Quality of Life Improvements for the Oak Hill Community:

Energy, Behavior, and Health Audit of the Union Hill Elementary School

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Executive Summary

The Oak Hill Community in Worcester, Massachusetts, comprises a ten-block area of parents, students, and teachers. Unfortunately, this neighborhood suffers from economic and communal challenges including employment, health, housing, and education instability. Issues like these make it difficult for residents of the community to build social capital. Social Capital "refers to the individual and communal time and energy that is available for such things as community improvements, social networking, civic engagement, personal recreation, and other activities that create social bonds between individuals and groups" ("Social Capital," n.d.). In a small community such as Oak Hill, a lack of social capital leads to various difficulties that adversely affect the community. Residents of the Oak Hill Community also lack proper education towards being environmentally conscious, The reason that the residents lack this focus on the environment is because they are instead focused on their daily financial, health, and crime problems.

These issues have an enormous impact on the youth of the community, especially the 350 K-6 students who attend the Union Hill Elementary School because it is an underperforming school. From the lack of performance of the school over a four year period, Union Hill was labeled a level-four school; in other words, it was one of the most underperforming schools in Massachusetts. Thus, the school was restructured: the school now has a new principal and half of the teachers were replaced. If "dramatic and sustainable improvement" is not shown over the next three years, the school will be shut down. With the lack of social capital, there is not a significant push from the community to improve the school because the community is focused on their economic, health, and crime instabilities.

The goal of this project is to develop strategies to improve the quality of life of the Oak Hill Community through environmental action and greenness. To accomplish this, we completed research toward our two major objectives: 1) to make recommendations to the Union Hill Elementary School focusing on greenness and energy conservation, and 2) to develop community outreach strategies for the Oak Hill Community. To make such recommendations and strategies, an energy, health, and behavioral assessment was necessary. The information gathered from these assessments serves two purposes: it 1) provides critically important data to base recommendations on, and 2) acts as a baseline to determine future improvement. In this

paper, we present our methods, findings, recommendations, and the related implications for the Union Hill Elementary School.

This project involves using an environmental goal to achieve socioeconomic change in an inner-city community. Thus, identifying the effects of environmentalism and their associated impacts on the community is essential to understand our methodology and our reasoning behind the recommendations that are made in chapter six. Such relationships and topics are focused on in order to establish the perspectives surrounding the core themes of our project. First, environmental consciousness is defined as it relates to this project. Next, the ways that environmental consciousness and green improvements affect economics and saving potential of residents, landlords and the Union Hill Elementary School, next, we discuss health and school performance of the staff and students of the school, we also discuss crime rates in the immediate surroundings; and how to solve crime through the beautification of the community. This discussion helps to connect the reason that we are making green recommendations in order to improve the financial situation, health, crime, and education of the Oak Hill Community.

One of the major products of this project is a set of recommendations to improve energy conservation, greenness, and ultimately, the educational environment at Union Hill Elementary School because this will help the economic and communal problems in the Oak Hill Community. To make informed and practical recommendations, it was necessary to obtain a baseline of the school's energy use. From this energy assessment we were able to conclude that the state of the building envelope is unsatisfactory. There were many places that we were able to identify that could be improved. Unfortunately, with the energy baseline and water usage baseline, we were unable to conclude whether or not they were acceptable. This is simply because we did not have the time to go in depth to calculate the amount of water and electricity that should be used by a school of this size and complexity. These baselines are crucial in order to record and show how much our recommendations are able to decrease the electricity and water usage and increase environmentally friendly habits. These baselines will be combined with our assessments in order to find ways to increase energy consumption through behavioral changes By involving the residents of the community with these changes, we will ultimately be able to increase their overall consciousness towards the environment and their community.

We determined that the largest impact on environmental consciousness is the behavioral aspect. Because of this we decided to perform a behavioral assessment on the Union Hill

Elementary School to find areas in need of improvement when it comes to the behavior towards being environmentally conscious. As part of our assessment we performed a principal interview, teacher survey, parent survey, and student survey. These surveys were very important to create an overall profile of the Union Hill Elementary School and surrounding Oak Hill Community. From these surveys, we have observed that the parents and students seem to recycle and conserve electricity at home more often as compared to the teachers at the school. Unfortunately, these parents are not fully educated about the use of money saving devices such as programmable thermostats. We believe that if these teachers are educated on the global effect of their decisions to recycle and conserve electricity, they will be more likely to do so. Also, if The Union Hill Elementary School makes a large effort to recycle and conserve electricity the teachers will be more aware of the global aspects, and again more likely to join in on the schools efforts.

We have determined that the school environment can have a large impact on the health of the students because they are spending much of their weekdays inside these old buildings that could still have harmful toxins within them. Because of this we have decided to perform testing in order to evaluate the current conditions in The Union Hill Elementary School. Our health assessment included creating a Health baseline, evaluating the lighting, testing the water, testing for lead, and evaluating the air quality. From our health baseline, we were able to determine the major health problems in The Union Hill Elementary School. These include headaches, nosebleeds, and asthma. We have found that there is over-illumination in the rooms at the school, which are proven to cause headaches. The dry air in the 1890 building is causing nosebleeds; this is because the heating system is overheating the building. Finally, we have not been able to identify any large sources or poor air quality that could disturb the student's asthma, but we feel that further testing should be completed. We combine the information obtained from the energy, behavioral, and health assessment into consideration in order to compile a list of recommendations to begin remedying these problems. We ultimately frame these recommendations in order to increase the quality of life within the students and staff of the Union Hill Elementary School, but if we can engage the community with our recommendations, the quality of life within the Oak Hill Community and the residents' involvement within their community will be increased.

Finally, we present many recommendations and alternatives that we believe will begin to improve the educational environment at the Union Hill Elementary School and improve the

quality of life of and the community's investment in the Oak Hill Community. These recommendations focus on technological upgrades and additions as well as behavioral changes that can be made through outreach and education at the Union Hill Elementary School. Our recommendations are broken into Green, Building Envelope, Health, Energy consumption, and Outreach Recommendations. Our hope is that the school will act as a precedent to the community and the students will transfer their knowledge to the community over time. It is also important to note that these recommendations are only the first step to improving the community. In order to try to simplify our extensive list of recommendations, we conclude with a recommended implication strategy

Table of Contents

List of Figures

List of Tables

Chapter One

An Introduction to the Problems Within the Oak Hill Community and Union Hill Elementary School

The Oak Hill Community in Worcester, Massachusetts, shown in Figure 1, comprises a ten-block area of parents, students, and teachers. Unfortunately, this neighborhood suffers from economic and communal problems including employment, health, housing, and education instability.

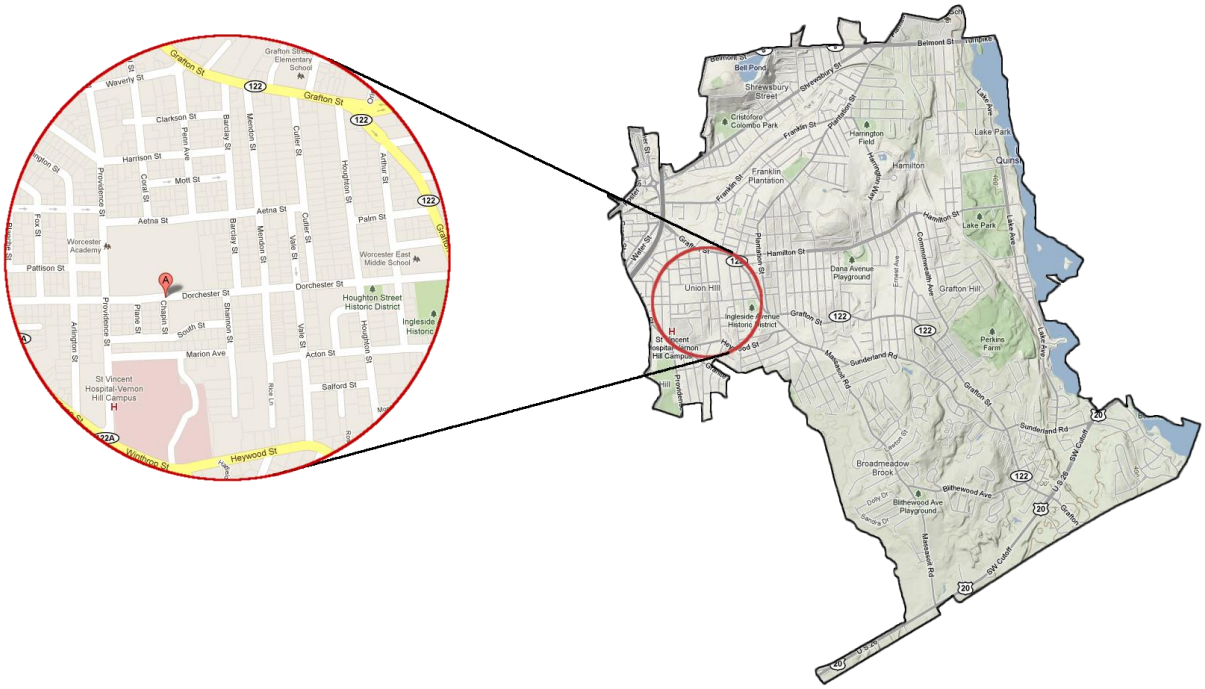


Figure 1. Map of the 01604 area. The area inside the red outline represents the Oak Hill Community. In the blowout to the left, the 'A' balloon marker represents the location of the Union Hill Elementary School.

The community's economic stability is endangered from the unemployment status of the families currently living in the Oak Hill Area. For example, while there is a 8.6% national average, the unemployment rate in Oak Hill is almost 40% higher ("Strategic Plan 2011-2013," 2011; "United States Unemployment Rate," 2011). Furthermore, the residents of the community are more at risk for health problems, and are in particular danger because they do not know if they have health problems. In fact, the Oak Hill Community Development Corporation has identified that only 16% of residents have a primary care doctor compared to the 85% U.S average ("Strategic Plan 2011-2013," 2011; "Summary Health Statistics for U.S Adults," 2010; "USA

Quickfacts," 2011). This obstructs proper medical diagnosis and treatment and amplifies the health risks associated with the lack of environmental consciousness. Issues like these make it difficult for residents of the community to build social capital. Social Capital "refers to the individual and communal time and energy that is available for such things as community improvements, social networking, civic engagement, personal recreation, and other activities that create social bonds between individuals and groups" ("Social Capital," n.d.). In a small community such as Oak Hill, a lack of social capital leads to various difficulties that adversely affect the community.

One such difficulty for the Oak Hill Community is that most residents are not environmentally conscious, and as a result, they have a low quality of life because the lack of environmental consciousness has the potential to seriously endanger the health and stability of the community. In other words, residents are not aware of the economic, health, and community benefits of being 'greener' and conserving energy and do not partake in efforts to become greener and conserve energy. In turn, their quality of life is poor because there is little support from most of the community to improve it. The reason that the residents lack this focus on the environment is because they are instead focused on their daily financial, health, and crime problems. As we discuss in chapter two, environmental consciousness actually helps to counteract these financial, health, crime, and education concerns; but again, many residents are not aware of this.

These issues have an enormous impact on the youth of the community, especially the 350 K-6 students who attend the Union Hill Elementary School because it is an underperforming school. The school is shown in Figure 2. For instance in Language Arts, "the state average for English Language Arts was [sixty-three percent proficiency] in 2010" (Union Hill School Test Scores, n.d) while Union Hill only scored an eleven percent proficiency rating among students. From the lack of performance of the school over a four year period, Union Hill was labeled a level-four school; in other words, it was one of the most underperforming schools in Massachusetts. In fact, this designation means that Union Hill is part of the lowest four percent in the state. Thus, the school was restructured: the school now has a new principal and half of the teachers were replaced. If "dramatic and sustainable improvement" is not shown over the next three years, the school will be shut down. With the lack of social capital, there is not a significant push from the community to improve the school because the community is focused on

their economic, health, and crime instabilities. Clearly, there is need for social capital within this community because the school is in need.

Figure 2. The Union Hill Elementary School consists of two buildings. The picture on the left is the building built in the 1890s and the picture on the right shows the building built in the 1960s.

Understanding the community and school or our project allows us to better identify the scope, understand potential impacts of this project, and make specific recommendations for improvement. Union Hill Elementary School is an integral part of the Oak Hill Community and this project because it is directly linked to the state of the community and can be used as an example for the rest of the community.

The goal of this project is to develop strategies to improve the quality of life of the Oak Hill Community through environmental consciousness and greenness. To accomplish this, we completed research toward our two major objectives: 1) to make recommendations to the Union Hill Elementary School focusing on greenness and energy conservation, and 2) to develop community outreach strategies for the Oak Hill Community. The project focuses on the younger generation of the community, who will ultimately transfer environmentally friendly habits to the rest of the area. As such, the Union Hill Elementary School will serve as a precedent to demonstrate the advantages of being green and energy conscious. Ultimately, this project is not intended to immediately solve the problem of the Oak Hill Community. As described in the last section of chapter two, it is simply impractical to expect a large scale community habitual change given the scope and time constraints of this project. Instead, our hope is that our project will begin a movement within the community toward becoming green and provide strategies to further expand environmental consciousness within the community. By laying the foundation for

this movement, the Oak Hill Community Development Corporation will be able to more effectively enact community change over time.

To make such recommendations and strategies, an energy, health, and behavioral assessment was necessary. The information gathered from these assessments serves two purposes: it 1) provides critically important data to base recommendations on, and 2) acts as a baseline to determine future improvement. The first purpose is significant because accurate data is essential to make informed decisions specifically for the Union Hill Elementary School. In turn, the suggestions we make will have a bigger impact toward our goal. The second purpose is primarily significant to the Oak Hill Community Development Corporation, an organization that relies on signs of improvement to sustain federal grants for the further improvement of the community. Thus, by creating a baseline of Union Hill Elementary, green and environmental consciousness improvements can be shown in the future.

In this paper, we present our methods, findings, recommendations, and the related implications for the Union Hill Elementary School. In chapter two, environmental impacts on community development and educational success, we discuss the core factors that affect health, school and economic performance of the community that surround our project goal and objectives. In the third through fifth chapters, we present the methods and results for the energy assessment, behavior assessment, and health assessment respectively. In the sixth chapter, the recommendations chapter, we have compiled our recommendations to being improving on the problems found in our assessments. Finally, at the end of our paper, we present our conclusion, hopes for the future, and future extensions of this project.

Chapter Two

Environmental Impacts on Community Development and Educational Success

This project involved an environmental goal to achieve socioeconomic change in an inner-city community. Thus, identifying the effects of environmentalism and their associated impacts on the community is essential to understand our methodology and our reasoning behind the recommendations we focus on in order to establish the perspectives surrounding the core themes of our project. First, we define environmental consciousness as it relates to this project, 1) the ways that environmental consciousness and green improvements affect economics and saving potential of residents, landlords and the Union Hill Elementary School; 2) health and school performance of the staff and students of the school; 4) crime rates in the immediate surroundings; and 5) the beauty of the community are explored, 6) the difficulties involved in changing the environmental habits of the community are discussed. These topics are important to the project because they provide insights about the physical and psychological aspects of our work. The implications that are explored in this section help to connect the methods of our project to purpose within the community. In other words, it helps to connect the reason that we are making green recommendations in order to improve the financial situation, health, crime, and education of the Oak Hill Community.

Environmentalism

In order to grasp the relationship between our environmental goal and various community health factors, it was necessary to first understand the concepts of environmentalism. Most people associate environmental consciousness with the word 'Green,' which is a common term used in society today. The main reason that society began to be more conscious of the environment is the apparent effects of Global Warming (Fehr & Keith, 2011). Climate changes cause a great concern in society to protect their futures, which enacted a large movement towards being 'Green' (Le Treut, 2007). Even though the term is used very often, most people do not know exactly what it means. Many people associate 'Green' with conserving energy, but there is more to it: being 'Green' means that everything one does has the least impact on the earth and does not use any "ecological capitol."

It is also important to understand the connection between this idea of greenness and how it fits into a school environment. A prime example of this notion is a green school. According to

The Center for Green Schools, a 'Green' School is "a school or facility that creates a healthy environment that is conductive to learning while saving energy, resources, and money" (Green Existing Schools, n.d.). By helping the school become more environmentally conscious; this will indirectly improve their health, safety, and learning environment.

Economic Benefits of Environmental Consciousness

One way to raise awareness in the community is to show the economic benefits of being green because economically disadvantaged people, including Oak Hill residents, are attracted to any mechanism that saves them money. There is even legislation being discussed in the United States to help these economically depressed areas; for example, the Green Opportunities and Environmental Justice Act states, "by assessing social and economic disadvantage, we can target areas that will benefit from green initiative programs such as green economy, green collar jobs, and environmental justice programs" (Green Opportunities and Environmental Justice Act, n.d.). Three specific groups of people within the community can be affected by these benefits that come through green change: the staff and students of Union Hill Elementary School, the families in the Oak Hill area, and the landlords of the community. This section highlights the importance and impact of both green infrastructural and green behavioral changes.

The education mission of schools makes them an integral part to the community, any money that can be saved can help improve the overall educational environment. This saved money can then go towards improving the education of the children. For instance, due to the sheer size and amount of energy that is used in a school, there are many opportunities to reduce energy consumption. In fact, schools, like Union Hill Elementary, "face energy bills up to 60% higher than" any other buildings (Yallop, 2004). Schools have less money to spend on school supplies and educational materials due to this increased cost ("Advanced Energy Design," 2008). As a result of saving money, there will be a better environment in the school which will help to improve the education of the youth of the community. In turn, these students will have more opportunity to positively affect the world around them.

Material changes that improve capital.

Because the income in the Oak Hill Community is lower than the national and Worcester average, families have particular intent for obtaining the financial benefits of being green. With this economic problem, the goal is not to find every area where the money can be saved, but

where the most effective changes can be made because families simply do not have the time and resources available to implement every green technology. Families in this community have a particularly high rate of mobility; thus, they are unlikely to be able to invest long term into their residence. Also, due to the economic situation of these residents described earlier, they are unlikely to have the funds on hand to invest in being green. For instance, "according to the U.S. Department of Energy, drafts can waste 5% to 30% of [homeowner's] energy use" (Barrow, 2011). Instead of going through and replacing the doors and windows of the house, which may save more money in the long run than other techniques, homeowners can use simple and cost effective techniques such as caulking or weather stripping which have a much faster return on investment. This would benefit the residents immensely because it would save them money while taking a relative small amount of time and would be accessible due to the low initial cost.

Capital improvement leads to behavioral change.

Green behavioral changes also have immense potential for the residents of this community to save money because there is no start-up cost involved. Green behavioral changes must coincide with green technology improvements for the most effective cost savings. Explained by Faris (2010), when families make energy saving changes to their homes they may not be used correctly. The tendency is that families that have energy saving appliances use them more inefficiently because they feel they can use those appliances more frequently just because it is a green product. We focused on low investment, easy to implement green solutions to help improve the green behavioral changes. This allows the residents of the Oak Hill Community to benefit financially through being environmentally conscious because money would be saved through energy conservation. Residents could then use this saved money to further improve their quality of life.

Landlords in the Oak Hill Community could also save money. This population is so important because this area "has a high percent of renters," and by association, landlords ("Oak Hill CDC," 2011, p. 45). Thus, there is a large opportunity for financial savings, which is good because of the pressure that landlords face due to the recent foreclosure rate and high mobility of residents. The poor economic situation, in addition to additional pressure from the poor housing market causes tremendous housing instabilities in this area. In turn, landlords are affected because an empty residence actually costs them money. Just one example is that landlords must heat vacant homes in order to show and sell it.

One factor that greatly affects this housing instability is the energy bills that families must pay. If landlords made long term investments to their properties, family energy bills would decrease, and the property would become much more stable. On a larger scale, housing instability would decrease, and the economic situation of the Oak Hill Community would improve. One example that was discussed earlier involved the residents' ability to decrease drafts. Here, the landlord would prefer to replace the windows because the long term investment would save more money over time. Other times, residents simply don't have the means to improve the energy efficiency of their residence. For instance, many families may live in an apartment that is affected by the same Heating, Ventilation, and Cooling (HVAC) system. The families do not have the option to make any changes, such as changing heating system filters, but the owners can (Barrow, 2011). Such improvements would benefit everyone involved: the landlords, residents, and the community. The landlords would make more money as a result of reduced vacancy, residents would spend less on utility bills, and the economic stability of the community would improve.

Building Factors That Affect Health and School Performance

Many aspects of a school building potentially cause serious health risks. These risks, compounded with a resulting decrease in school performance, make such aspects critically important to the school because of its role of education. These risks include: 1) lead poison; 2) poor lighting; 3) poor air quality; 4) fluctuating temperature; and 5) mal nutrition. Negating these risks makes the school a more suitable place for learning. According to the Advanced Energy Design Guide for K-12 Buildings (2008), "A better environment that includes favorable light, sound, and temperature can help students learn better." This has been proven in studies conducted in schools; for example, in seventeen studies, Kats (2008) demonstrated productivity increases of two percent to more than twenty-five percent as a result of improvements such as increased indoor air quality and high-performance lighting systems. Similar increases in school performance are possible at Union Hill Elementary school, especially because it is a level four school. Such risks must be taken into consideration for the good of the education of the students, and more broadly, for the good of the education of the community.

Lead poisoning.

One large risk to the health of the community is exposure to lead because the potential negative effects of lead on the community housing stock are tremendous: even a very minute exposure may cause damage. According to the United States Environmental Protection Agency (2008), "Many homes built before 1978 have lead-based paint. The federal government banned lead-based paint from housing in 1978." Lead exposure is an issue for the community as a whole: in the greater Oak Hill area, that is, the 01604 area, 88% of the housing stock was built before 1978 ("Oak Hill CDC," 2011, p. 42). Clearly, the vast majority of the Oak Hill Community may be at risk for lead poisoning. The community includes Union Hill Elementary school, which means this risk is especially relevant due to the age of the school: One building of the school was built in the 1890s and the other was built in the 1960s. Because the building date of the school is well before lead-based paint was banned, children are at risk.

