexibility of conventional atmospheric venting, sidewall venting or direct venting. To help ensure optimum performance, A. O. Smith offers professional start-up service on BTP and BTPV models.

VENTING OPTIONS
- BTP models designed for conventional atmospheric vertical venting. Barometric draft regulating damper provided. Order Vent Kit Part # 170777-005.
- BTPV models designed for horizontal atmospheric sidewall venting or direct venting, using optional vent kits.
  - For sidewall venting order Vent Kit Part # 192049-000.
  - For direct venting order Vent Kit Part # 192050-002.

LOW-NOx POWERED GAS BURNER (NATURAL GAS ONLY)
- Pre-mix design with internal Flue Gas Recirculation (FGR)
- Safety features include internal blocked flue sensor, separate pilot system, internal thermal cutoff and anti-flashback barrier

FULLY AUTOMATIC CONTROLS
- Including safety shut-off, high-temperature limit control
- Dual thermostat, adjustable from 120° F to 180° F

DRAFT EQUALIZING COMBUSTION CHAMBER
- Patented dome system ensures optimum flue loading and efficient heat transfer by balancing pressure inside combustion chamber

ASME TANK CONSTRUCTION ON ALL MODELS
- Rated working pressure: 160 PSI

FACTORY-INSTALLED AGA/ASME TEMPERATURE & PRESSURE RELIEF VALVE

GLASS-LINED TANK WITH MULTIPLE ANODE RODS
- For optimum protection against tank corrosion

FLAME INSPECTION PORT

HANDHOLE CLEANOUT
- For easy cleanout of sediment from tank bottom

HIGH-ALTITUDE INSTALLATION
- Adjustable air intake damper easily reset for high-altitude installation by authorized start-up agent

CODES AND STANDARDS
- Meets ASHRAE/IESNA 90.1-1999 thermal efficiency and standby loss requirements
- Meets SCAQMD R1146.2 low-NOx requirements

WARRANTY
- Three-year limited tank warranty
- For complete warranty information, consult written warranty shipped with water heater, or contact A. O. Smith Water Heaters

Commercial Gas Water Heaters

DIMENSIONS AND SHIPPING WEIGHTS (continued)