We are concerned with the potential negative effects of lead poisoning on the students inside the school because "lead poisoning occurs when a person swallows, absorbs, or inhales lead in any form" (lead indoor air quality, 2011). This is very likely to occur with students in an elementary school because children are in the school for extended periods of time which increases the chance for exposure. In addition, younger children are much more likely to come in contact with lead, and thus, get lead poisoning. Due to the increased risk for school children, it is essential that lead be taken into consideration.

Lead poisoning is especially concerning to the students of Union Hill Elementary school because of the effects of lead poisoning and their potential impact on school performance. As stated by the American Academy of Child & Adolescent Psychiatry (2004), even when exposed to small amounts of lead levels, children may appear inattentive, hyperactive and irritable. Children with greater lead levels may also have problems with learning and reading, delayed growth, and hearing loss. At high levels, lead can cause permanent brain damage and even death. This fact is also stressed greatly by the United States Environmental Protection Agency (2011). Lead is particularly important to Union Hill Elementary because students often exhibit this behavior (M. Morse, personal communication, 2011). In addition, in an article named "The Effects of Lead Exposure on School Outcome," Tarr, Raymon, and Tufts (n.d.) add that exposure to lead increases the criminal behavior of the children. This is particularly relevant because due

to the high occurrence of children outburst on a daily basis at the school (M. Morse, personal communication, 2011).

Lead poisoning has a large impact on the nervous system and the brain. These effects cause lead exposure in schools to have a large impact on the performance of the students. "As the amount of lead in a child's blood increases, research shows a decrease in math and reading scores" (Ripple effects, 2011). It has also been noted that students "with special education status had significantly higher blood lead level" (Tarr et al., n.d.). This fact helps show that higher levels of lead in students' blood streams decreases their performance. The New Jersey Department of Health sums by indicating that "lead poisoning can cause developmental disabilities, behavioral problems, decreased IQ, and other neurological impairments that affect a child's ability to learn" ("An Important Message," 2008).

To limit these effects, the lead must be identified and removed. This is especially important because "early identification and treatment of lead poisoning reduces the risk that children will suffer permanent damage. Treatment begins with removal of the child from the sources of the lead" (Lead Exposure, 2004). The identification of potential lead in the school is necessary in this project to determine lead exposure of the students and to create a safer learning environment. Furthermore, lead is important to Union Hill Elementary School because 1) there is a possibility that there is lead in the Union Hill Elementary School; 2) the associated affects have serious potential to hinder school performance; and 3) it is underperforming. Thus, if there is a decrease in school performance, for example, from lead, the school is at risk to be shut down.

Lighting.

Lighting affects the overall health and comfort of the students and staff of Union Hill Elementary School. It is of principal importance because good lighting equals a better learning environment. A key factor in poor lighting is over- and under-illumination. "Over-Illumination occurs when there's too much light (or the wrong type of light) present for a specific activity. It's common in public buildings constructed before 1995." This is specifically important because the oldest building at Union Hill was constructed in 1890 and newest was constructed in 1960; thus, there is likely to be over-illumination. As shown in Figure 3, "The threshold level [for over-illumination] is around 700 lux" (Edle, 2011).

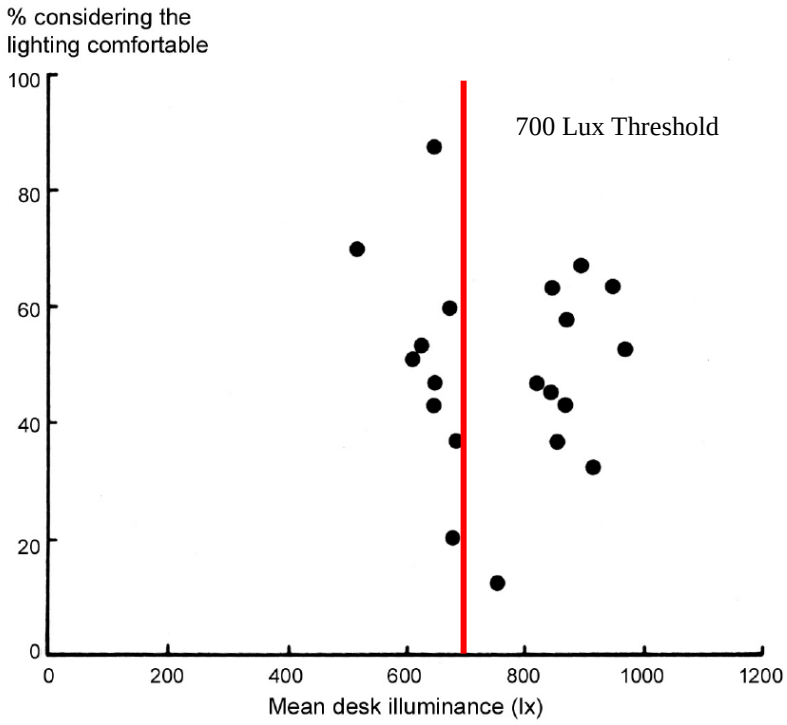


Figure 3. Luminance Health Threshold. The percentage of people in each of twenty deep, open-plan offices who considered the lighting comfortable, plotted against mean desk luminance in the offices (Boyce, 2003, p. 231).

After this threshold, "over-illumination is thought to cause headaches, fatigue, stress, increased risk of certain carcinomas, and high blood pressure" ("Over-Illumination," 2008). Clearly, over-illumination can lead to minor health risks which may cause unnecessary trips to the nurse's office, and thus, distractions to learning. Because the goal of the school is education, these distractions must be eliminated to achieve the better education.

Under-illumination has a similar effect. For example, under-illumination, or "conditions that make it difficult to see what needs to be seen or which distract attention from what needs to be seen are likely to produce eyestrain." In turn, this could lead to "irritation of the eyes, evident as inflammation of the eyes and lids; breakdown of vision, evident as blurring or double vision; and referred effects, usually in the form of headaches, indigestion, giddiness, etc." (Boyce, 2003, p. 475). If lighting of a room is not designed correctly it can cause discomfort to the students and staff who use the rooms, which decreases students' ability to learn.

A third light concern is light glare and flickering. These create distractions which reduce the effectiveness of the lights. In order "to achieve a lighting installation that will be liked… it is necessary to provide lighting which allows easy visual performance and avoids discomfort"

(Boyce, 2003, p. 186). In fact, according to The American Society of Heating, Refrigerating and Air-Conditioning Engineers (2011), "Some studies show that day lighting, which uses the sun to produce high-quality, glare-free lighting, can improve academic performance by as much as [twenty percent]" because there are no distractions and children feel more connected to the environment, which calms them. Using proper lighting techniques is essential to the Union Hill Elementary School because of the clear relationship between lighting and school performance. By reducing distractions in the classroom, including over-illumination, under-illumination, glare, flickering, headaches, and eyestrain, the educational environment for the children is improved.

Air quality.

Air quality in a school is critical because in an area, such as Oak Hill, of lower income increases the risk of having poor air quality. This is especially pertinent to Union Hill because about fifteen percent of the students have asthma, which makes them more at risk for illnesses that come from poor air quality The North Carolina Department of Health and Human Services has noted that "poor [indoor air quality] in schools can be associated with many issues, including but not limited to moisture and mold growth, combustion pollutants such as carbon monoxide, volatile organic chemicals/compounds, and radon." ("Indoor Air Quality," 2011). Because the Union Hill Elementary School is using a temporary boiler, the school community is at particular risk to combustion pollutants. The Center for Eco literacy notes the relationship between lower income and air quality when they state:

> Lower-income and minority children disproportionately suffer from poor indoor air quality and related problems in conventional schools. Children in low-income families are [thirty] percent to [fifty] percent more likely to have respiratory problems that lead to increased absenteeism and diminished learning and test scores. (Kats, n.d.)

They also noted that this diminished air quality has negative effects on the students' health by causing respiratory problems, especially the fifteen percent of the student body with asthma. Because Union Hill Elementary students come from lower income families, they are more at risk to decreased health and school performance.

Poor air quality affects the socioeconomics and health of the community. J. Jewet (2011) from the Massachusetts Medical Society indicates that "poor indoor air quality in schools can seriously exacerbate pediatric asthma and allergies." As discussed in chapter one, the eighty-five percent of residents of the community do not have access to medical care, so these asthma risks

further endanger the children. Because of this, some students may not even be aware that they have asthma. The Center for Eco literacy (n.d.) notes "it costs nearly three times more to provide health care for a child with asthma than a child without asthma." Clearly, air quality can be linked to financial benefits. Improved air quality can help to negate asthma. According to Kats (n.d.), "a recent Carnegie Mellon review of five separate studies found an average reduction of 38.5 percent in asthma in buildings with improved air quality." If the air quality at Union Hill Elementary School is improved, this will help families in the Oak Hill community save money on medical expenses as well as improve their overall quality of life.

Temperature.

Inadequate temperatures in the classroom can have negative effects on the learning process. The Nondestructive Test Resource Center notes that "if a student is too cold or too hot, they will have more of a hard time concentrating on what their learning task is" ("Understanding Different Learning Styles," n.d.). If the temperature of a room can be kept at an optimal temperature, students are able to focus. In fact, "temperatures above 80 degrees [Fahrenheit] tend to produce harmful physiological effects that decrease work efficiency and output" ("Influence of the School Facility on Student Achievement," 1999). Maury Tiernan (2001) adds that the lower limit for temperature is 72 degrees Fahrenheit (other authors may cite 68 or 70 degrees Fahrenheit). The temperature is an important thing to study at Union Hill Elementary School because of the age of the heating and cooling systems. The current heating systems have distribution problems such that some rooms are extremely hot while others are very cold. This in turn causes discomfort to the staff and students and could lead to decreased performance. This is a particular problem here because if the school shows signs of such decreased performance, it will be shut down.

Obesity and nutritional choices.

A major issue in the Oak Hill Community is access to nutritional foods; this directly affects the health of students but does not appear to affect their academic performance. This is important to the Union Hill Elementary School because The United States Center for Disease Control and Prevention (2011) has found that "the percentage of children aged 6–11 years in the United States who were obese increased from [seven percent] in 1980 to nearly [twenty percent] in 2008. Similarly, the percentage of adolescents aged 12–19 years who were obese increased

from [five percent] to [eighteen percent] over the same period." This problem can be addressed in schools through education, but, unfortunately, "**education** on nutrition and physical health is limited in the curriculum" (Obesity, n.d.).

In addition to the limited curriculum on nutrition, the Union Hill Elementary School is located in a low income area and for many low-income families, access and affordability of fruits, vegetables, and other health foods is limited. Specifically, Union Hill has little access to organic products in supermarkets and stores due to the lack of business in Oak Hill (M. Sawyer, personal communication, 2011). Many supermarkets are moving out of the cities' downtown core in favor of the more profitable neighborhoods and suburbs" (Obesity, n.d.). This problem is being evaluated at the Union Hill Elementary School to find a solution to start healthier eating habits for the students and their families.

Crime Reduction

There is no place for crime in the neighborhood of a school; thus, one of the most important goals of our project is to reduce crime in the street and bad behavior in Union Hill Elementary School. This section first explores the pre-existing crime theories and studies. After that, these theories are linked to Union Hill Elementary School. Next, the relationship between environmental factors and crime reduction are presented. Finally, opposing views are examined. One of the largest contributors to crime in today's streets can be explained by the broken windows theory, which was proven in New York:

> Consider a building with a few broken windows. If the windows are not repaired, the tendency is for vandals to break a few more windows. Eventually, they may even break into the building, and if it's unoccupied, perhaps become squatters or light fires inside. Or consider a sidewalk. Some litter accumulates. Soon, more litter accumulates. Eventually, people even start leaving bags of trash from take-out restaurants there or breaking into cars. (Kelling & Wilson, 1982)

Additional support of this theory comes from Lowell, Massachusetts, only forty-two miles away from the school. In 2005, researchers from Harvard University and Suffolk University cleaned up half of the areas that were affected by littering, loitering, and broken street lights. All other areas were left unaffected. "Researchers then monitored the results and found that there were 20 percent fewer calls to police from the spruced-up areas compared to areas receiving traditional

police response" ("Research boosts broken windows theory," 2009). A similar result could be obtained in the Oak Hill Community.

In fact, this theory is of considerable relevance for the surrounding Oak Hill Community. Unfortunately, as shown in Figure 4 below, M. Sawyer (2011) has indicated that the sidewalks of the street of the one block area around Union Hill Elementary School are often filled with litter and that the area has been identified as a hot spot for crime (personal communication).

Figure 4. Littering on Dorchester St. Union Hill Elementary School can be seen in the distance to the right of the picture.

In fact, there is no better evidence of this relevance than the broken window on the south side of the 1890 building of the Union Hill Elementary School. If such litter and broken windows are not identified and fixed, they will only get worse.

Crime rates are not a problem in only the immediate surroundings. As can be seen in Figure 5, the greater Worcester area approaches twice the chance of rape, robbery, and assault compared to Massachusetts and the United States. Last year the Oak Hill CDC developed a business plan that would help them gain grants for community outreach; apart of this report pertained to the Oak Hill community crime rate. The community is at particular risk because "Worcester police have reported to the Oak Hill CDC [that] they have seen a [thirty-five] percent

spike in crime" in this area ("Oak Hill CDC," 2011, p. 59). Currently, the crime rates in the surrounding area of Union Hill Elementary School are bad and are getting worse; thus, it is imperative that crime is reduced in the community.

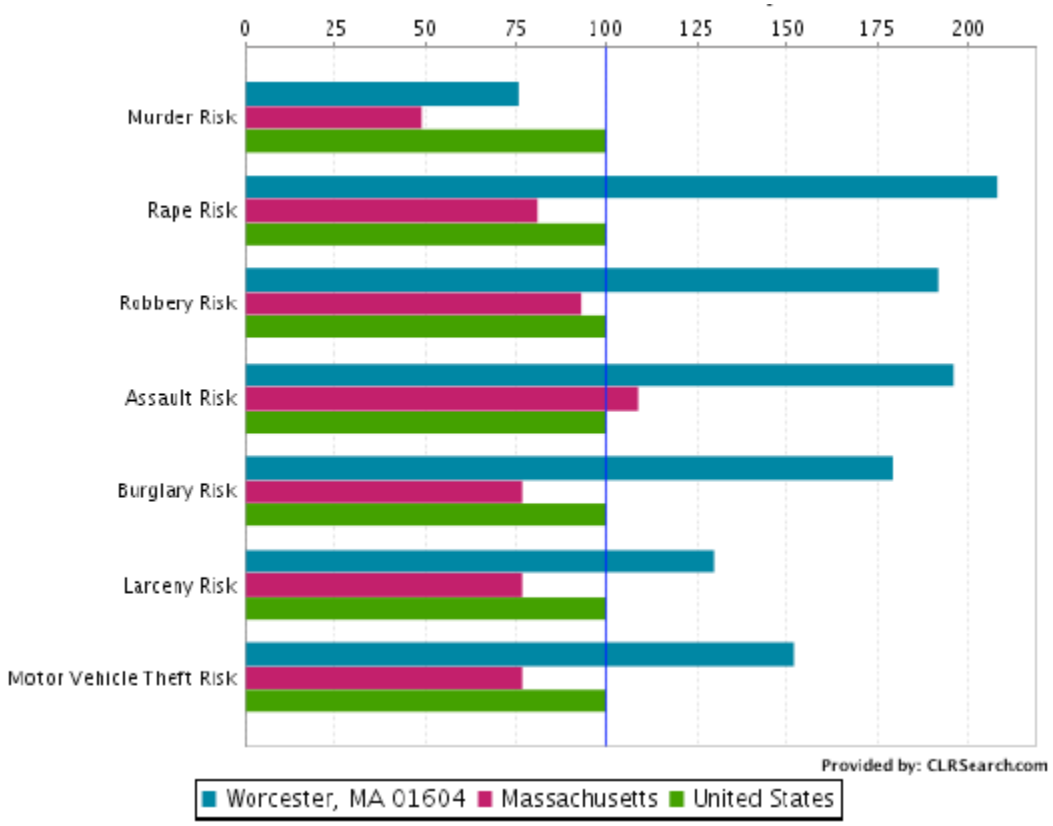


Figure 5. 2010 crime rate indexes for Worcester, MA.

Crime rates in the Oak Hill Community can be reduced by environmental factors. For example, "a 30-year study conducted by researchers at Morton Arboretum revealed when landscaping projects are promoted in communities, neighborhoods, housing projects and prisons, self-esteem increases and vandalism decreases" ("Green spaces reduce crime," 2011). A study conducted by Barton and Pineo has shown that stressed individuals feel better after exposure to natural scenes. Accordingly, "green spaces also reduce instances of aggression and violence" (2009). This relationship between crime and greenness is of particular interest to this project: through increasing the greenness of the community, the crime rates will also be reduced.

Others are not convinced that crime can be reduced by environmental factors. For example, others may note that "increased vegetation translates to an increase of crime by

offering hiding places for criminals and their criminal acts." Contrary to these common beliefs, maintained greens spaces actually reduce crime. In fact, Barton and Pineo (2009) note that, "vegetated spaces cut crime by half… [and inspire] pride for surroundings." This pride then "translates into less litter and less graffiti." For Oak Hill, this reduction of litter and graffiti further improves safety according to the broken windows theory. In addition, vegetated landscapes invite more people to use them, ensuring more eyes on the watch to prevent crime on the streets.

As social capital increases as a result of our environmental goal, safety also increases. The Human Environment Research Laboratory at the University of Illinois makes an interesting connection between social capital, safety, and greenness: "Green spaces are gathering places that create close-knit communities and improve well-being and in doing so, they increase safety" (Kuo & Sullivan, 2001). Because our overarching goal is environmental in nature, it is useful to determine the effect of such factors on crime. The relationship between our environmental goal and crime indicates that crime will be reduced as a result of our green recommendations.

Beautification

One of the goals of our project is to develop a strategy to continuously beautify, or improve the appearance of, the community. This concept is important because it has the potential to seriously impact the Oak Hill Community: crime and health risks could be reduced, property value and social capital could be increased, and the way people think, feel, and behave could be improved. Beautification is the primary deterrent to factors which contribute to the snowball effect associated with the broken windows theory; thus, it is important to continuously beautify so that this domino effect is minimized (Kelling & Wilson, 1982).

In addition to reduced crime, beautification leads to many financial benefits for the entire community. For example, Neely (1988) points out that, "planting a tree can significantly increase property values." As an example, "the U.S. Tax Court recently calculated a [decrease of] value of [nine] percent… for the removal of a large black oak." Neely adds that planting a single tree has the potential to raise property value by one to ten percent. In addition, trees can save home and business owners money by providing shade which cools in the warmer season. Because the Oak Hill Community has lower annual income and higher unemployment than surrounding areas, such financial benefits are essential to all residents. It would allow them to have more opportunities for socioeconomic improvement.

Aesthetic enhancement has numerous psychological benefits. Again, vegetation makes a huge difference due to its color. One study from the University of Georgia found that "the majority of emotional responses for the color green indicated feelings of relaxation and calmness, followed by happiness, comfort, peace, hope, and excitement,… and thus created feelings of comfort and soothed emotions" (Kaya & Epps, 2004). Community stress levels are also reduced as crime rates are reduced because residents do not fear for their safety (Barton & Pineo, 2009). In other words, beautification reduces crime, and reduced crime leads to a less stressful community. In turn, a less stressed community leads to a community with more social capital, which is good because of the current lack of social capital.

Over the past decade, there has been a lot of media and government attention of the benefits of being green. Over time, this created the shift toward an energy efficient and environmentally conscious society and a perception "that being green is… correct" (Fehr & Keith, 2011). Because Kruglanski (1989) notes that there is a certain sense of personal fulfillment and happiness when people are right, there is a clear psychological profit to being green. These psychological benefits are especially important because they are one factor which increases the social capital of the community: in turn, improved social capital boosts the economy and well-being of the community.

One way to improve the appearance of the community is to make it more walkable, which is important because a walkable neighborhood has health and financial benefits; two areas of immense need for the Oak Hill Community. Figure 6 shows that the Oak Hill area has a walk score of fifty-five out of one hundred, indicating that it is in the lower percentile of the 'somewhat walkable' category ("Walkable neighborhoods," 2011). The walk score is higher closer to Worcester center, and much worse to the south-east of this location. Improvement in this area is beneficial for a variety of reasons. First, "the average resident of a walkable neighborhood weighs six to ten pounds less than someone who lives in a sprawling neighborhood" (Smith, 2008). This fits in very well into our previous discussion about obesity and nutrition. In addition, the environment and community health improves because pollution decreases and air quality increases as a result of the reduced dependence on automotive transportation.

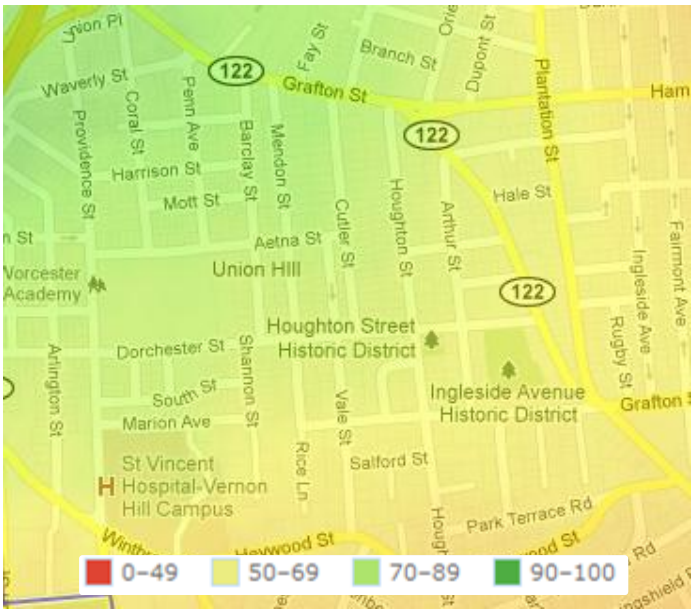


Figure 6. Walk score of Union Hill Community. Walk scores are higher closer to Worcester center. The surrounding area to the south east reaches very low walk scores.

A research report released by Front Seat Management indicates that an increase of "one point of Walk score is worth up to $3,000 [property value]" ("Walkable neighborhoods," 2011). Clearly, there are even more financial benefits to beautification. "Comparisons between the more walkable and less walkable neighborhoods show that levels of social capital are higher in more walkable neighborhoods" (Rogers, Halstead, Gardner, & Carlson, 2011). Such factors are clear examples of the importance of improving the appearance of the community.

Conclusion

To improve the environmental consciousness and greenness of the Oak Hill Community, it was necessary to accomplish two objectives. First, an energy, behavioral, and health assessment of Union Hill Elementary School was conducted. These assessments create a baseline for future comparison, identify risks, and focus the second objective. Second, energy efficient and green recommendations, in addition to outreach strategies, were developed and presented to the Oak Hill Community Development Corporation (CDC). After these objectives are completed, the community will begin to show increased environmental consciousness and the Oak Hill CDC will be prepared to disseminate environmentally friendly habits. In addition, families, schools and landowners will save money, green space will beautify the community,

people will be healthier and more conscious of their health, and crime rates will dissipate. Clearly, our environmental goal has to the potential to seriously impact the community.

Chapter Three
Energy Assessment

One of the major products of this project is a set of recommendations to improve energy conservation, greenness, and ultimately, the educational environment at Union Hill Elementary School. To make informed and practical recommendations, it is necessary to obtain a baseline of the school's energy use.

Although not all energy audits are the same, the methods are generally broken into four common phases.

1. Building and Utility Data Analysis
2. Walk-through Survey
3. Collecting and Analyzing Specific Energy Use
4. Analyze competing Energy Alternatives

The first phase was a building and utility data analysis because it was necessary to collect the data first in order to make useful recommendations for the school.
Krarti (2000) states that its main purpose is to "determine patterns of energy use" and evaluate the characteristics of the energy systems (p.2). In order to determine a pattern, at least three years of energy usage data was collected. In particular, it was important to identify the effect of weather on energy costs and to classify the building based on its size and purpose.

The next phase, the walk-through survey, is designed to identify potential energy saving measures, determine the extent and goals of the audit, survey operating conditions of Heating Ventilation and Air Conditioning (HVAC) and electrical systems, and classify spaces of the facility (p. 5). This phase is critically important because it identifies the extent of the energy audit. This also determines the specific processes needed for the Union Hill Elementary School.

The third phase involves collecting and analyzing specific energy use for all non-negligible electrical systems, evaluating the efficiency of the HVAC system, and finding where conditioned air is lost from the building envelope. During this collection phase, quantitative data was the best determinant because the auditing tools produce numerical data. This data was of particular interest to our project because it helped show us where the heat loss was occurring and where it needed to be fixed in the buildings; correcting these deficiencies in the building

envelope helps the Union Hill Elementary School save money on energy costs and increase school performance.

The fourth phase of an energy audit was to analyze competing energy alternatives, and is discussed chapter seven.

Along with the four phases an energy audit also includes all of the following:

- Developing an energy baseline
- Develop an oil baseline
- Perform an office equipment assessment, including lighting
- Assess the heating, ventilation, and cooling systems
- Assess Union Hill Elementary Schools water consumption
- Assess the energy usage of the building envelope of both buildings for Union Hill Elementary

After all four phases and these other important parts of the energy audit are covered recommendations can be made to improve the schools energy conservation, greenness, and the educational environment for the students.

Determining Critical Systems on Which to Perform an Energy Assessment

Because the best practices for an energy audit for Union Hill Elementary School cannot be determined until after the walk-through audit. Research was done to determine the most critical systems to evaluate for the school. An energy audit requires assessment of a different set of systems based on the building to be evaluated. However, several critical systems should be evaluated in every energy audit because they have the highest capacity to be changed and the most likelihood to improve energy conservation.

Depending on the building, energy use due to infiltration/exfiltration of air through surfaces can be substantial compared to total energy use; thus, the building envelope is one critical system. The primary focus of assessment is air leakage through thermal bridges, shown in Figure 7, because it "can have many negative consequences including reduced thermal comfort, interference with the proper operation of mechanical ventilation systems, degraded indoor air quality, moisture damage of building envelope components, and increased energy consumption" (Emmerich, Persily, & McDowell, n.d.).

Figure 7. Home Energy Audit: Evaluating Efficiency
(Hampshire, n.d.).

Even though retrofits that reduce the effect of thermal bridges may not be cost effective in large commercial buildings, it is still vitally important to evaluate. Evaluation provides a baseline off which we can manipulate to help create the best opportunity for energy savings for Union Hill Elementary school. As described in the roofing section in chapter six, many opportunities for roofing change exist including shingle, asphalt, wood, metal, and slate ("Pros and cons of popular roofing materials," n.d). The many different options of the building envelope that can be considered and the associated potential energy savings create a great opportunity for energy conservation.

It is no surprise that another critical system is the heating ventilation and air conditioning system, which keeps thermal comfort under control by maintaining temperature and humidity levels. "Lowering the temperature to 68 degrees Fahrenheit or less in the major areas of the building when it is occupied, and maintaining even lower temperatures in less critical areas, will conserve energy" (Baron, 1982, p. 55). This is important because this is valuable information that can be taught to the students of Union Hill Elementary School which then helps our goal of having the students transfer their knowledge to the community. In fact, there are opportunities to "save around 10% a year on heating and cooling bills by simply [lowering a] thermostat [by] 10°–15°" for eight unoccupied hours a day ("Energy Savers: Thermostats and Control Systems," n.d.). Union Hill has a plan to implement a new HVAC system, from Honeywell in the upcoming summer. This makes the mechanical aspect of the HVAC system not applicable to

the energy audit (Gene Olearczyk Interview, 2011). Because we do not have to worry about the mechanical aspects of the HVAC system our energy audit can focus more on the temperature at which the school is kept at during the school day. In addition, the energy efficiency of such a system is difficult to relate to inner-city elementary students. On the other hand, settings can make a huge impact on the energy savings for the school.

The electrical system also has high potential to increase energy conservation. This system includes common electronic devices such as computers, monitors, printers, and projectors as well as lights. The goal of the energy audit relative to the electrical system is to determine if any component is not being used properly. For example, there exist concrete standards for how bright lights should be in different environments ("Regulations of Illumination," 2011). On average good lighting quality should be at two watts per square foot (Baron, 1982, p. 143). Also according to OSHA, occupational safety and health administration, the minimum lighting average in classrooms must be 30 foot candles or 323 lux. This information allows a baseline to be shown to the school about how well or how poorly they are using their energy throughout the lighting of the school. Shown in the Figure 8 below lighting consumes the most energy out of all other components in buildings.

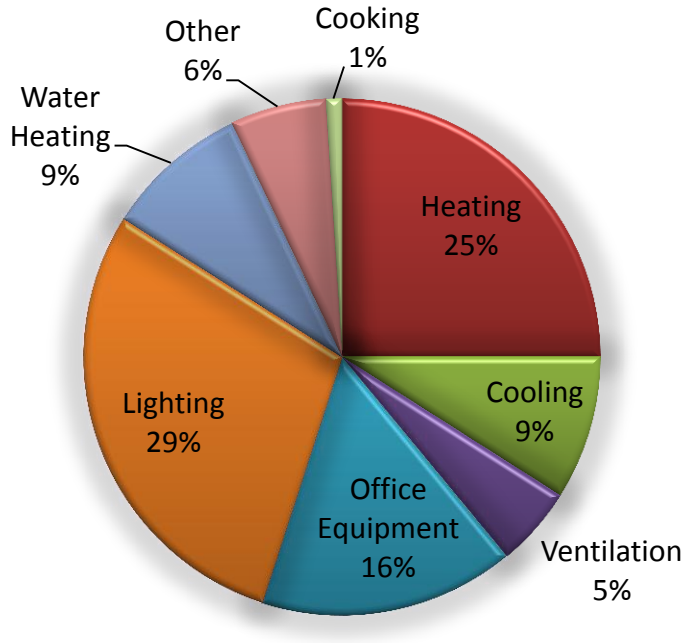


Figure 8. Energy Use in Commercial Buildings. ("A Look at Office Buildings," 2011).

Figure 8 also shows the energy use in commercial buildings like Union Hill Elementary School. The chart is showing that the largest energy consumers are lighting and office equipment. Both of these components are prevalent in Union Hill Elementary School and have the most potential to improve. “Office equipment constitutes the fastest growing part of electrical loads, especially in commercial buildings” (Krarti, 2000, p. 10). Office equipment is not usually thought as a large energy consumer and by informing the community and school changes can be made. The electrical system is of such importance to our project because electrical devices are found everywhere in a school; thus, there are great potential savings.

To compare the four critical systems a design criteria matrix was created to have a numerical comparison between the systems. The matrix is based on six criteria: Tooling, potential savings, and relevance to union hill, low replacement cost/period, low initial cost, and education capacity. These criteria have different values depending on the importance to the energy audit and through evaluating each system we are able to come up with an evaluation of how well each system fits into improving Union Hill Elementary School. From Table 1 below you can tell that the top choice for Union Hill is electricity.

Table 1. Critical systems design criteria matrix.

			Criteria (max rating)						
		System	Tooling (20)	Potential Savings (20)	Relevance to Union Hill (30)	Low Replacement cost/Period (5)	Low Initial Cost (10)	Education Capacity (20)	Totals (110)
HVAC	Electrical	Lighting	15	12	25	5/3	7	20	87
		Appliances	16.5	10	22	3.5/4.5	7.5	18	82
		Motors	9	10	0	1/2	2	0	24
	Mechanical	Heating	9	18	10	1/4	1	0	43
		Cooling	9	16	10	1/4	1	0	41
		Ventilation	9	14	15	1/4	1	0	44
	Settings	Heating	19	16	30	5/5	10	19	104
		Cooling	19	14	30	5/5	10	19	102
		Ventilation	16	12	25	5/5	10	3	76
	Building	Insulation	14	19	18	0/5	2	11	69
		Water	19	13	25	3/4	8	17	89
		Utility	15	15	12	5/5	10	5	67

Lighting is one of main energy saving options to look into because lighting is twenty-nine percent of buildings energy. Energy saving techniques such as turning off the lights when not in use and opening shades for sunlight translates very well to teaching students energy conservation. Similarly, it is very simple to teach the students to turn the appliances off when they are not in use or put them into power saving modes. The final section of the electrical system is motors, which is the least relevant system in the energy audit of Union Hill Elementary School because it has a very high replacement cost and time period, and has little effect on the school.

In order to determine the most relevant energy audit for the Union Hill Elementary School, several criteria were evaluated for general systems of an energy audit. The most critical systems could then be selected based on these evaluations. By performing a detailed audit on the selected critical systems, better energy recommendations, and therefore, more energy savings

result. In turn, the school will have more resources to allocate to the education of students and we can use the school as a better example for the community.

Energy Results and Discussion

This section shows Union Hill Elementary school could become more energy efficient by presenting information that we collected from the 1) energy baseline; 2) lighting; 3) office equipment; 4) water usage; and 5) building envelope. The school is within acceptable tolerances in certain categories, but needs retrofits in a lot of areas, evident form the data we collected. This helps give the reader an idea of the type of information that we gathered before we considered our recommendations. Rooms were classified and numbered as shown in appendix A and as described in appendix F. Then, eighteen typical rooms were chosen as case studies such that every room did not have to be assessed.

Energy baseline.

As part of our energy audit, we compiled a baseline of energy use. The baseline allows us to go to businesses with proposals having information backing us up and make educated recommendations to the school. These recommendations are formed by the compiled data that can be graphically and numerically represented in our arguments. This data helps show the flaws in Union Hill Elementary schools energy usage as well as help link social behavior to energy usage. From this baseline, we wanted to get an idea of how much electricity is used in the school on both a yearly basis and a daily basis.

Union Hill Elementary School uses electricity provided by national grid. In Appendix B is the utility assessment-energy usage, we obtained a list of electricity usage for the Union Hill elementary School from Gene Olearczyk whom is the facility manager at Worcester Public Schools. In order to better represent this data we created a graph to show the electricity usage over two years. It can be seen below in Figure 9.

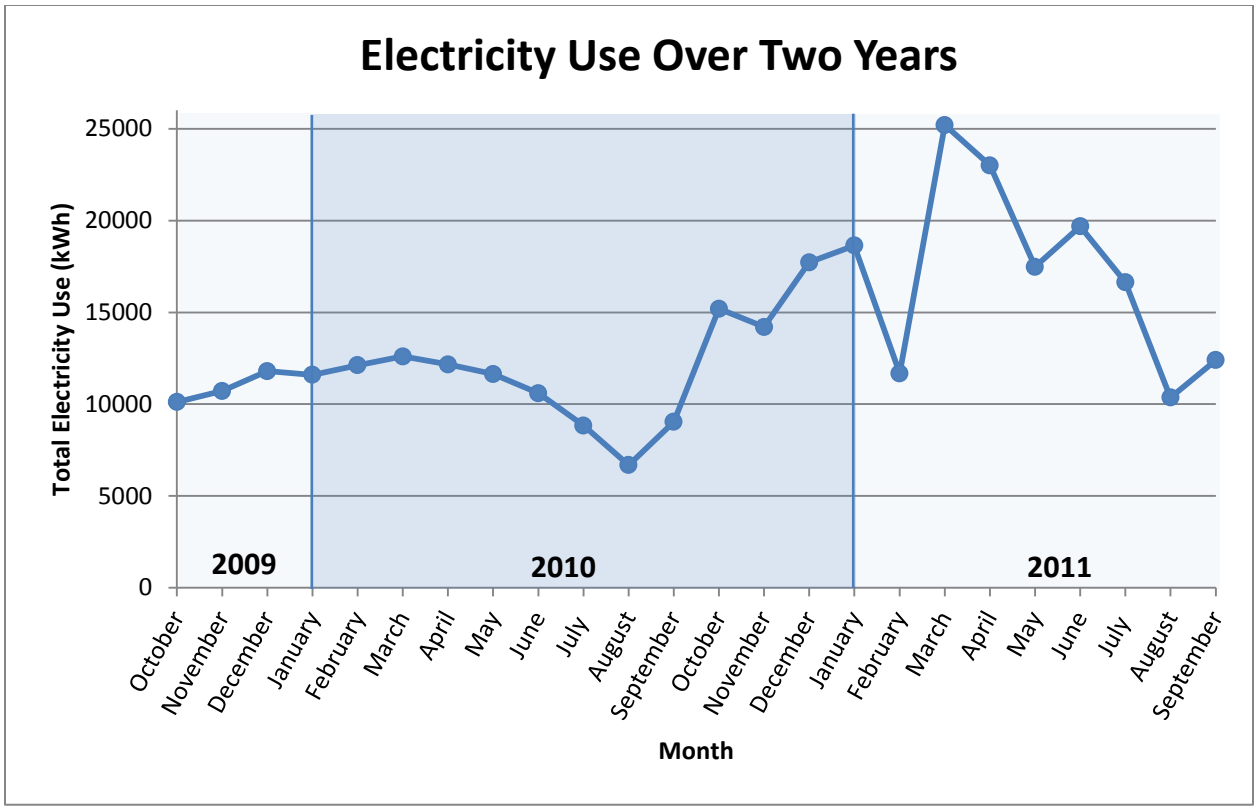


Figure 9. Electricity usage of the Union Hill Elementary School over two years.

From Figure 9, it can be seen that the electric use is stable until august of 2010. Also the electric usage is lower in the summer. This is because the lights and appliances are being used less when school is not in session.

One trend with this graph that is difficult for us to explain is the electric usage after august 2010. It becomes very sporadic and increases greatly in value as compared to the usage before august 2010. Events that occurred during September of 2010 may account for this increase and sporadic use of energy. In September of 2010, Union Hill Elementary School began to implement its course of actions to improve their educational standard after being deemed a level four school in March of 2010. This involved renovations of the school including replacing the roof, renovating the bathrooms, and replacing the ceilings in the hallway. This work can account for an increase of electric usage in order to run the tools needed to perform these renovations. The sporadic use of electricity has to do with the fact that all of the renovations did not occur at the same time and some jobs required more electricity than others. To get a reading of the current electrical usage a study must be done at the school for a considerable amount of time.

Since our electrical data for the school during last year is not consistent to the actual readings we recorded the electric meter readings every day for a full week, excluding the weekend to gather our own data. Our study determined that there was a consistent consumption of electricity throughout the week. A graph of the data can be seen below in Figure 10.

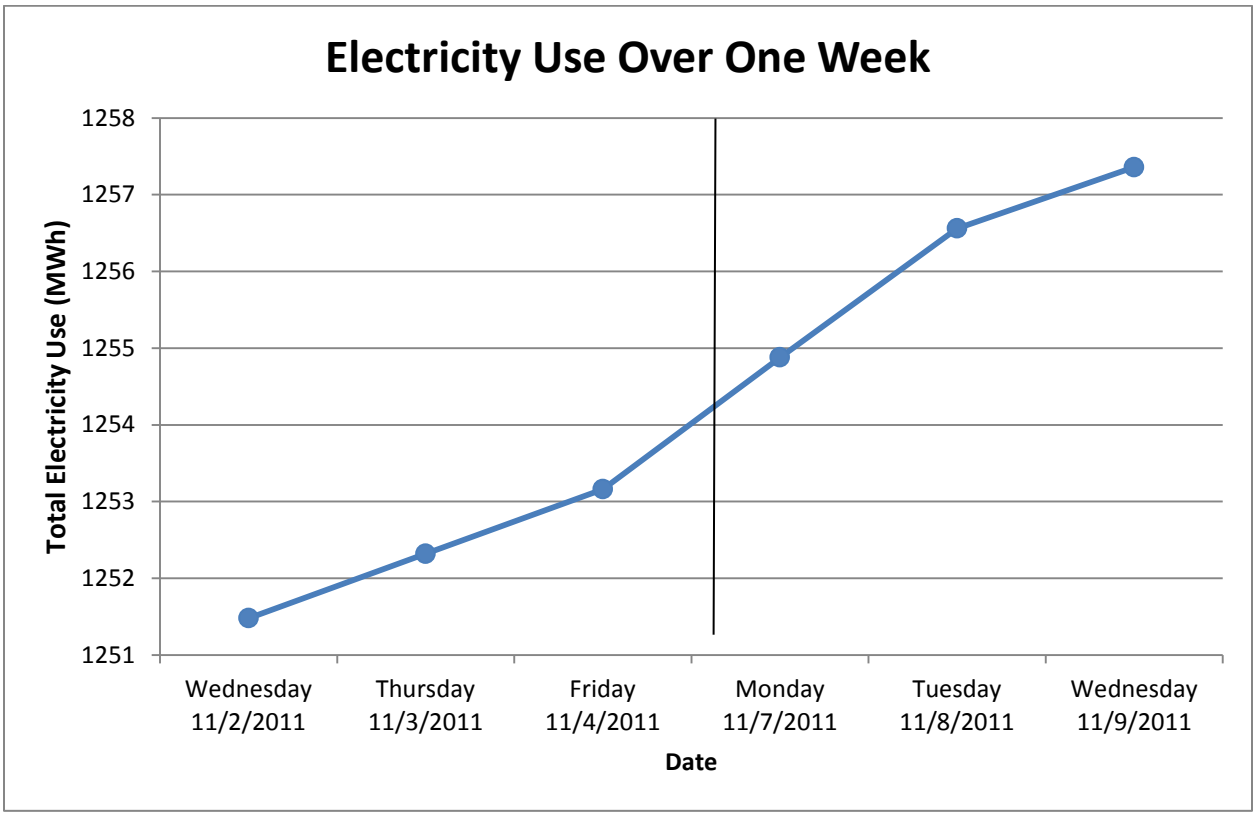


Figure 10. Electricity usage for Union Hill Elementary School over one week.

As can be seen in this figure, most days seem to use the same amount of electrical usage because the slopes are relatively similar. However, it can be seen that the change over the weekend between Friday and Monday is more than or equal to the change between the other days. This is an issue because electricity usage on the weekend should be minimal. On this figure has given us information not only on how to help the schools energy usage, but also on how to help the overall quality of life in Oak Hill. This information can be used to create a baseline for comparison when we create our recommendations for the school, and will also allow the school to be a precedent for the community.

Lights.

We decided to complete a detailed light assessment because our background research indicated that there would be major energy saving potential with light retrofits. Many items must

be analyzed during an energy assessment of a building, and lighting is one of the most important systems. Our inspection of the lights determined their intensity and the efficiency of the bulbs themselves. This was accomplished by using a LUX meter (see Figure 11) that measured the intensity of the lights in various rooms throughout Union Hill Elementary school.

Figure 11. Lux Meter.

In our analysis of the lighting, we took measurements on different types of days; for example, a cloudy day has a much different LUX reading than that of a sunny day. In general we found that during most conditions Union Hill Elementary school was over illuminated. On sunny days we found that most rooms were over twice as illuminated as necessary, and on cloudy days they were close to fifty percent over illuminated compared to the minimum requirement. The nightfall illumination varied, some rooms were very over illuminated while others were way under the standard. The way we measured the rooms to ensure accuracy of our data collection was by taking nine separate measurements throughout a classroom, this varied depending on the size of the room. Here is an example of a classroom we audited in the 1960 building and how we measured the data. Refer to Appendix J for a diagram of room 364 where we took lux meter readings in a classroom. While someone was taking the readings of the lights another person was simultaneously filling out an excel worksheet, refer to Appendix J for room 364. This makes it easy to see the significant differences between the light readings on cloudy days, sunny days, and nightfall through this example. These readings are too high for a school, and should be changed to help the school save money on energy costs.