MODEL NUMBER	INCHES OR CM	DIMENSIONS A	B	C	D	E	F	G	H	J	SHIPPING WEIGHT WITH BURNER
BTP-300-300	Inches	91-1/2	14	1	26-1/2	1-1/2	44-3/4	6	66-1/2	83	2150 Lbs.
	CM	232.4	35.6	2.5	67.3	3.8	113.7	15.2	168.9	210.8	975.2 Kg
BTP-300-600	Inches	91-1/2	14	1	26-1/2	1-1/2	44-3/4	8	66-1/2	83	2150 Lbs.
	CM	232.4	35.6	2.5	67.3	3.8	113.7	20.3	168.9	210.8	975.2 Kg
BTP-300-800	Inches	91-1/2	14	1-1/4	26-1/2	1-1/2	44-3/4	10	66-1/2	83	2308 Lbs.
	CM	232.4	35.6	3.2	67.3	3.8	113.7	25.4	168.9	210.8	1046.9 Kg
BTP-300-1000	Inches	91-1/2	14	1-1/4	26-1/2	1-1/2	44-3/4	10	66-1/2	83	2308 Lbs.
	CM	232.4	35.6	3.2	67.3	3.8	113.7	25.4	168.9	210.8	1046.9 Kg
BTP-300-1250	Inches	91-1/2	14	1-1/4	26-1/2	1-1/2	44-3/4	12	66-1/2	83	2584 Lbs.
	CM	232.4	35.6	3.2	67.3	3.8	113.7	30.5	168.9	210.8	1172.1 Kg
BTP-300-1500	Inches	91-1/2	14	1-1/2	26-1/2	1-1/2	44-3/4	12	81-1/2	83	2774 Lbs.
	CM	232.4	35.6	3.8	67.3	3.8	113.7	30.5	207	210.8	1258.3 Kg
BTP-400-600	Inches	91-1/2	15	1	32-1/2	2	55	8	76-1/2	81	3207 Lbs.
	CM	232.4	38.1	2.5	82.6	5.1	139.7	20.3	194.3	205.7	1454.7 Kg
BTP-400-800	Inches	91-1/2	15	1-1/4	32-1/2	2	55	10	76-1/2	81	3212 Lbs.
	CM	232.4	38.1	3.2	82.6	5.1	139.7	25.4	194.3	205.7	1456.9 Kg
BTP-400-1000	Inches	91-1/2	15	1-1/4	32-1/2	2	55	10	76-1/2	81	3212 Lbs.
	CM	232.4	38.1	3.2	82.6	5.1	139.7	25.4	194.3	205.7	1456.9 Kg
BTP-400-1250	Inches	91-1/2	15	1-1/4	32-1/2	2	55	12	76-1/2	81	3212 Lbs.
	CM	232.4	38.1	3.2	82.6	5.1	139.7	30.5	194.3	205.7	1456.9 Kg
BTP-400-1500	Inches	91-1/2	15	1-1/2	32-1/2	2	55	12	91-1/2	81	3402 Lbs.
	CM	232.4	38.1	3.8	82.6	5.1	139.7	30.5	232.4	205.7	1543.1 Kg
BTP-400-1750	Inches	91-1/2	15	2	32-1/2	2	55	14	91-1/2	81	3528 Lbs.
	CM	232.4	38.1	5.1	82.6	5.1	139.7	35.6	232.4	205.7	1600.2 Kg
BTP-400-2000	Inches	99-1/2	15	2	32-1/2	2	55	14	91-1/2	89	3669 Lbs.
	CM	252.7	38.1	5.1	82.6	5.1	139.7	35.6	232.4	226.1	1664.2 Kg
BTP-500-2250	Inches	110	15	2	32-1/2	2	55	16	91-1/2	100	4277 Lbs.
	CM	279.4	38.1	5.1	82.6	5.1	139.7	40.6	232.4	254	1940 Kg
BTP-500-2500	Inches	110	15	2	32-1/2	2	55	16	91-1/2	100	4419 Lbs.
	CM	279.4	38.1	5.1	82.6	5.1	139.7	40.6	232.4	254	2004.4 Kg
BTP-600-720	Inches	115	15	1-1/4	32-1/2	2	55	10	76-1/2	109	3667 Lbs.
	CM	292.1	38.1	3.2	82.6	5.1	139.7	25.4	194.3	276.9	1663.3 Kg
BTP-600-1000	Inches	115	15	1-1/4	32-1/2	2	55	10	76-1/2	109	3667 Lbs.
	CM	292.1	38.1	3.2	82.6	5.1	139.7	25.4	194.3	276.9	1663.3 Kg
BTP-600-1250	Inches	115	15	1-1/4	32-1/2	2	55	12	76-1/2	109	3667 Lbs.
	CM	292.1	38.1	3.2	82.6	5.1	139.7	30.5	194.3	276.9	1663.3 Kg
BTP-600-1500	Inches	115	15	1-1/2	32-1/2	2	55	12	91-1/2	109	3837 Lbs.
	CM	292.1	38.1	3.8	82.6	5.1	139.7	30.5	232.4	276.9	1740.4 Kg
BTP-600-1750	Inches	115	15	2	32-1/2	2	55	14	91-1/2	109	3837 Lbs.
	CM	292.1	38.1	5.1	82.6	5.1	139.7	35.6	232.4	276.9	1740.4 Kg
BTP-600-2000	Inches	115	15	2	32-1/2	2	55	14	91-1/2	109	3837 Lbs.
	CM	292.1	38.1	5.1	82.6	5.1	139.7	35.6	232.4	276.9	1740.4 Kg
BTP-600-2250	Inches	115	15	2	32-1/2	2	55	16	91-1/2	109	4477 Lbs.
	CM	292.1	38.1	5.1	82.6	5.1	139.7	40.6	232.4	276.9	2030.7 Kg
BTP-600-2500	Inches	115	15	2	32-1/2	2	55	16	91-1/2	109	4619 Lbs.
	CM	292.1	38.1	5.1	82.6	5.1	139.7	40.6	232.4	276.9	2030.7 Kg

†Indicates model equipped with "Wayne" burner.
All other "H" dimensions are for models equipped with "Power Flame" Power Burner.
Certified Minimum Installation Clearances to Combustibles:
Front: 18 Inches
Back: 0 Inches
Sides: 0 Inches
Top: 5 Inches
A clearance of 24 Inches should be maintained from serviceable parts such as relief valve, power burner, drain valve and anodes (anodes are located on side above cold water inlet).
Minimum gas supply pressure: 7 Inches W.C.
Maximum gas supply pressure: 13 Inches W.C.
BTP models are Category I appliances (Fan Assisted) and require a negative draft. These units should only be commonly vented with other Category I negative draft appliances per the latest addition of the National Fuel Gas Code. An approved/listed Type "B" venting material is recommended. A negative draft of -0.02"

Appendix D | Structural Load Calculations

Roof Structural Calculations	
Span:	25 ft
Spacing:	5 ft

Dead Load		
1/2" Roof Decking	3	PSF
4 Inch. Polystyrene Insulation	1.5	PSF
Waterproofing Membrane	0.7	PSF
GreenGrid Trays	15	PSF
Superimposed Dead Load	5	PSF
Total Dead Load	25.2	