Figure 12. Typical Union Hill Elementary Classroom.

All the classrooms seemed to have this problem of over-illumination, whether it was on a cloudy or sunny day. Over-illumination results in extra cost in electricity that could be used towards other resources for the school. Here, we discuss a classroom in the new building that was over-illuminated on both types of days. If you refer to Appendix A, you can see the schematics of the 1890 building and how we designated different types of rooms. The room that we'll be looking at is room 000; this was a generic classroom that can be found throughout the 1890 building. As usual, nine measurements were taken in the classroom on each type of day: sunny, cloudy, and nightfall. After these measurements were taken, the average lux readings were found with all the lights on, with no lights on, and with half the lights on if it was applicable.

A classroom needs a minimal of 300 lux of light; however, it was found that most classrooms were well above this number. If you look at Figure 13 below, you can see the average light readings of rooms that needed a minimal of 300 lux of lighting.

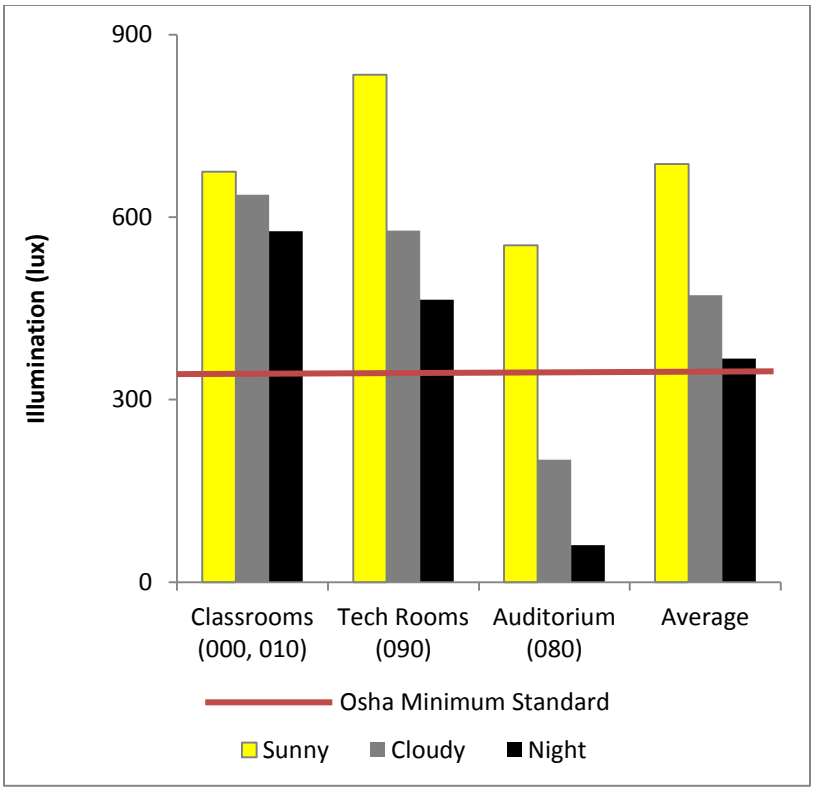


Figure 13. Average light readings for rooms that have a 30 ft-candle OSHA minimum illumination intensity.

Room 000 on a sunny day with full lights had an average lux reading of 674.78 and 636.67 on a cloudy day. Also, even with a night sky the classroom had an average lux reading of 577. This helps shows that most of the rooms were over illuminated and new lighting options should be looked into in order to help this problem: these options are discussed in the light section under the recommendations chapter.

Next, we'll show you a room in the 1960 building which was over-illuminated as well; this helps prove that the problem is occurring in both buildings. If you refer to Figure 14 below you can see the light readings for room 305 in the new building. This room can be found in our schematics of the building in Appendix A.

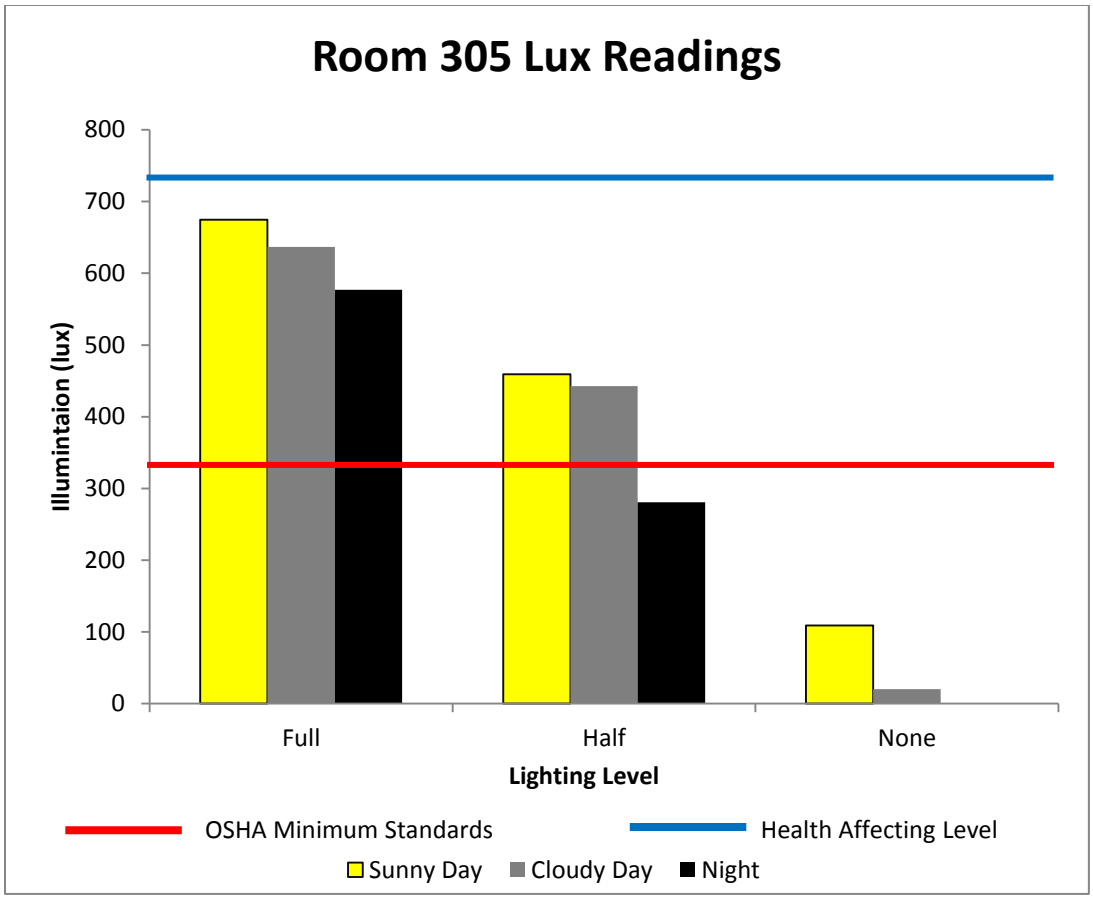


Figure 14. Light readings of room 305.

When the lights were fully on, the lux readings were almost double the amount that the OSHA minimum standards require during all conditions. Even when only half the lights were on, they still illuminated more than enough light during sunny and cloudy conditions. These lights are close to endangering the health of the faculty and students at the school as well; the health standard for lights are discussed more in depth in our health assessment section. These readings help show Union Hill Elementary School that new lights help this over-illumination problem and in the end will save them money on energy costs. Solutions to this problem are discussed in our recommendations section in order to help save Union Hill Elementary money. In addition to the lux readings, our group looked at the types of lights that the school was using and how they can be changed in order to save Union Hill Elementary school more money.

Currently at Union Hill Elementary School, people use 700 Series 32 Watt 7100K F32T8/TL741 fluorescent lights, otherwise known as T8 fluorescent lights, are used. Approximately 1023 of these bulbs are turned on for at least 60 hours a week. These lights can be dangerous for an environment such as Union Hill Elementary school because if these lights

break and a student happens to digest some of the chemicals inside that bulb then he or she will have to go to the hospital immediately. These types of lights are dependent on an electrical current flowing through in the glass tube. According to Umpqua Energy, “a good case [can be made] in the argument that LED technology is more green than fluorescent and that it should be promoted more than it currently is” (Umpqua Energy, n.d.).This is because there are many flaws with fluorescent lights, including: toxicity, energy usage, and heat radiation. The light that is given off by these fluorescent lights is in the ultraviolet range and can be very dangerous to the health of the students and staff at Union Hill Elementary school. The toxicity of fluorescent lights comes from the chemical mercury that is present in the bulb which is highly dangerous for the environment.

Office equipment.

As part of our energy audit we completed a thorough assessment of the equipment in the offices and classrooms that consume electricity. This is because limiting electrical use of these systems has a serious potential to save the school money. To complete part of this analysis we used a Kill-A-Watt meter, as shown in Figure 15 below. Although there are many functions of this device, the instantaneous wattage was of most use to this project. It is also important to note that this meter is compatible with only 120 Volt electrical sockets. Thus, a Kill-A-Watt meter was not of use to get the energy consumption for some electronics, including large printers.

Figure 15. Kill-A-Watt Meter.

In order to record the energy use of office appliances, we decided to use a Kill-A-Watt meter because this tool is an easily accessible tool that allows us to find the energy usage that is required for our project. The display shows how many watts of electricity are being used instantaneously by the appliance that is plugged into the meter. We recorded these measurements for every appliance in the office or classrooms as well as recorded the instantaneous electric use of appliances when they are in standby mode. From these measurements we are able to multiply by the amount of time these appliances are being used during a typical day to find the total electric demand of a given room. Below in Table 2, the measurements from room 305, which is a typical classroom, can be seen. A table was chosen to represent this data to better show methodology. Tables with the measurements from the other rooms can be seen in appendix K.

Table 2. Room 305 Kill-A-Watt measurements.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consumption (kW-hrs)
Lights	32	32	1	60	64.896
Computer	4	100	20	20	19.84
Projector	1	242	5	15	4.395
Monitor	4	23	1	16	2.08
Network switch	1	7	7	168	1.176
Printer	1	10	3	0.33	0.50631
ELMO camera	1	10	1	15	0.303

From this table, it can be seen that we analyzed every electrical component in the room, which included the lights, computers, monitors, projectors, network switches, printers, and the ELMO presentation camera. We took the measured watt consumption when the devices were both on and in standby. We used interviews with teachers and staff to find out the typical weekly usage of these devices, and through our calculations, we found typical energy consumption for the devices in Kilowatt Hours. The typical week consists of a normal school week and does not include the summer weeks because the electrical usage would be much lower since most of the classrooms and rooms are not being used. These readings were used to help us focus our recommendations on the items that use the most electricity in the school.

Finding the components that consume the largest amount of energy allows us to confine our recommendations to the ones that make the largest impact. To get an idea of the devices that use the most electricity in the school, we represented the data in Figure 16 below, which

compiles the electric usage of all the rooms in the school. Looking at the chart the different components are along the x axis and the y axis shows the amount of energy they consume per hour. The largest components are the ones that we can make recommendations that have the largest positive affect on the school.

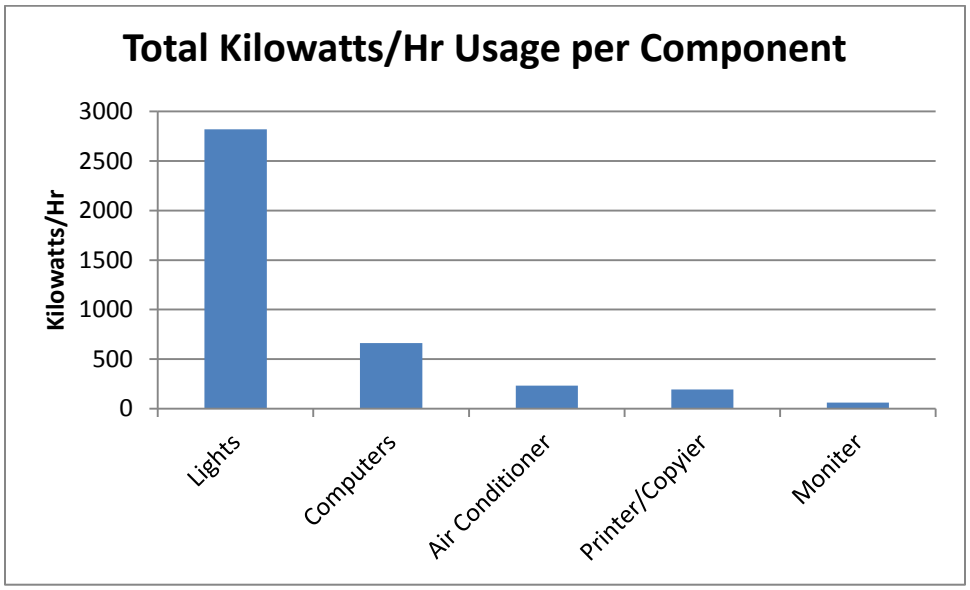


Figure 16. Total electric usage of components in Union Hill Elementary School.

From Figure 16, it can be seen that the two major components that use the most electricity are the lights and computers, which suggests recommendations that include changes to these components can save the school the most money. Because of this, we compiled detailed recommendations to lower the demand of these components. We also have created some recommendations to lower the electrical usage of air conditioners as well as printers and copiers. These suggestions are presented in our recommendations section. In addition to helping us with our recommendations, these measurements will help create an energy baseline that will help track the decrease of electrical usage when compared to assessments completed in the future.

Heating, ventilation, and cooling.

Currently, the Union Hill Elementary School is run from a temporary boiler which is costing them double what a normal boiler would so the need for a new heating, ventilation, and cooling system is needed for the school. The temporary boiler is a potential health hazard because it produces soot which travels into the classrooms; this is discussed in further detail in the health assessment chapter. One problem that arose when we began the assessment was that the 1890 building was running on a temporary boiler. This is because the boiler in the building

was no longer operational and could not be fixed. The temporary boiler is inside of a tractor trailer out front of the 1890 building. A picture can be seen below in Figure 17.

Figure 17. Temporary boiler in front of the 1890 building.

This temporary boiler costs the school ten times more to heat their building compared to the boiler that they used to have (personal communication, M. Morse). Also, the school is paying double for the running cost of the temporary boiler. However, this boiler is simply a temporary fix until they school can replace both of their boilers in the summer of 2012.

G. Olearczyk is the Worcester Public Schools Facility Manager and he has the information and power to make changes to the school's boiler systems. Our interview with him made clearer the scope of our potential recommendations with respect to the HVAC system. He stated that both boilers will be replaced by boilers fired by natural gas. He also noted that an energy management system will be installed in order to control the heating of these buildings. At this time they are still deciding which system will work best, but as of now they are sure that it will be a web based system.

The 1890s building is heated by water that is very inconsistent in heating rooms and to show this, a temperature study was conducted. We wanted to get an idea of how well the heat is currently managed inside the building. This is because we heard complaints that some rooms can become very warm while others remain cold. In turn, the temperature would cause distractions to the students and take away from their education. This is particularly important because the school is currently a level-four school, as discussed in the introduction of this report. In this study, we placed temperature loggers in three rooms in the 1890 building to record the temperatures for a full day. We chose rooms 001, 191, and 203 because they were directly on top

of each other and this would make the effects of solar heat gain the same in all three of these rooms. A graph of the results can be seen below in Figure 18.

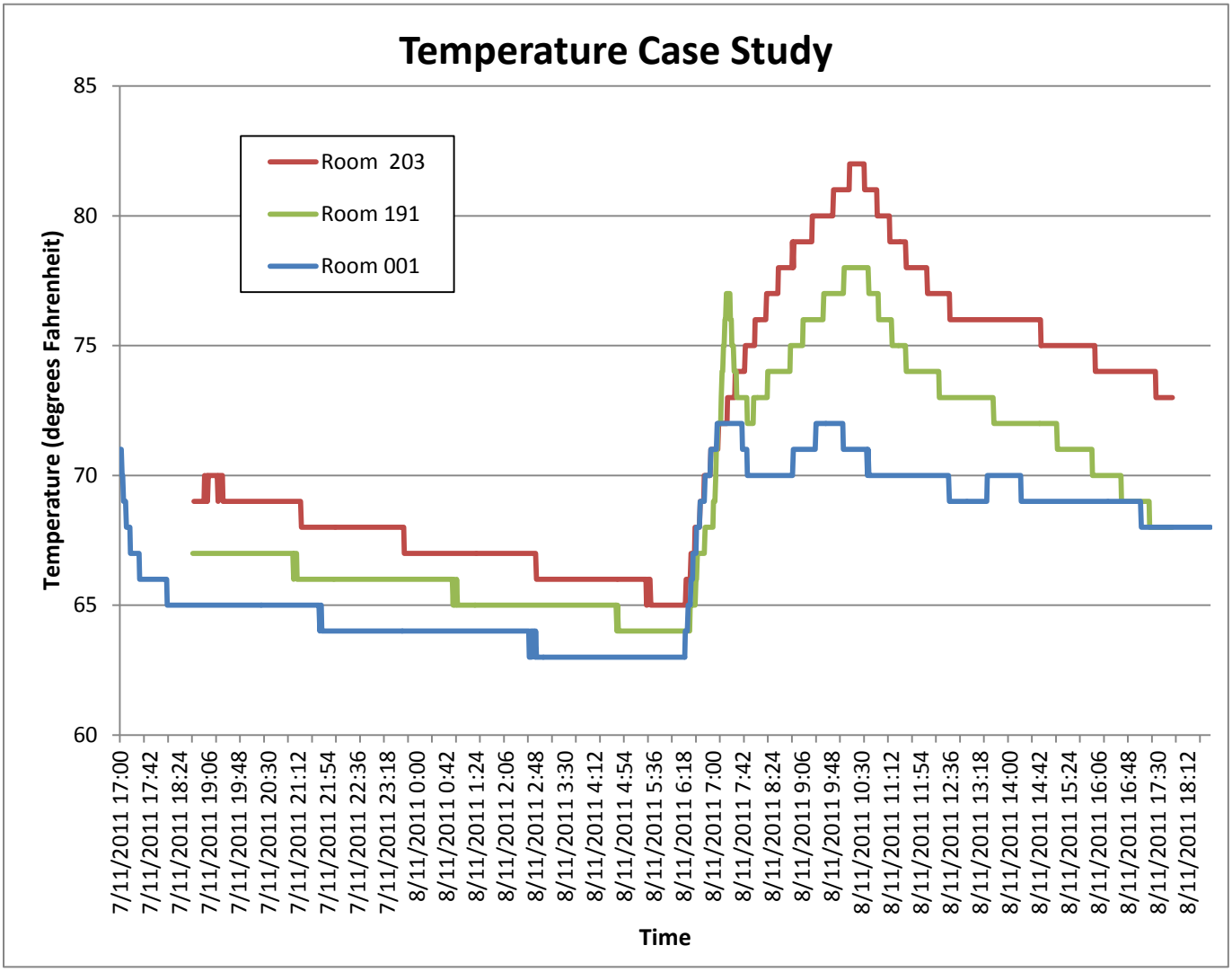


Figure 18. Temperature case study including rooms 001, 191, and 203. Sample measurements can be found in appendix M.

The figure above shows that the boiler is turned on and off at the correct times because at night the temperature of these three rooms is relatively low which means it is not heating the school while unnecessary. The temperatures begin to increase at around 6:00 am and reach a maximum temperature around 10:30 am. As we noted in our literature review, the temperature of a room has a large impact on the comfort of the students and students and in turn affects the performance. After the school opens at 7:50 am, the students are at the school when it is not at the optimum temperature which is between 72 degrees and 80 degrees Fahrenheit. This figure

shows the uneven heating of these three rooms. Being on different levels of the school the boiler is inefficient in heating the entire building. Room 203 becomes too hot during the day and room 001 becomes too cold during the day because of the uneven heating.

It can be seen in the figure that room 203 is warmer than eighty degrees from 9:30 am to 10:30 am. This helps show that the fluctuation of temperature in the school is directly affecting the academic performance of the school; and could be a factor in why Union Hill Elementary fell to a level 4 school. We feel that this uneven heating in the classrooms is something that should be addressed. Because these measurements were taken when it was 56 degrees outside, we expect that the temperatures in the classroom will only be more extreme in the summer and winter. These extremes only hinder school performance.

In addition to our heating ventilation and cooling assessment, we evaluated the use of air conditioners in the Union Hill Elementary School. Besides lights the air conditioner is the second largest component of energy consumption. This indicates that there is a lot of room for savings in this area; this won't only affect the school but the community as well. This is because most residents have an air conditioner as well, so from these recommendations we can help the school and the community saves money on energy usage. We assessed the energy usage by calculating if the air conditioners being used were too large for the room. Because of the financial state of the community and school we do not have the option to buy new air conditioners for the school so their age or energy consumption cannot be changed but we can make sure the air conditioner is utilized to its best ability. If the air conditioners are too large this means, they can be downsized to save money on electricity. On the other hand, if these air conditioners are too small, this creates an uncomfortable work space for the occupants causing a drop in performance. The two rooms we concentrated on for this study were the main office suite and the computer room in the 1960 building. In Figure 19, the office suite can be seen. The areas that are air conditioned are shaded in blue.

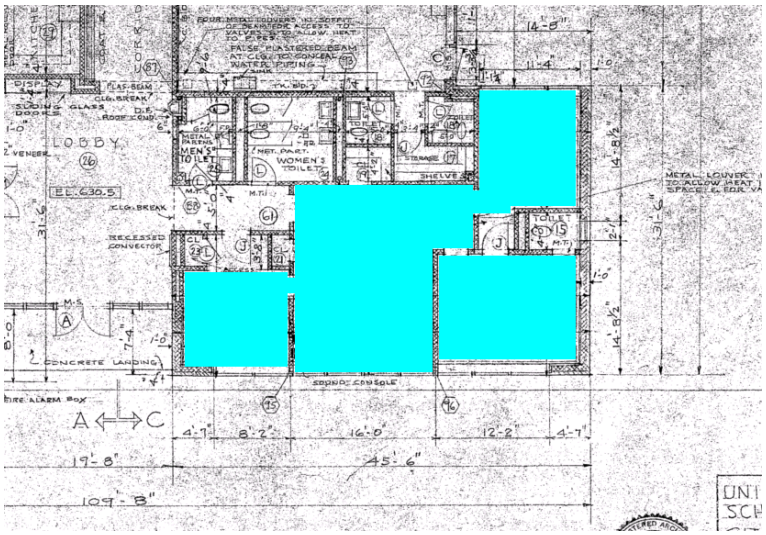


Figure 19. Air conditioning space in office suite of 1960 building.

The main office suite is cooled using five air conditioners; three are rated at 8,000 British Thermal Units (BTU) per hour and two are rated at 10,000 BTUs per hour. This makes a total of 44,000 BTUs per hour cooling the main office suite. According to Energy Star in their article named “Properly Sized Room Air Conditioners” they noted that 44,000 BTU per hour is enough to cool over a space over 3,000 square feet. Our calculations show that the main office suite has an area of 910 square feet. Energy Star recommends approximately 21,000 BTUs of cooling for a room of this size and usage pattern. This means that the air conditioners cool the room with 23,000 BTUs of cooling more than necessary when all of the air conditioners are on.

Room 391 is a computer lab and each computer releases heat and with the large amount of computers in the room cooling of the room is essential. It can be seen below in Figure 20. The blue shaded region shows the 860 square foot area that is affected by the current air conditioning units.

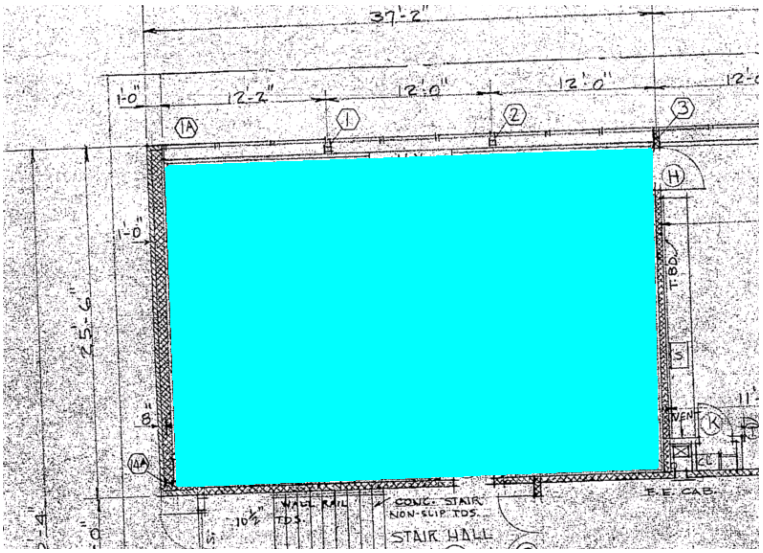


Figure 20. Air conditioned space in computer laboratory 391 of 1960 building.

After such factors as the effect of the number of computers and number of children in this room, we found that more cooling is necessary, to improve the performance of the students, per Energy Star standards. Through our calculations, we have found that the room needs 47,000 BTUs per hour. This is found by calculating the heat given off by the computers which was found to be approximately 420 BTUs per hour for each computer in the room. There are 28 computers in the room and thus as a total they give off approximately 11,760 BTUs per hour. Second, we calculated the amount of heat given off by the students which is given by 600 BTUs per hour for each student. There is a maximum of 28 places for students to sit in this room, so they would give off 16,800 BTUs per hour in total. The tech room is cooled using two air conditioners: one rated at 8,000 BTUs per hour and one rated at 10,000 BTUs per hour. This totals to 18,000 BTUs per hour used to cool this room. According to Energy Star, this is only enough to cool 800 square feet with typical electrical equipment and human use; however, this space has much increased electrical and human use than a typical space. This means that the air conditioners are not able to cool this room completely. Although this was not what we were expecting to find during our energy assessment, we feel that this deficiency could have negative affects to health. This deficiency results in possible overheating of the computers and un-comfortable work conditions for the students. We also performed these calculations for computer lab 191 in the 1890 building which currently does not have any air conditioners. The room alone needs about 9,000 BTUs per hour to keep it cool but after factoring in the twenty-five computers and twenty-five students, we found that the room needs 34,500 BTUs per hour in order to

maintain a comfortable environment for students and staff, as well as create an optimal operating environment for the computers. Our suggested changes for air conditioners are presented in our recommendations section.

Water.

One part of our energy assessment included an assessment of the water usage of The Union Hill Elementary School. This included both creating a baseline of water use for the school, and testing the building for any water leaks in the pipes that could account for water loss. Our water readings were taken from the water meter which is located in the boiler room of the 1960 building. Although Union Hill Elementary School has two buildings all of the water readings go through the 1960s building. A picture can be seen below in Figure 21.

Figure 21. Water Meter located in 1960 building boiler room.

The meter is a valuable tool for performing a water assessment. This meter shows us the amount of water that runs through it in order to supply the building. The meter readings need to be multiplied by 100 in order to convert it to cubic feet of water. As seen below in Table 3, we collected readings for water usage for a full week and compiled our results.

Table 3. Water Utility Readings.

Date	Time	Meter Reading	Water Usage (ft^3)	Change In Usage (ft^3)
Wednesday 11/2/2011	1:14 PM	588440	58844000	N/A
Thursday 11/3/2011	12:23 PM	588610	58861000	17000
Friday 11/4/2011	12:17 PM	588800	58880000	19000
Monday 11/7/2011	12:15 PM	589000	58900000	20000
Tuesday 11/8/2011	12:18 PM	589410	58941000	41000
Wednesday 11/9/2011	11:14 AM	589570	58957000	16000

This baseline allows the Union Hill Elementary school to be able to track their water usage after completing our recommendations to help conserve water. Unfortunately due to time constrictions, we were not able to complete a full assessment to decide if the water usage in the school was at an acceptable level. Most of the bathrooms have already been updated with all new fixtures that help keep water usage to a minimum.

The second part of our water assessment included a test to see if any of the pipes or fixtures was leaking water because leaks can waste a considerable amount of water. This was completed by achieving a water meter reading at night after everyone had left the building and achieving a meter reading first thing in the morning before anyone uses water. We got these readings from the night custodian, and the morning custodian. The readings can be seen below in Table 4.

Table 4. Leak test results.

Date	Time	Water Reading (ft^3)
11/29/11	9:00 PM	059136000
11/30/11	6:15 AM	059136000

From the table above, it can be seen that in the nine hour period between these two readings there was no change. This means that there are no significant water leaks in The Union Hill Elementary School. We have also found that no significant water leaks exist in the school that waste water.

Building envelope.

As part our energy audit, we performed an analysis of the building envelope of the school. The building envelope greatly affects how much heat and conditioned air leaves the building. This affects the energy efficiency of the building. The audit included inspection of

doors and windows to find areas where conditioned air can leave the building. We also used a FLIR thermal recorder to analyze the thermal efficiency of the doors, windows, and external surfaces of both of the buildings. Building envelope "can have many negative consequences including reduced thermal comfort, interference with the proper operation of mechanical ventilation systems, degraded indoor air quality, moisture damage of building envelope components, and increased energy consumption" (Emmerich et al., n.d.). In our analysis we found that all doors and windows showed signs deficiency. These problems include the poor sealing of doors and windows, and poor insulating values of the doors, windows, and roof. Union Hill Elementary School does not seal these properly and thusly allow conditioned air out of the building. This causes the need to heat more in the building to keep up with the loss of heat. This will ultimately result extra cost for energy to heat the building. In this discussion, we show the problems we have found with the doors and windows not sealing correctly in The Union Hill Elementary School.

We first show two examples of these problems by using the front doors of both the building built in 1890 and the building built in 1960. Both of these sets of doors had the same problems concerning sealing.

Figure 22. Main doors of the 1960 building (inside).

The problem can be seen above in Figure 22 is a picture of the front doors to the newer building which was built in 1960. The gaps between the doors and frame create an area for conditioned air to leave the school. Upon initial inspection the doors seem to be fine; there are no broken panes of glass and the doors close correctly this can be seen above in Figure 22. These doors are also always closed during normal operation for safety concerns which also helps keep conditioned air in. After we looked at the doors closely, we could tell that there was a significant gap between the doors as noted in the picture by the arrows, this also occurs on the top and bottom of the doors.

Figure 23.Main door of the 1890 building.

Another set of doors that we looked at was the front doors of the building built in 1890. Because of the shear age of these doors, they are not able to keep the conditioned air inside of the building. A picture of one of them is above in Figure 23. There are two of these doors next to each other with windows above that have been covered up by plywood. Upon initial inspection it is visible that these doors are extremely outdated. They are most likely the original doors that were used in 1890. They are solid wood doors with a small single pane window. Only one of the two doors is used during the day and they are always closed when not being used for security reasons. We noticed many areas in which these doors allow conditioned air out. This can be seen in Figure 24 below.

Figure 24. Main door of 1890 building inside: Left is top of door, middle is side of door, and right is bottom of door.

These doors are not able to seal completely when they are closed. This is apparent in Figure 24 because sunlight can be seen coming through these cracks. This case occurs with just about every door in both buildings.

Another part that was examined in our analysis was the windows of the school. Upon initial inspection it is very noticeable that these windows leak both air and water. It has been addressed to us many times by both staff and students that these windows are a nuisance because they are difficult to maintain and control. These windows are original to both of the buildings. This can be seen in Figure 25 which is a window of a classroom in the 1960s building.

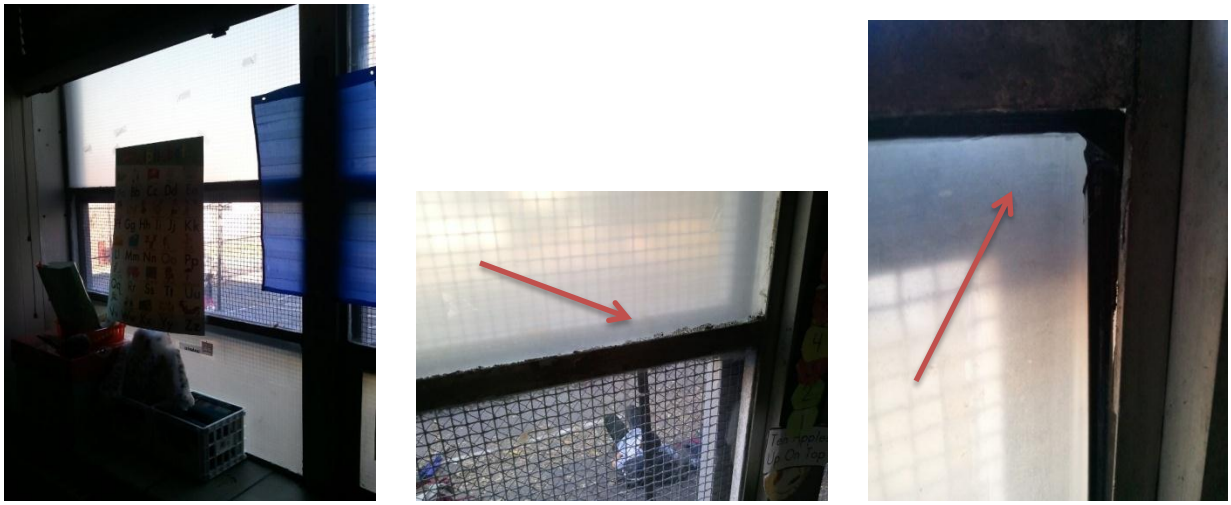


Figure 25. Typical classroom window: whole window on left, window frame in middle, leaking repair on right.

Because the windows are in such bad shape temporary repairs have been made which are shown in the pictures above. An example of these repairs is shown in the left picture; the window has been repaired with Plexiglas in order to stop leaks through the window. The Plexiglas significantly decreases the ability for these windows to retain heat inside the classrooms. The picture in the middle shows that the aluminum frame is beginning to corrode. This is a sign that these windows have been leaking water from the outside. Finally the picture on the right shows that the repairs of these windows were insufficient, this is because the Plexiglas is beginning to pull away from the frame as the glue used gets older. This allows for more air to be lost as well as more water will leak in and cause further damage; both of these problems directly affect the energy costs of the school.

The problems that have been found in these doors and windows are very common for all doors and windows in the Union Hill Elementary School. The doors do not seal properly and

allow a significant amount of air to leak through them. The window panes are separating from the frame which is allowing both water and air to leak into the building. These doors and windows are seen as large reasons for increased need for heat and these problems are addressed in our recommendations section.

During our investigation one other problem we saw was that the doors and windows are single pane windows. This means that the doors and windows are not insulated very well and allow heat to transfer through them which causes the heating system to work harder. We used out FLIR thermal recorder to visually show the amount of heat that was being lost through the doors and windows in the school. Unfortunately, the only day we could use the thermal recorder was a relatively warm day so it is a bit difficult to see the differences. Below is a picture of the front lobby doors from the outside.

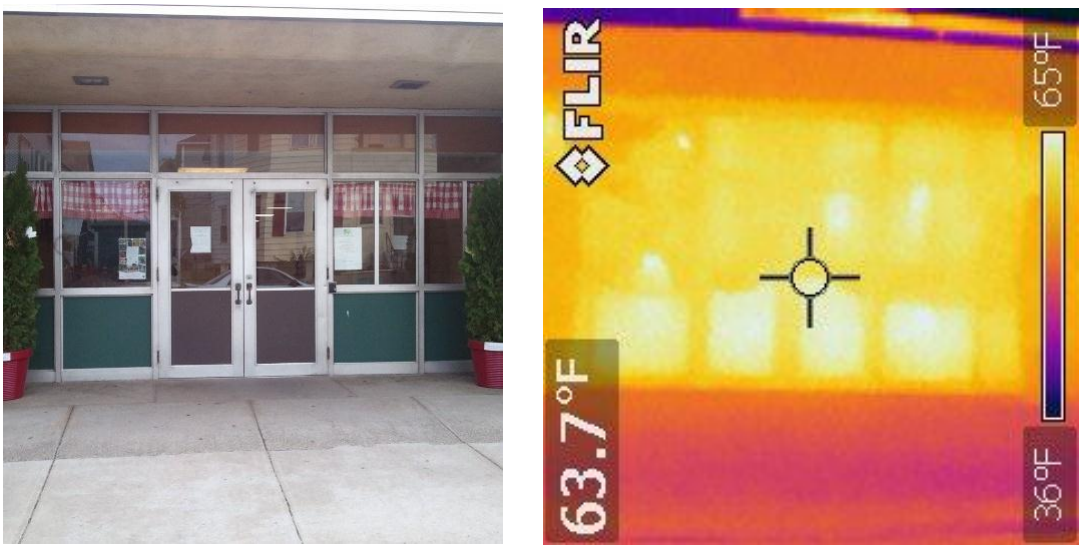


Figure 26. Main doors of the 1960 building (outside). Picture on left, thermal image on right.

In Figure 26, there are two images; on the left is a picture that does not show the thermal differences and the picture on the right shows the thermal differences. One piece of information that we gather from this picture is that the plastic panes are allowing heat to transfer through them to the outside. This means that heat created inside the building is lost through these plastic panes. We used our FLIR thermal recorder to see how efficient the main doors of the 1890 building are in keeping the heat inside the building. Below in Figure 27 is a picture of the front entrance of the 1890 building with the two doors and sealed up windows above. To the right of

that is a picture taken with the FLIR thermal recorder and shows the temperatures of these doors and covered windows.

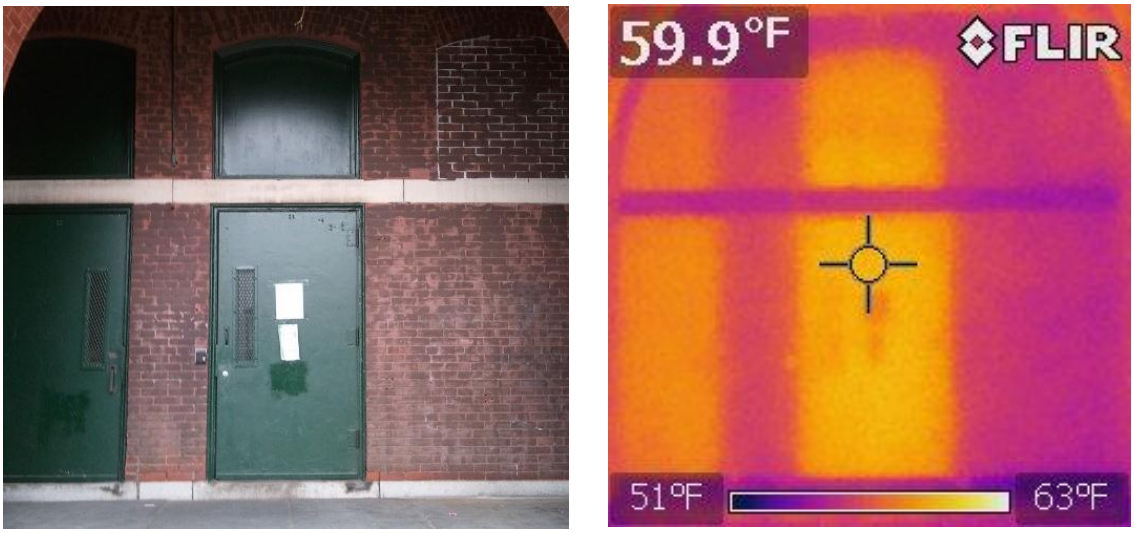


Figure 27. Main door to 1890 building: picture on left, thermal image on right.

It can be seen in the thermal picture that the doors and windows are a higher temperature than the surrounding brick around them. This means that these doors and covered windows are allowing the heat inside of the building to be radiated outside through the doors and windows. Also these doors allow a significant amount of heat the radiate through them and accounts for a large portion of heat loss in the buildings.

We then used the FLIR thermal recorder to analyze the heat being lost through the windows, this helped us determine the flaws in their current windows as well as helped us make recommendations for new ones. We chose to use a set of windows from the 1960 and 1890 building to study. Below are pictures of classroom windows from the 1960 building and a picture taken with the thermal recorder which shows the differences in temperatures.

Figure 28. Classroom windows on south side of 1960 building: picture on left, thermal Image on right.

From Figure 28 it can be seen that the window panes are significantly warmer than the surrounding bricks and window frame. This shows that heat is being lost through the windows; thus, the school is wasting energy and is wasting resources. This picture shows us that these windows are allowing heat from the classroom to escape through the glass panes. This causes drafts in the room and creates an uncomfortable learning environment that directly affects how the children behave and perform in the classroom. We also used the FLIR thermal recorder to get a thermal image of a window from the 1890 building. This can be seen below in Figure 29.

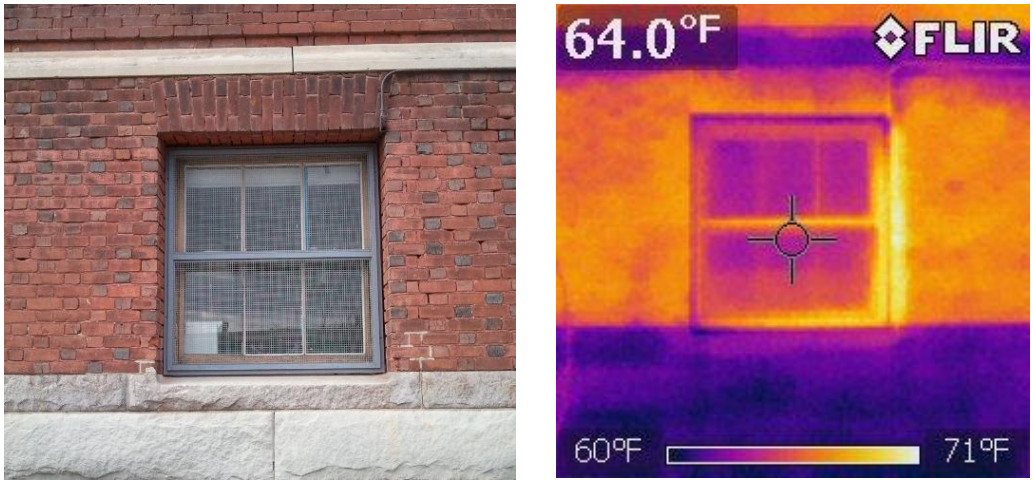


Figure 29. East window on first floor of 1890 building: on left picture, on right thermal image.

From this thermal image it can be seen that the outer casing of the window is warmer than the surrounding bricks. This indicates that the window casings are allowing heat to escape the

building. This is most likely due to the age of the windows which has caused them to deteriorate and lose their sealing capacity.

Besides the windows and doors, where the air conditioners were installed was another area where significant heat loss was found. Figure 30 below shows a typical air conditioner installed using a piece of medium density fiberboard (MDF).

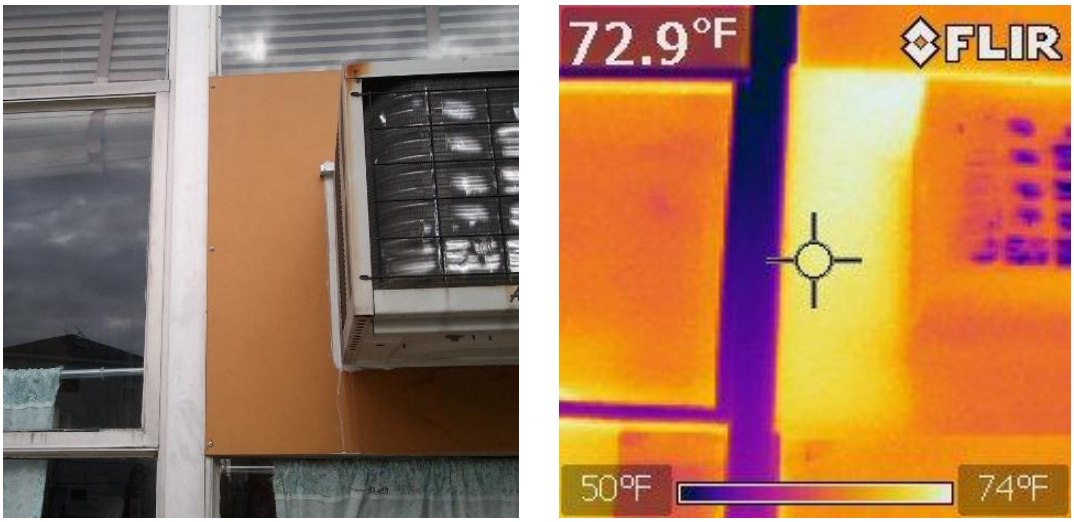


Figure 30. Main office air conditioner mount: Picture on left, thermal image on right.