Allowable Dead Load:		
Total Uniform Load	159	PSF
Def. Live Load	89	PSF

Snow Load:			
(Values Calculated from ASCE 7-05)			
Ground Snow Load, p_g	30	PSF	Fig. 7-1
Flat Roof Snow Load, p_f	**23.1**	PSF	Eq. 7-1
Minimum p_f per ASCE 7-05	**22.0**	PSF	
Exposure Factor, C_e	1.0		Table 7-2
Thermal Factor, C_t	1.0		Table 7-3
Importance Factor, I	1.1		Table 7-4
Note: Value in bold represents controlling snow load			

Load Combinations				
1.2D + 1.6S				
1.2 (25.2 PSF) + 1.6 (23.1 PSF)	67.2	PSF	< 89 PSF	OK
67.2 PSF * 5'	336	PLF		

20K3				
Self-weight	6.7	PLF		
Total Load	493	PLF		
Unfactored LL	266	PLF		
336 PLF + 6.7 PLF	342.7	PLF	< 493 PLF	OK
23.1 PSF * 5'	116	PLF	< 266 PLF	OK

W16x31		
67.2 PSF * 12.5	840 PLF	
(WL^2)/8	65.5 ft-kip	
ΔTL= L/240	1.25 Inch.	
ΔTL	0.49 Inch.	< 1.25 In. OK
ΔLL= L/360	0.83 Inch.	
ΔLL	0.23 Inch.	< 0.83 In. OK

W18x35		
67.2 PSF * 12.5'	840 PLF	
(WL^2)/8	131.2 ft-kip	
ΔTL= L/240	1.25 Inch.	
ΔTL	0.72 Inch.	< 1.25 In. OK
ΔLL= L/360	0.83 Inch.	
ΔLL	0.34 Inch.	< 0.83 In. OK

30K11		
Self-weight	16.4 PLF	
Total Load	499 PLF	
Unfactored LL	190 PLF	
336 PLF + 16.4 PLF	352.4 PLF	< 499 PLF OK
23.1 PSF * 5'	116 PLF	< 190 PLF OK

Appendix E | Daylighting Renderings

Gymnasium – Lights off – No skylight

Gymnasium – Lights off – With skylight

Gymnasium – Lights on – With skylight

Appendix F | Cost Analysis Details

Suburban Wellness Center - Original Design

20500 Seneca Meadows Parkway
Germantown,
Maryland

Penn State
Cory Abramowicz
8-Apr-08

Unit Cost Detail Report

LineNumber			Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 22 Plumbing							
221223132140			Water heater storage tank, galvanized steel, 125 psi, 300 gallon, 36" diameter, 76" L.O.A., ASME	2.00	Ea.	$6,324.58	$12,649.16
Division 22 Subtotal							**$12,649.16**
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)							
237433107120			Rooftop air conditioner, multizone, cool/heat, variable volume distribution, 90 ton cooling, includes, standard controls, curb and economizer	2.00	Ea.	$183,660.00	$367,320.00
238416106100			Dehumidifier, self contained, 120 to 155 lb./Hr., 4500 CFM, includes filters and standard controls	1.00	Ea.	$65,971.17	$65,971.17
Division 23 Subtotal							**$433,291.17**

Suburban Wellness Center - Proposed Design

20500 Seneca Meadows Parkway
Germantown,
Maryland

Penn State
Cory Abramowicz
8-Apr-08

Unit Cost Detail Report

LineNumber			Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 00 Non-CSI							
000000000001	U		Green Roof System	24,000.00		$0.00	$360,000.00
000000000002	U		Zero-VOC Paint	200.00		$0.00	$9,406.00
Division 00 Subtotal							**$369,406.00**
Division 08 Openings							
086213100030			Skylights, fixed dome type, 22" x 46"	14.00	Ea.	$290.03	$4,060.42
Division 08 Subtotal							**$4,060.42**
Division 22 Plumbing							
221223132140			Water heater storage tank, galvanized steel, 125 psi, 300 gallon, 36" diameter, 76" L.O.A., ASME	2.00	Ea.	$6,324.58	$12,649.16
Division 22 Subtotal							**$12,649.16**
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)							
237433107140			Rooftop air conditioner, multizone, cool/heat, variable volume distribution, 120 ton cooling, includes, standard controls, curb and economizer	2.00	Ea.	$234,978.10	$469,956.20
237433107140	A		Commissioning, commissioning with documentation of design intent, performance verification O&M training, max	1.00	Project	$1,762.34	$3,524.68
238416106100			Dehumidifier, self contained, 120 to 155 lb./Hr., 4500 CFM, includes filters and standard controls	1.00	Ea.	$65,971.17	$65,971.17
238416106100	A		Commissioning, commissioning with documentation of design intent, performance verification O&M training, max	1.00	Project	$494.78	$494.78
Division 23 Subtotal							**$539,946.83**