From Figure 30 it can be seen that the MDF is hotter than the surrounding frame and glass panes. This means that the MDF is decreasing the efficiency of these windows by allowing heat from the inside of the room to radiate outside.

The final analysis of the building envelope includes the roof because this is an area where major improvement for thermal insulation may occur. We used the FLIR thermal recorder to not differences in temperatures on the roof to find areas in need of improvement. Unfortunately, as discussed before, the day we used the thermal imager was relatively warm, so it is difficult to see any differences in temperatures on the roof. On initial inspection we saw that the roof had mechanical ventilators for the classrooms as well as vents for the plumbing. This can be seen in Figure 31 below.

Figure 31. Rooftop of 1960 building East wing.

There were no leaks from the roof reported and from inspection the rubber membrane did not look to have any wholes or areas where a leak could occur. After using the FLIR thermal imager we found one spot that showed us the roof can be better insulated. This can be seen in Figure 32 below.

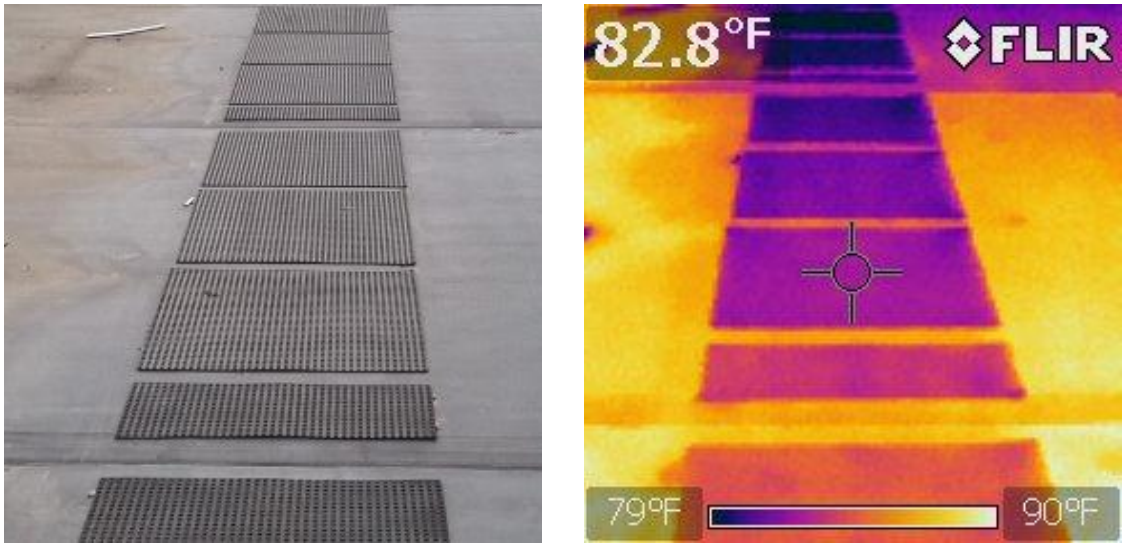


Figure 32. Rooftop of 1960 building walking panels: picture on left, thermal image on right.

From Figure 32 it can be seen that if the roofing material were thicker than it would be able to hold in more heat. The thermal image shows that these walking panels are significantly cooler than the surrounding rubber membrane. This is because the added insulation of these walking panels allows these areas to hold more heat inside the building rather than having it radiate to the outside.

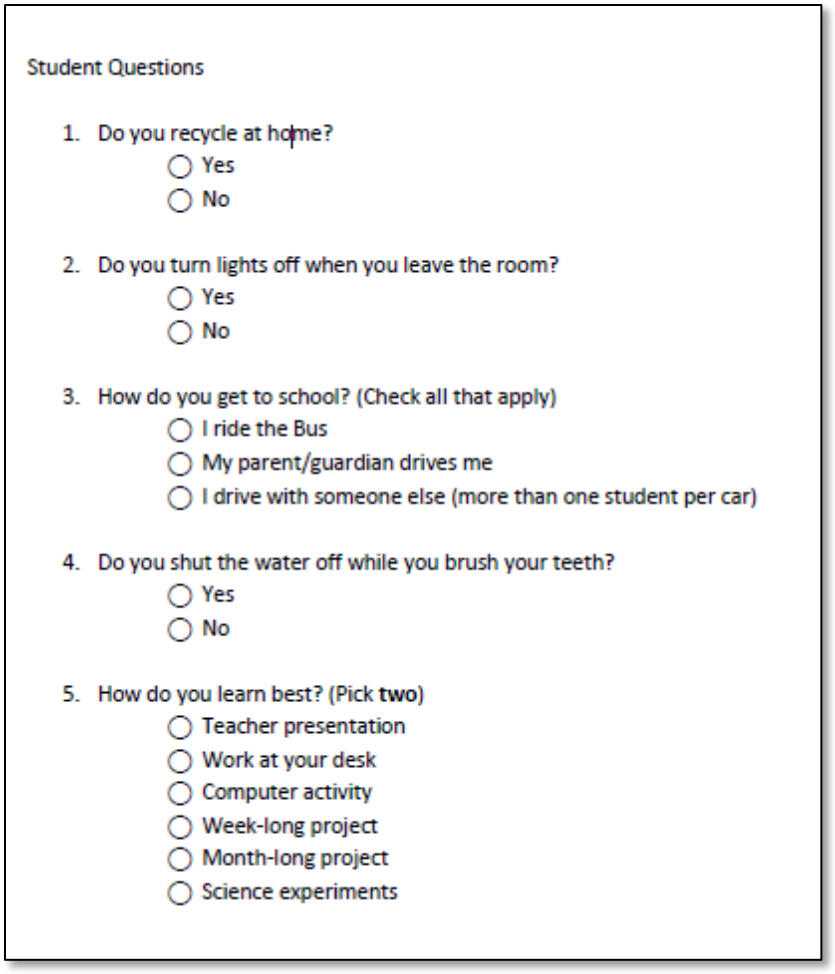
Summary

From this energy assessment we were able to conclude that the state of the building envelope is unsatisfactory. There were many places that we were able to identify that could be improved. Unfortunately, with the energy baseline and water usage baseline, we were unable to conclude whether or not they were acceptable. This is simply because we did not have the time to go in depth to calculate the amount of water and electricity that should be used by a school of this size. However these baselines are crucial in order to record and show how much our recommendations will be able to decrease the electricity and water usage. These baselines prove to be important as we move onto our next chapter, in which we assess the behavior of the Union Hill Elementary School towards being environmentally conscious. These behaviors are what directly affect the electricity usage and water usage through habits that have been created. We use these assessments to find ways to change the behaviors Union Hill Elementary school, and by involving the residents of the community with these changes, we will ultimately be able to increase their overall consciousness towards the environment and their community.

Chapter Four
Behavioral Assessment

A behavioral assessment is critical to complete our project goal of improving the quality of life of the community because it is necessary before we can make recommendations regarding habitual change. The data that was obtained by this assessment is instrumental in focusing our outreach strategies and recommendations and producing an environmental consciousness baseline. Without such data, it would be difficult to evaluate the relative priority of various outreach strategies, and in effect, students, parents, and teachers would not learn effectively from our outreach.

The behavioral assessment was a tool to categorize how the school functions and identify areas where improvements can be made to the social behavior found in the classroom environment and community. The data collected in this process helped shape the outreach strategies that were recommended to the Oak Hill Community Development Corporation. To begin this process we had an interview with Principal Morse of Union Hill Elementary which helped outline the major areas of the school that needed to be looked at, these areas are related to energy saving and behavioral habits and are discussed in more detail in the principal survey section of this chapter. Next we observed and recorded the current behavior of the school toward being green; we collected this data by surveying and examining the school. Quantitative data is more useful than qualitative data to determine a baseline because it is easier to formulate into a recommendation unlike qualitative data. A survey of the students, staff, and parents was conducted to try and better understand the environmental knowledge and conservation tendencies of the community. An example of one of the three surveys we gave can be seen below. All the surveys and result can be seen from Appendix P-T.



Student Questions

1. Do you recycle at home?
   - ◯ Yes
   - ◯ No

2. Do you turn lights off when you leave the room?
   - ◯ Yes
   - ◯ No

3. How do you get to school? (Check all that apply)
   - ◯ I ride the Bus
   - ◯ My parent/guardian drives me
   - ◯ I drive with someone else (more than one student per car)

4. Do you shut the water off while you brush your teeth?
   - ◯ Yes
   - ◯ No

5. How do you learn best? (Pick **two**)
   - ◯ Teacher presentation
   - ◯ Work at your desk
   - ◯ Computer activity
   - ◯ Week-long project
   - ◯ Month-long project
   - ◯ Science experiments

Figure 33. Student Survey.

For example, to measure the understanding of the importance of turning off appliances, questions such as, 'when you leave a room do you make sure all of the lights are turned off' were included.

This data serves three purposes. First, areas which require behavioral improvement are preliminarily identified. These are crucial because they focus our outreach goals. Second, the survey acts as a pre-test for the Oak Hill Community Development Corporation so that they can determine the usefulness of our questions and conduct a better, larger scale survey in the future (Oak Hill CDC, 2011). Third, this data can be used as a baseline to compare against in future years. The second part of the behavioral audit relates to the effectiveness of teaching techniques to students, some programs that will implement these different techniques are the Worcester Tree Initiative and Region Environmental Council that are discussed in our recommendation chapter. This can be found through classroom observations, student and teacher comments, and our direct

involvement in school activities. Through these observations we believe that, "faculty can then use this information to refocus their teaching to help students make their learning more efficient and more effective (Angelo, n.d.). This part of the behavioral audit is important because Union Hill Elementary is a level four school and this information helped determine the most effective means of outreach for the students. The information extracted from these activities creates background knowledge on the staff, students, and parents involved in the school, which helps to focus our recommendations.

Behavioral Assessment Results and Discussion

We determined that the largest impact on environmental consciousness is the behavioral aspect. Because of this we decided to perform a behavioral assessment on the Union Hill Elementary School to find areas in need of improvement when it comes to the behavior towards being environmentally conscious. As part of our assessment we performed a principal interview, teacher survey, parent survey, and student survey. These results focus our recommendations towards areas in need of the most improvement and allow our recommendations to be most effective.

Principal interview.

As our energy audit is being completed, we need to know what changes the school wants to be done and what changes are being made in the next years. Principal Morse has all of the information on these topics; our interview with her helped our energy audit become more relevant because she had specific areas for us to look to develop more energy efficiency recommendations. One of the many areas that Principal Morse expressed interest in retrofitting was the windows of both, the 1890 and 1960 building. The old school has its original windows and the city is investing a substantial amount of money into replacing them. This makes the windows and suggestions to replace them and make them the most energy efficient of great importance to our project. Buildings are "unbearably hot, [rooms] can get to 100 degrees" (M. Morse, Interview, 2011).This shows the understanding that the boilers that both buildings are currently running on are inefficient and need to be looked at. Although this is a high priority of the school we have no control over the boilers because Honeywell is implementing new boilers over the summer (E. Olearczyk, Interview, 2011).

Lighting may have an effect on students having headaches. Improvement to the lighting is a large part of the energy audit because of the over illumination of the school and from Principal Morse we have found out that the lights are also affecting the children.

Summary: “Start with one thing and do it well, you can’t fix all the deficits we have here” (M. Morse, Interview, 2011). This is important to keep in mind when we are completing our audit. We cannot fix Union Hill Elementary School completely but we must make sure the projects we chose to improve are completed to the best of our abilities.

The behavior of the students affects the overall education and environmental friendliness of Union Hill Elementary School; the students’ behavioral habits have proven to be subpar because the Union Hill is currently a level four school and needs to improve in order for our major objectives and goals to be completed. “Students have disrespect for the land” (M. Morse, Interview, 2011). These behaviors have a negative effect on the environmental awareness activities that we are trying to implement into the community and school. In order to for our suggestions to be successful we must first change the behaviors of the students.

Students do not understand yet the benefits that come from recycling, both educational and environmental. Even though M. Morse (2011) indicated that “most teachers don’t get [the science of recycling],” Principal Morse and us believe that it would be great to implement recycling into the school because of the potential educational benefits and increase in environmental awareness for the students and faculty at Union Hill Elementary. These benefits are discussed in the recycling section of the recommendation chapter.

From our interaction with the school and Principal Morse, many behaviors in the school need to be changed. These behaviors have a great impact on the outcome of our project, and needs to progress in order for the school to benefit from our outreach that will indirectly help them from being a level four school any longer. A possible road block for these behavioral changes is the high regularity of students being sent to the principal’s office. Principal Morse personally informed us that, there are a high amount of students acting out in the school. We have also observed these actions from working at the school over the past 7 weeks. These actions distract students from schoolwork, and can easily distract them from the outreach we’re trying to implement in the school system.

Teacher survey.

As part of both our energy assessment and behavioral assessment we needed to conduct a survey on the teachers of Union Hill Elementary School. We needed to get an average use for the computers in the classroom so we could best depict the energy usage of the computers. We also wanted to take the opportunity to create a profile of how the teachers are trying to conserve energy and recycle in the Union Hill Elementary School and at home. This profile could be used to determine the current environmental consciousness of the school and serve as a baseline to compare results from surveys given in later years after our recommendations have been implemented. A sample of the surveys given to the teachers and results can be found in appendices S and T.

Recycling is an important aspect of being environmentally conscious. If these students are taught to recycle in school, there is a higher chance for them to carry this habit to their home life and begin recycling at home. From our survey we determined that only fifty percent of the classrooms recycle. This is depicted in Figure 34 below.

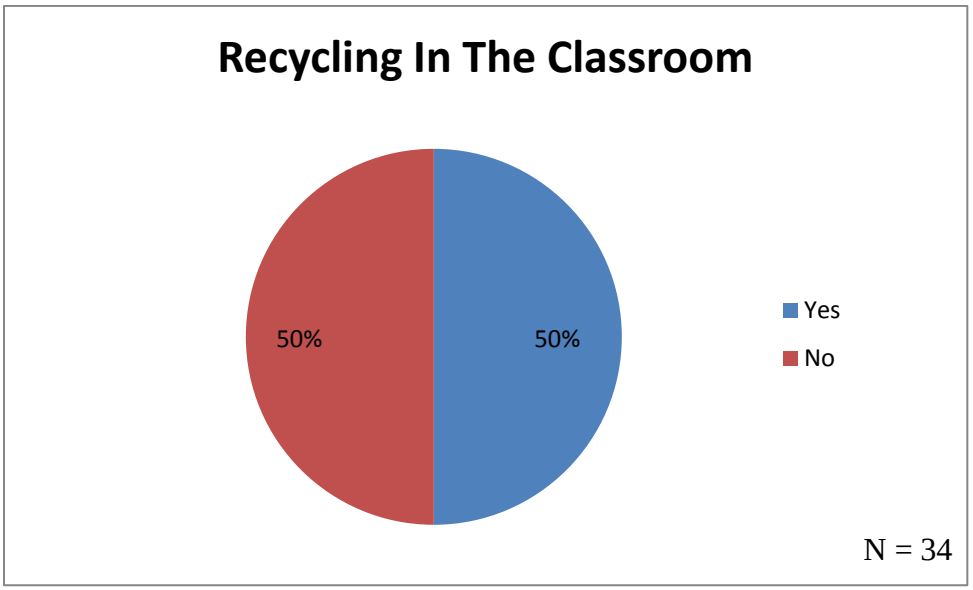


Figure 34. Percentage of teachers who recycle in their classroom.

From this information, we can conclude that there is already a significant effort in the school to recycle. Unfortunately it is only half of the classrooms that recycle and ultimately we would like to see that all of the classrooms recycle. This is important because recycling could help reduce the waste created by the school as a whole. We made recommendations to help

increase the amount of recycling in the school. This is presented in detail in our recommendations section.

Conserving energy is as much about the appliance, as it is about the behaviors of the users. Computers do not need to be on when in use, and can be put in sleep mode to save energy. This can only be done if the users choose to do so; from our survey we found that only forty four percent of the teachers put their computers on standby. This can be seen below in Figure 35.

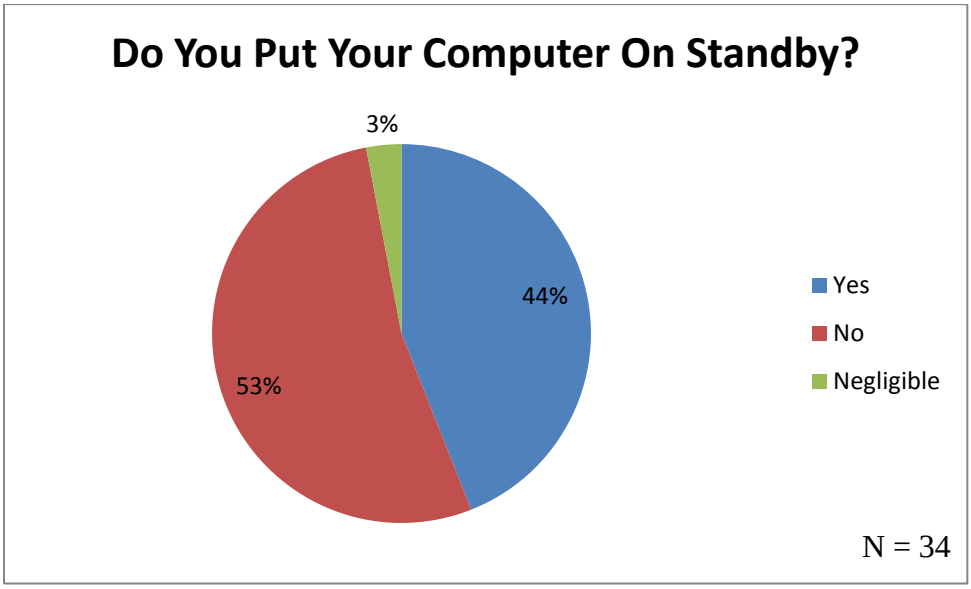


Figure 35. Percentage of teachers who put their computers on standby.

Teachers and staff need to begin turning their appliances on standby. This will reduce the amount to electricity that would be used to power these appliances when nobody is using them. This will be done through education of the teachers and staff to show them that there are advantages of putting their appliances on standby. Further information on our recommendations towards office equipment can be found in our recommendations section.

One final aspect of being environmentally conscious is reducing the amount of pollution being created. One way that we found the Union Hill Elementary School can reduce the amount of pollution being created is to limit the amount of cars being driven to work. From our survey we found that all of the teachers drive to school. We asked the teachers if they have ever thought about other motives of transportation to get to work. The results can be seen below in Figure 36.

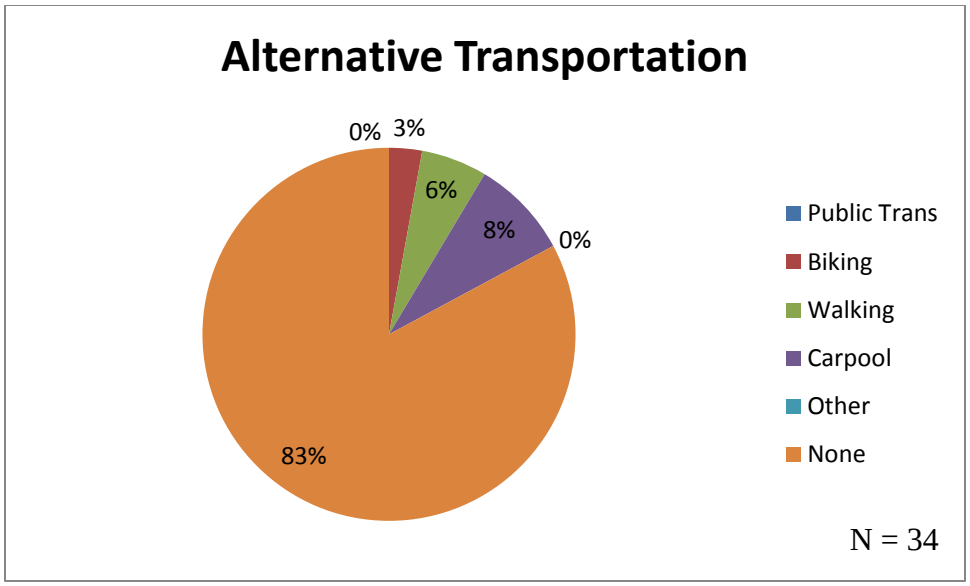


Figure 36. Teacher's considerations towards alternative transportation methods.

From this survey, we found that eighty three percent of the teachers have not even considered any alternative transportation to get to work. This is an issue that should be addressed within the school because transportation has the potential to save the environment, and save the teachers money by carpooling. We discuss this further in our recommendations section.

This survey has not only helped us to create a more accurate depiction of electricity usage in classrooms, but it has given us a profile on the environmental consciousness of the school. We use this information to focus our recommendations to increase the knowledge of the teachers on topics such as recycling, office equipment, and alternative transportation options. For a list of our recommendations, please refer to our recommendations section.

Parent survey.

As part of our behavioral audit, we obtained information from the parents of the students at the Union Hill Elementary School. This information was obtained through a survey given to parents as they came to pick their children up after school. From this survey, we were able to create a profile on the current environmental consciousness of the parents. This profile could be used to determine the current environmental consciousness of the parents and serve as a baseline to compare results from surveys given in later years after our recommendations have been implemented. This information is useful to see how well information taught in school to the students is being transferred to their parents. A sample of the survey given can be seen in appendix S, and the complete results can be seen in appendix T.

As mentioned before, recycling is a large portion of being environmentally conscious. It helps to reduce the total amount of waste being created and put in landfills. Because of this, we wanted to gain some understanding about how many parents recycle in their homes. From our survey, we found that eighty five percent of the parents we surveyed recycle. The results from this can be seen below in Figure 37.

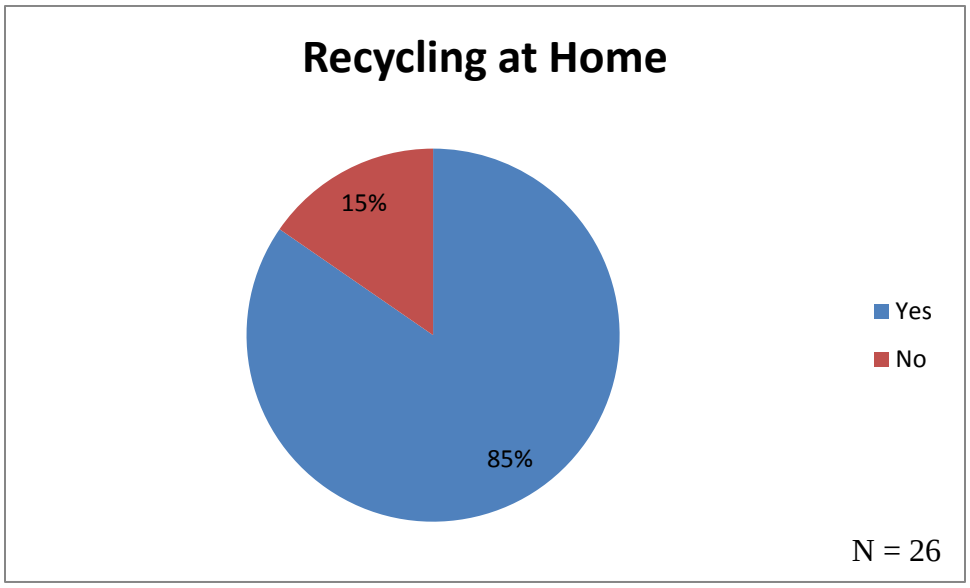


Figure 37. Percentage of parents that recycle at home.

Parents recycle a significant amount more as compared to the amount of recycling that is done in school. This is also higher than the United States average, which is eighty-one percent (Wills, 2011). We believe this is because Worcester has a waste removal program that requires residents to pay for waste removal by the garbage bag. However it is free to recycle wastes that can be recycled. This type of program causes residents to recycle as much waste as possible in order to reduce the amount of waste that they must pay in order to have removed. If these residents can be educated further about the advantages of recycling, then we could increase this recycling percentage to one hundred percent. This could be done through education material sent home to the parents and educating the students about recycling. This is discussed further in our recommendations section.

Another large aspect towards becoming environmentally conscious is conserving electricity. In order to find out how much effort is put forth by the parents to conserve electricity, we asked them how often they turn off lights in unoccupied rooms. The results that we found

were very helpful towards creating our profile. We found that ninety-six percent of the parents surveyed turn lights off in unoccupied rooms. The results can be seen below in Figure 38.

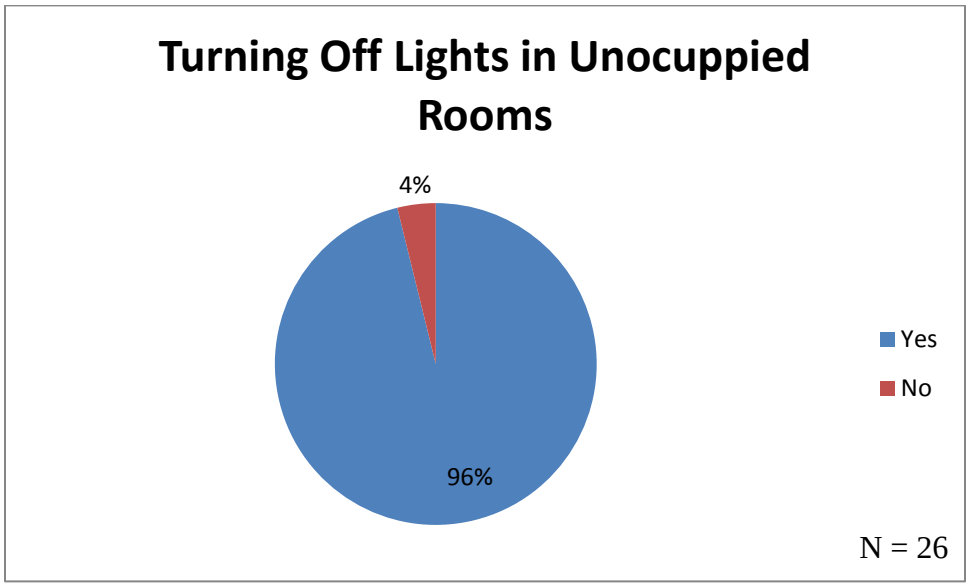


Figure 38. Percent of parents who turn off lights when they leave the room.

The parents are very conscious of conserving electricity where they can. We believe this is because the parents have to pay for the electricity that they use, and if they can limit it as much as possible then they can save much needed money. Unfortunately, the parents are not as educated in the areas where they can save the most money which is heating. We decided to ask them if they used a programmable thermostat to control their heating in their homes. The results showed us that most of the parents did not use one, or did not even know what a programmable thermostat was. This agrees with a study completed by the United States Department of Energy, which showed that fifty percent of residents did not know how to set their thermostat ("Measuring the Usability", 2011). Only thirty-eight percent of these parents said that they did use one. The results to this question can be seen below in Figure 39.

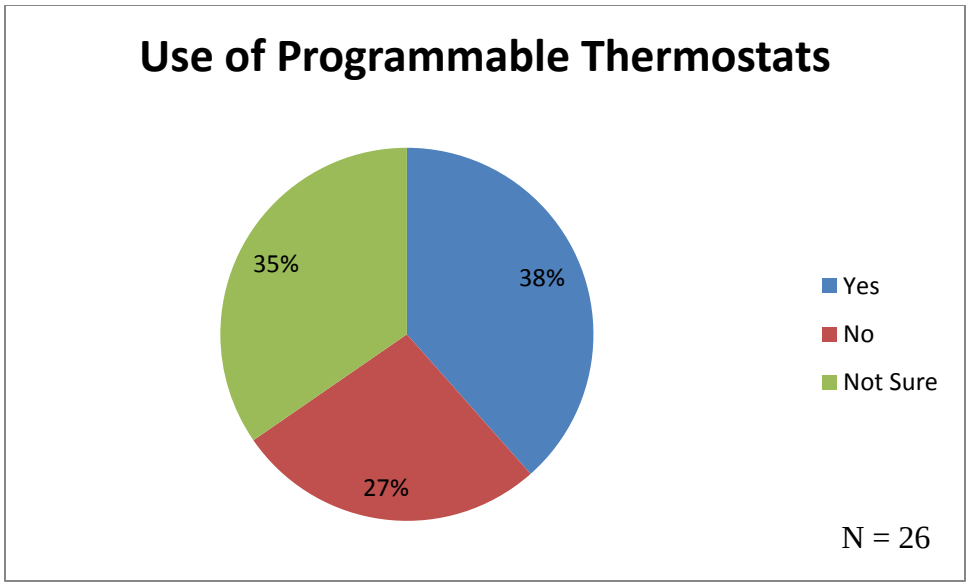


Figure 39. Percentage or parents that use a programmable thermostat in their homes.

These results show us that the parents are doing as much as possible in order to save money on their electric bill and garbage removal, but they are not educated on the most influential devices to save money which are programmable thermostats. If residents can be taught the economic value of using programmable thermostats to turn down the heat during the night and when their homes are unoccupied, then they will be able to save much more money on their heating bills as well. We believe that more education material should be created in order to teach parents the advantages of using such devices as programmable thermostats. We discuss this more in our recommendations section.

Student survey.

As part of our behavioral audit, it was necessary to obtain information from the students at The Union Hill Elementary School as well. This information was obtained through a survey given to students as they left school. From this survey, we were able to create a profile on the current environmental consciousness of the students. This profile could be used to determine the current environmental consciousness of the students and serve as a baseline to compare results from surveys given in later years after our recommendations have been implemented. This information will also be useful to see how well information taught in school to the students is being absorbed. A sample of the survey given can be seen in appendix Q, and the complete results can be seen in appendix R.

These surveys from the students have confirmed what we have found from the parent survey. This is because ninety percent of the students said that they recycle at home and eighty-one percent of the students said that they turn off lights when they leave the room. This is the same percentages as the parents of these students. From this information we can conclude that the students are aware of recycling and conserving energy at home. This could be due to the fact that their parents are aware that they can save money by recycling and conserving electricity, so they enforce their children to do so as well.

From this survey, we also collected data on transportation as well as preferred ways of learning in school. This information will help with the organization of transportation at The Union Hill Elementary School and with creating educational material for the students to teach them how to be environmentally conscious. The first piece of information that we looked at was how the students get to and from school. The results from this question can be seen below in Figure 40.

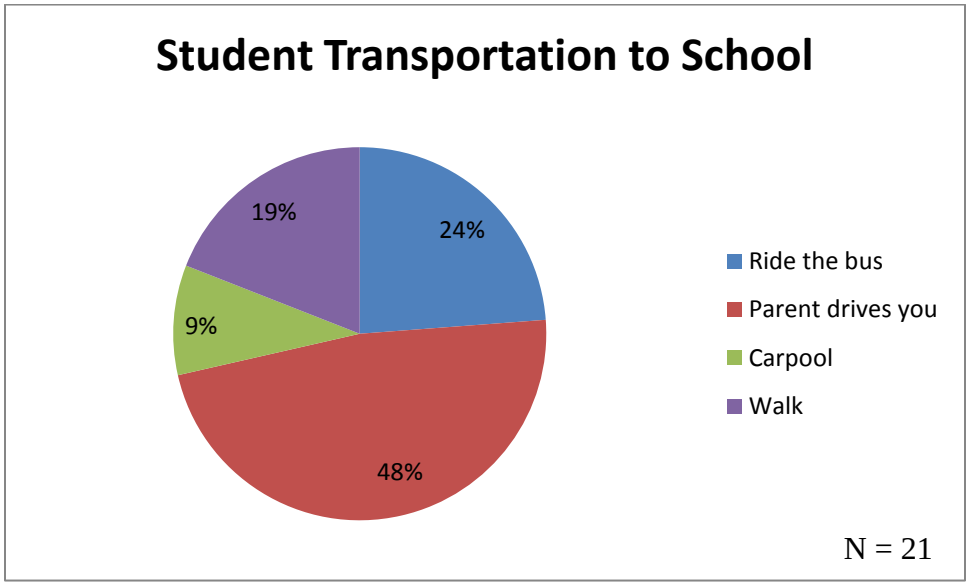


Figure 40. Student Transportation to and from school.

This figure shows that a total of fifty eight percent of students are driven to school, but only nine percent are brought to school in a car pool. This shows us that there is a significant area for improvement to reduce the amount of cars used to get to and from school. This could be completed through organizing car pools for the parents and promoting students to walk or ride bikes to school. This is discussed in more detail in our recommendations section.

The last information that was collected from the students is their input on the methods for education that they like the most. This information is helpful in order to teach students in methods that they prefer. The results from this section of the survey can e seen below in Figure 41.

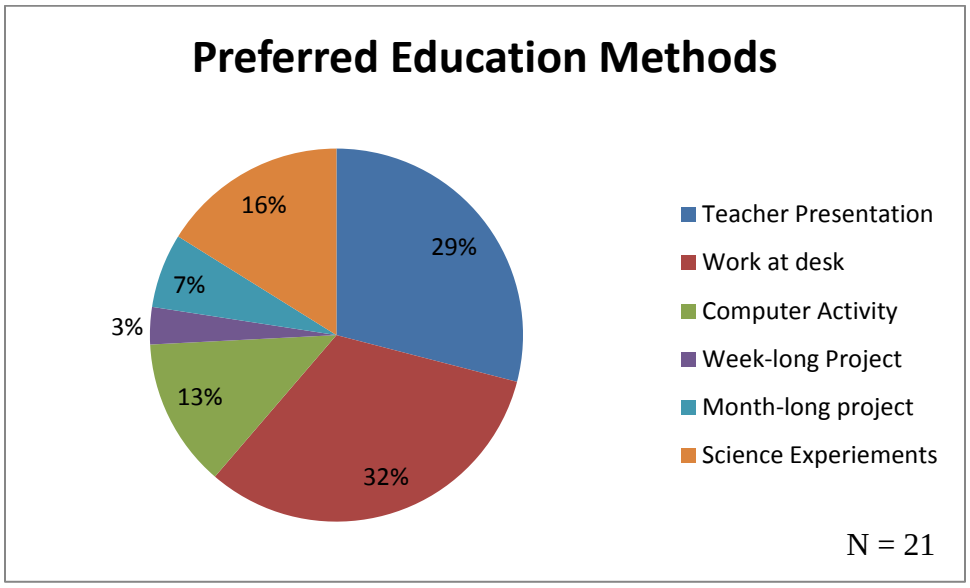


Figure 41. Students' preferred education methods.

From this figure, it can be seen that the students prefer many types of education methods. The two that are most prominent are working at their desks and teachers giving presentations. Because of this we feel that these methods should be used more often than the others, but it is also seen that the students prefer other methods such as science experiments, computer activities, and long term projects. We feel that these methods should be involved in the teaching curriculum in order to give the students diversity. These methods for teaching are presented in our recommendations section.

Summary

These surveys were very important to create an overall profile of the Union Hill Elementary School and surrounding Oak Hill Community. From these surveys, we have observed that the parents and students seem to recycle and conserve electricity at home more often as compared to the teachers at the school. We believe this is because the parents are trying to save as much money as possible in their residence, this is why they turn to recycling to limit the amount of garbage bags that they need to purchase from the city of Worcester. The parents also make a large effort to conserve as much electricity as possible through turning off lights in

unoccupied rooms in order to lower their electricity bill. Unfortunately, these parents are not fully educated about the use of money saving devices such as a programmable thermostat. We believe that if parents were educated about the amount of money saved from using such a device to turn the heat down at night and when the building is unoccupied, they will be more willing to use it.

The area that we found that could be improved the most is the teachers of The Union Hill Elementary School. These surveys show that the teachers are not as conscious about recycling and conserving electricity as compared to the parents. This could be because the teachers do not save any money from recycling or turning lights off in the school. We believe that if these teachers are educated on the global effect of their decisions to recycle and conserve electricity, they will be more likely to do so. Also, if The Union Hill Elementary School makes a large effort to recycle and conserve electricity the teachers will be more aware of the global aspects, and again more likely to join in on the schools efforts. In our recommendations section, we discuss these issues further, including the need to introduce an environmental council inside the school in order to involve the teachers, students, and parents with the schools efforts to become more environmentally conscious.

Chapter Five
Health Assessment

Before health suggestions are made for the school, a health assessment that involved multiple preliminary health tests had to be completed: this was done to ensure the students were learning in a healthy environment. As discussed in the literature review, the relationship between health and school performance was developed. In addition, health risks of the community were discussed in the literature review and introduction. Because there is potential for improvement in these two areas in the Oak Hill Community, a health assessment must be completed because practical recommendations cam be made. This section illustrates the type of information that we have gathered in order to make our recommendations more beneficial to the Union Hill Elementary School and Oak Hill Community. Our methods are outlined as follows:

First, we decided the most feasible tests that could be performed on the school. We focused on the critical areas of need that were identified during our energy audit, principal interview, and nurse interview: lighting, water, lead, and air quality.

i. Establish Health baseline: Interview the school nurse
ii. Energy Assessment: Used and analyzed in relevance to health baseline.
iii. Lead and Water Assessments: Testing kits were purchased
    1. Went to the school and took readings from different parts of the school to test for any harmful toxins.
    2. Contacted companies that perform more in depth health tests on the school.
iv. Air Quality Assessment: Determined testing that could be done by outside companies because we do not have the resources required to accomplish an air quality test.

Health Assessment Results and Discussion

We have determined that the school environment can have a large impact on the health of the students because they are spending much of their weekdays inside these old buildings that could still have harmful toxins within them. Because of this we have decided to perform testing in order to evaluate the current conditions in The Union Hill Elementary School. Our health assessment included creating a Health baseline, evaluating the lighting, testing the water, testing

for lead, and evaluating the air quality. From these tests, we were able to find areas that can be improved in order to increase the health of the staff and students at The Union Hill Elementary School.

Health baseline.

Before any testing that was done on Union Hill School, we first developed a basic health baseline to help us develop recommendations for the school. This baseline was used to identify critical areas that need improvement and serve as a comparison point for future evaluations.

On the eighth of November, we met with the nurse of Union Hill School and received information pertaining to health issues at the school, such as:

- Headaches
- Nosebleeds

The nurse explained that random nose bleeds were occurring in the classroom due to the lack of air flow and humidity. These dry rooms caused 10 nose bleeds over the course of 10 days, which comes out to an average of a nosebleed a day. The period of time when this occurred was from October 30, 2011- November 8th, 2011.

The interview with the nurse also showed that there were six headaches in the same time frame as the nose bleeds; we believe this is due to the over illumination of the lights , which was explained in the lighting section of chapter two. The fact that six students reported themselves to the nurse means they were not fully functional and had to leave the classroom. The physical well-being of students has to be accounted for and should be a priority for a school environment.

The air quality of the school is not yet known, but is necessary to take into account for the overall health of the school because roughly 14 percent of the student body has asthma. In, addition to the percentage of asthma in the school being well above the ten percent national average; there has been complaints of soot coming out of the tempt boiler that is used to heat the 1890 building. This puts the students at risk of worsening there asthma and visiting the nurse more often for their inhaler. By performing an air quality test, the school may be able to see if any major issues exist. This topic is described in more detail in chapter six under the air quality section.

In our meeting with the nurse her beliefs are that the school is not the cause of many of the students' health visits. Improvements exist that can seriously impact the health at the school.

Although we do not fully know if they are the causes of the nurse visits, any improvements we make regarding health usually involves improvement in:

- School Performance
- Social Behavior
- Nutritional Habits

The largest symptom that the school deals with is stomach aches. In the previous ten days there were twenty-three stomach aches. The nurse believes that these aches are a result of the students' diets at home. By teaching the students how to be more nutritionally educated they can then bring this back to their home lives and not have these problems in school anymore. Overall, it was difficult to do gather a full health baseline because the health records are not fully recorded on the existing electronic database. Instead, the nurse only records monthly data by paper at the school and only records major medical problems with the electronic database.

Lights.

The first testing we performed on the school for the health assessment was testing the intensity of the lights, it turns out that most lights are over illuminating various areas of the building. Over-illuminating the classrooms at Union Hill Elementary then there could be negative effects to the students and staff in a health aspect as well as their academic performance. If you refer to the light section in Chapter 3 of Energy Assessments, is our methodology for performing the light audit. An example of a lights assessment in a typical office in the 1960 building shows the health risks that come from over illumination. We collected data to measure the average lumens during a sunny day, a cloudy day, and at night at Union Hill Elementary. The minimum amount of lumens to light an office area is about 300 lumens by OSHA standards and starts affecting health at around 700 lumens. Therefore, we measured the illumination of the lights in each room to see if these lights were over illuminating and or affecting the health of the students. By referring to the figure below, you can see an example of one office in the new building that showed signs of over illumination.

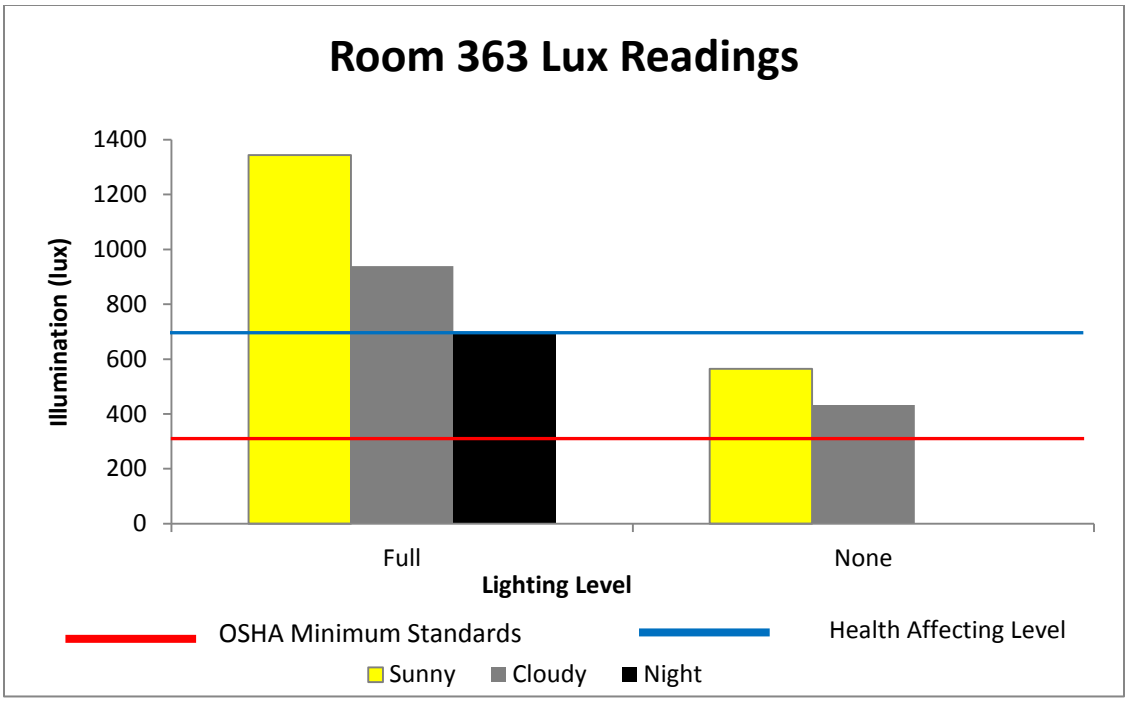


Figure 42. Light readings performed in room 363 of Union Hill Elementary.

The average lumens during a sunny day with all the lights on was measured to be around 1344.17 lumens and 564.83 lumens with all the lights off, having half the lights on was not applicable in this case. Also, on a cloudy day the average lumens were measured to be around 700.33 lumens with all the lights on.

This is the case for many of the rooms in the school and is a major concern to address because these headaches, fatigue, and other health problems can have an impact on academic performance. During a typical day at Union Hill Elementary our group found that more often than not all the lights were turned on in a classroom. "Health effects of over-illumination or improper spectral composition of light include increased headache incidence, worker fatigue, medically defined stress, and increased anxiety" (Health Effects about Over-Illumination, n.d.). In this case the lumens in the office ranges from 700 to 1350 lumens with all the lights on. To see all the office readings, refer to Appendix J. The minimum amount of lumens that each of these rooms should have is about 300 and they are well above that in most conditions.

These health issues are not what you want in a school environment because they also have a negative impact on the academic performance of the students. "Classroom lighting plays a particularly critical role in student performance" (Phillips 1997). The Union Hill students are subjugated to this over-illuminated environment that can be a factor in why it's a level four

school. In order to help improve the school performance and prevent these health risks at Union Hill Elementary, suggestions are made in our recommendations section in order to solve this problem.

Water.

Water quality is another health risk, we found that the water is safe to drink but the quality has room for improvement. Even though water is tested for harmful compounds at a nearby water treatment plant, there is always a risk that it can become contaminated en route to the school. Water is found all over the school in toilets, sinks, and water fountains. We decided that the water fountains were the most important source to test because they are a student's primary drinking source during school. Toilets and sinks were not tested due to time and financial constraints. We selected one water fountain from each building. Measuring was done via test strips from PRO-LAB Water Quality Tests. Complete data can be found in Appendix N, but is summed up in Table 5 below:

Table 5. Water quality test result summary. Results that were safe or ideal were colored green and results that were unsatisfactory were colored orange.

Risk	1960	1890	Safe Range
pH	5.5	5	6.5 - 8.5
Alkalinity	60	40	80 - 180
Chlorine	0.1	0.15	0 - 4
Hardness	35	25	50
Iron	0	0	0 - 0.3
Copper	0	0	0 - 1.3
Nitrate	0	0	0 - 10
Nitrite	0	0	0 - 1

As Table 5 shows, several of the tests came back with unsatisfactory results. Fortunately, no tests came back with unsafe results. This water is completely drinkable, but could be better.

Lead.

Our initial lead testing showed us that there is not an iminent threat of lead to the students in The Union Hill Elementary. However, only a fraction of the school was tested, so there may still be lead risks in the school.

As part of our health assessment, we tested areas of the schools for traces of lead. We used a lead test kit purchased at Home Depot. A picture can be seen below in Figure 43.

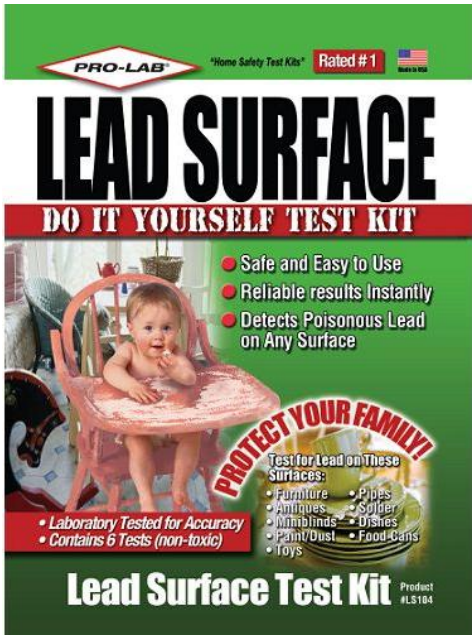


Figure 43. Lead surface kit.

This test kit included 6 test strips in which water is added using an included pipette. After the strips are activated with water, they are placed on a prepared surface for 2 minutes. In order to prepare a pained surface, we scraped paint off the wall in discreet places to bare metal.

If the strip turned pink or purple, lead was present. We decided to complete three tests in each school. Two of which were performed on paint and the third was performed on plumbing. Figure 44 below shows a picture of the three test strips used in the 1960 building:

i. First strip was completed on the paint on a heater in a classroom
ii. Second strip was used to test paint on a door frame
iii. Third strip was used to test a pipe in a utility room

Figure 44. Lead test strips from 1960 building: on left, door Frame paint; in middle, heater paint; and on right, plumbing.

As can be seen in the picture both the heater paint and door frame paint tests came up negative for lead paint. The test on the plumbing turned pink, which indicates that there is a low amount of lead on this pipe. The pipe being tested was a copper pipe but the strip was layed over a soldered connection. Solder can contain lead and still be safe because the risk of this being disturbed is very minimal. The amount of lead in the solder is minimal as well.

Figure 45 below shows a picture of three test strips used in the 1890 building. First strip was used to test paint on a classroom wall. Second strip was used to test paint in a utility crawl space. Third strip was used to test a pipe in a utility crawl space

Figure 45. Lead Test Strips from 1890 building: on left, classroom wall paint; in middle, utility wall paint; and on right, pipe.

As can be seen in Figure 45 all three test strips came up negative for lead. The test strip from the utility room wall was orange because the wall was damp and did not allow the strip to dry off. The test strip from the pipe turned black because the pipe was dirty.

After all these tests, we realized that they wasn't sufficient amount of evidence to say there was no trace of lead exposure in the school. This is because the tests we used were limited to testing only a few areas of the school, which is why we believe further testing should be done to ensure the children are learning in a healthy environment. These testing recommendations are discussed in chapter six.

Air quality.

As part of our health assessment, we decided that an air quality test was necessary for Union Hill Elementary School due to the current condition of the temporary boiler and the prevalence of asthma in the school. Students spend up to eight hours of a day in the building, and as we spoke about in chapter two, air quality can have a large impact on both the health of these students as well as their performance. The three major parts of air quality that we wanted to test were carbon monoxide levels, carbon dioxide levels, humidity, and particulates in the air. Unfortunately, through our search for a set of instruments to measure these levels, we found that they are far more expensive and intensive than we had anticipated. The time that would take to complete an air quality test is far beyond the time we had available to complete it. Because of this, we began researching to find a company that could complete an air quality test. We have found that the Massachusetts Department of Public Health offers thorough air quality testing on public buildings on request. This is completed through their Emergency Response/ Indoor Air

Quality Program. More information about this program can be found in our recommendations section.

Summary

From our health baseline, we were able to determine the major health problems in The Union Hill Elementary School. These include headaches, nosebleeds, and asthma. We have found that there is over-illumination in the rooms at the school, which are proven to cause headaches. The dry air in the 1890 building is causing nosebleeds; this is because the heating system is overheating the building. Finally, we have not been able to identify any large sources or poor air quality that could disturb the student's asthma, but we feel that further testing should be completed. We now combine the information obtained from the energy, behavioral, and health assessment into consideration in order to compile a list of recommendations to begin remedying these problems. We will ultimately frame these recommendations in order to increase the quality of life within the students and staff of the Union Hill Elementary School, but if we can engage the community with our recommendations, we will be able to increase the quality of life within the Oak Hill Community and increase the residents' involvement within their community.

Chapter Six
Recommendations

In this chapter, we present many recommendations and alternatives that we believe will begin to improve the educational environment at the Union Hill Elementary School and improve the quality of life in the community. These recommendations focus on technological upgrades as well as behavioral changes that can be made through outreach and education at the Union Hill Elementary School. Our hope is that the school will act as a precedent to the community and the students will transfer their knowledge to the community over time. It is also important to note that these recommendations are only the first step to improving the community.

The data from the energy, behavior, and health assessment in chapter three, four, and five was analyzed to make the most practical recommendations. This data is the primary evidence and deciding factors for our recommendations. First, this data was used to help identify areas in need of the most improvement so that our recommendations will have the most impact. Second, the available alternatives for these areas of critical need were identified. It is necessary to understand all alternatives available for these areas before the most effective recommendations can be made. Next, we organized the available solutions to better relate their associated impacts. Finally, after presenting all of the recommendations, an implementation strategy was created.

In general, our recommendations focus on specific areas of improvement due to the method that was used to organize them. Recommendations were organized in an approach such that they are grouped by area of influence instead of community impact. For example, they are grouped under categories such as building envelope, energy consumption, and outreach instead of saving money, changing behavior, and beautification. Thus, the recommendations seem to lose complexity with regard to our overall goal because they are not presented with regard to the connections and impacts that were described in the literature review. We chose to group our recommendations this way because it was very difficult to rank recommendations based on community impact. For example, we would have needed to decide if crime reduction or economic stability was more important to the community.

It was also hard to organize our recommendations based on community impact because it was hard to place many recommendations due to the vastness of their associated implications. For instance, a green roof affects health, greenness, financial stability, and beautification within the community, so we need to decide which of these categories it fits best in. However, this is

difficult to do because we would need a very detailed analysis to determine the most important implication of a green roof. Although we recognize that a detailed analysis for every recommendation is the most useful to the Oak Hill Community Development Center, this was simply not possible do to the sheer number of recommendations and alternatives that are provided later in this section. We were able to provide a more detailed analysis on the recommendations that we felt were the most important to our overall goal. To get a complete list of all of our recommendations, please see appendix U. To help deal with these complexities, we created Table 6, which maps the categories of recommendations to impacts in our goal.

Table 6. Recommendation impacts. Darker sub-category backgrounds indicates that it is more important within the category.

Category	Sub-Category	Health	Energy/ Green	Saves Money	Beautify	Behavior	Greater Community
Green Recommendations	Recycling		X	X	X	X	X
	Water Conservation		X	X		X	
	Transportation Organization		x	x		x	x
	Wind Energy		X	X			
	Solar Power		X	X			
Building Envelope	Windows and Doors	X	X	X	X		
	Roofing	X	X	X	X		
	HVAC	X		X			
Health Recommendations	Air Quality	X				X	X
	Lead	X				X	X
Electricity Consumption	Lighting	X	X	X		X	
	National Grid relationship/incentive		X	X		X	X
	Office Equipment		X	X			
Outreach	Community Garden	X	X		X	X	X
	Planting Trees	X	X		X	X	X
	Cleaner Streets Program	X			X	X	X
	Teaching					X	X

Several criteria helped us determine qualitatively the relative importance between each category of recommendations. The first criterion is educational effectiveness because students must be able to learn so they can transfer their knowledge to the community. Another criterion is cost effectiveness. Union Hill Elementary School is more likely to implement a recommendation if it is more cost effective and has a faster payback period. Ease of implementation is another important criterion: if the suggested change is not easy to be made then there will be resistance from teachers, students, and the community. The final criterion is environmental effectiveness, which is important if the school is going to be used as a precedent to the community. The sub-categories in Table 6 above are ordered by relative importance. Note that the categories are not ordered by relative importance.

In the next sections the recommendation categories are described: first, green recommendations; second, building envelope; third, health recommendations; fourth, electricity consumption; and finally, outreach. Each subsection starts with an overall summary recommendation and then has a detailed explanation. A full list of recommendations is shown in appendix U.

Green Recommendations

As discussed in our assessment chapters, through our health, behavioral, and energy assessments, we have found some areas in need of improvement. These areas include 1) recycling programs; 2) water conservation; 3) transportation operation; 4) wind energy; and 5) solar energy. These areas are discussed in this chapter including recommendations to help improve the deficits.

Recycling programs.

To improve the recycling efforts in the school, we recommend that a recycling movement is started. This will consist of a recycling committee composed of staff, students, and parents as well as posters and visual teaching to reinforce the importance of recycling.

Currently, teachers and students do not recycle at Union Hill Elementary School. All of our green recommendations that are explained in the rest of this section are worthless if the school has no motivation to be green at the simplest level. Changing and improving the schools mindset on recycling is important to the effectiveness of our recommendations. Recycling has many pros: first, it can improve the health of the community; second, it has great opportunity to

transfer knowledge to the community and keep them involved in the school; and finally, how to implement our recommendation with simple, small steps that start the change in the community and school.

Landfills have many health risks associated with living around them (Yallop, 2004). Recycling can help reduce the rate at which we fill our landfills. Schools can recycle about fifty percent of the items they use on a day to day basis, unfortunately they only manage to recycle about twelve percent (Yallop, 2004).

If the idea of recycling can be instilled in the young minds of Union Hill Elementary the more likely these behaviors will translate to the community. A recycling campaign at Union Hill Elementary is another source of outreach we have suggesting that Union Hill Elementary uses in order to help develop the students environmental awareness as well as their behavioral habits. Paper recycling provides great educational value for students and their families and is one of the simplest ways that we can help the environment. According to our surveys that can be referenced in our behavioral audit section, they help prove that the recycling habits of the Oak Hill Community are insufficient. We feel that a recycling campaign would effectively provide an outreach to help this problem; multiple free programs that the school may use in order to make this campaign a reality. These programs are known to provide paper retriever bins in distinctive areas of the schools and are paid for through all the recycled paper the school collects. Other ideas could be to use a contracting recycling service that provides a local hauler which will help the school "generate revenue or offset disposal costs". This program will help the school save money on waste disposals as well as provide the students with knowledge of recycling and how it helps the environment through the reuse of resources

The good thing about recycling is that it does not cost any money, it can only save money. According to Yallop (2004), schools have many different options to recycle including; envelopes, folders, and paper as well as plastic bottles. Because of these reasons we have compiled a list of steps to create an extensive recycling program at The Union Hill Elementary School.

- Create a recycling club composed of staff and students to help facilitate these recommendations as well as maintain the recycling program
- Look into any of the following programs and decide which is best for the Union Hill Elementary School

a. RecycleNow
b. Earth 911
c. The Go Green Initiative

- Put up recycling posters around the school to remind students the importance of recycling.

We believe that Union Hill Elementary School should implement a recycling program at the school because currently there is no effort put into recycling at the school. There are many benefits that come from this type of outreach. This can be accomplished through many programs:

- We have provided more information on the three programs listed in our recommendations.
    - RecycleNow is a program guide that provides a five step approach to developing and implementing a school recycling program. (http://www.recyclenow.com/what_can_i_do_today/start_recycling_at.html)
    - Earth 911 is a national organization that offers a lot of assistance and knowledge about environmental issues, specifically recycling. Tips from Earth 911 can be found at this link (http://earth911.com/recycling/paper/paper-recycling-at-school/) and provide a great educational value for students and their families. Using the links contained on the website allows educators and students to find a variety of standards-based activities that highlight the opportunities for increased paper recovery in their own schools and homes. Furthermore, there are video and case study highlights of the difference students can make for their school, their community, and their environment.
    - The Go Green Initiative is a simple, comprehensive program designed to create a culture of environmental responsibility on school campuses across the nation. Founded in 2002, the Go Green Initiative unites parents, students, teachers and school administrators in an effort to make real and lasting changes in their campus communities that will protect children and the environment for years to come. http://www.gogreeninitiative.org/

Water conservation.

Water is not billed to Union Hill Elementary School directly, so the best recommendation is to teach the students and teachers about water conservation that they can bring to their home lives.

We believe that a water conservation campaign will be helpful to Union Hill Elementary School. The reason why we looked into water conservation is because it doesn't just affect the schools water bill costs, but other energy conservation as well. Water is becoming scarce; thus, it is important to conserve water. "According to the United Natius Environmental Program, buildings consume 20 percent of the world's available water, a resource that becomes scarcer each year" ("Water's Role in Green Buildings," 2009). Thus, conserving water has various green benefits towards the environment as well as the Union Hill Elementary School. Many other benefits to water conservation exist:

> Not only will water bills go down, but as less water is heated, gas or energy bills also decline. If the whole community conserves, the price of water-related services will also go down. Water conserving communities will not need to pay as much to develop new supplies and expand or upgrade water and wastewater infrastructure. ("Why Conserve," n.d.)

As you can see, this is as much a community effort as it is a school effort. Having students keep an eye on water usage at school will get them to think about it all the time (Yallop, 2004). Water conservation does not always mean that there is a need to install expensive systems. Water conservation can be effective by just changing simple behaviors. These behaviors are as simple as turn off the water while you are brushing your teeth. Behaviors can be taught at the school then brought back to the homes through the students. Through lessons taught by teachers and informational posters our message can spread and a change can start throughout the community.

We have arranged some water conservation recommendations in order to help the community and Union Hill elementary school reduce their water and energy costs.

- Educate students and staff on the need to save water
- Install reduced flow nozzles on bathroom sinks.
- Instruct school chefs to only use dishwasher if full.
- Domestic Hot Water: Schedule setbacks to reduce water temperatures during unoccupied periods.
- Install motion detection faucets.

We feel that at minimum if new water appliances cannot be installed, a water conservation movement will help change the behaviors towards saving water and ultimately have the largest impact on the school and the Oak Hill Community.

Transportation organization.

We recommend that The Union Hill Elementary implement a campaign to begin reducing the amount of cars used to travel to school.

The use of vehicles that run off of fossil fuels is the largest source of greenhouse gasses, and in turn, is the largest source of global warming. This makes transportation a large source of global warming that schools can limit. Organizing transportation can reduce the use of cars by twenty to twenty-five percent and can be as simple as creating walking or cycling groups to allow students to travel to school together. Personal vehicle transportation to school causes many problems including traffic congestion, parking problems, and reduced air quality. Being driven to school can also cause students to arrive "stressed, distracted or not fully awake" ("Green Ways to School," n.d). An average of forty percent of elementary students are driven to school even though they live within 2 miles of their school. Organizing transportation can help limit carbon dioxide creation as well as help students become healthier (Yallop, 2004). In addition, the health benefits of walking to school can reduce the amount of childhood obesity in the United States. Some other things that should be considered are the creation of secure bike storage and access into the school (Yallop, 2004). In relevance to the Union Hill Elementary School an organization of transportation would be greatly beneficial. Our surveys have shown that a large percentage of the community in the Union Hill Elementary School have not considered alternatives for transportation, such as carpooling, public transportation, walking, and biking. We believe that if the staff, students, and parents are educated better about the alternatives that are available for transportation, they will be more likely to utilize them.

Solar power.

Solar power is an idealistic recommendation our hope is that through solar-massachussetts.org Union Hill Elementary School can get free solar panels and turn them into an energy conservation teaching material for the community to increase awareness and participation.

Solar power has the potential to further both of the goals of this project: Union Hill Elementary could become greener and the environmental consciousness of the community could

be improved through installing solar panels. As well as being great for energy the solar panels can be used as an attraction for the school which will get the community interested and more involved in the school.

There is a large movement in the country to create energy from the sun. In fact, the United States currently moved to the third biggest market for solar panels ("Solar Panels," 2009). Solar power is created through Photovoltaic cells that generate electricity (Strenk, 2010). Similar to wind energy, solar power is very environmentally efficient because it does not create any pollution and the sun is a renewable resource. The school would be able to "feed" or sell back unused energy created by their solar panels to the electric company in order to make money ("Solar Panels," 2009). In addition to being able to make money, "Federal and state governments provide numerous incentives for home and business owners who choose to install renewable energy" (Solar Panels, 2009).

Unfortunately, solar panels may not be the best option for Union Hill Elementary due to the extremely high startup cost of solar panels. Focusing on upgrading older systems instead of investing in new technologies at this time is likely a better option for Union Hill Elementary. However, if only a few solar panels are purchased and set up visible to the main office, the school could serve as a very good green precedent for the community for relatively low cost. On the other hand, some companies, such as SunRun Inc. or the Solar Electric Service Corporation will install solar panels for free. The Massachusetts Technology Collaborative may also offer this service. If solar energy can be obtained for free, the installation of solar panels is a great option. It is important to note that solar panels cannot be effectively combined with other recommendations such as a green or white roof. Thus, it is our recommendation to:

- Install solar panel array on roof for energy harvesting; install solar panel visible in main office to promote and inspire environmental consciousness.
    - Especially if solar panels can be provided for free.
        - Use http://www.solar-massachusetts.org/

Wind energy.

Wind energy should not be considered in Union Hill Elementary school because the disadvantages far outweigh the benefits.

The Union Hill Elementary School would not benefit from the use of wind turbines because the disturbance to education outweighs the positive benefits that may be obtained. Wind energy is one of the most environmentally effective forms of energy production and is an ideal recommendation under the perfect circumstances. According to Energy Informative, "wind is a green energy source, [and it] does not pollute the environment" ("Wind Energy Pros and Cons", 2011). Wind is created from the nuclear fission from the sun which causes uneven heating of the surface ("Wind Energy Pros and Cons", 2011) The uneven heating of the earth causes pressure differences and thus wind is created from the movement of air from areas of high pressure to low pressure. In order to capture this energy, Union Hill Elementary School would need to install wind turbines on the roof of their school. This causes a few problems, the most prominent being money. Although Wind turbines have the potential is save a ton of money, they have a very high startup cost because they are expensive to purchase and install. Another major problem with wind energy is the distraction to the students. Wind turbines have large moving propellers which can cause a distraction if they are seen outside of the window. Talking to principal Marie Morse children have trouble staying in class due to their behaviors and nurse visits, as described in chapter four and five (Interview, 2011). Any further distractions are not necessary at the school and in addition, the turbines create a lot of noise when they are operating which can break the concentration of students ("Wind Energy Pros and Cons", 2011). The idea of using wind energy is great but under the circumstances of Union Hill Elementary School it is not feasible to implement.

Building Envelope Recommendations

As discussed in our energy assessment chapter, the building envelope is comprised of every part of the building that comes in contact with the outside environment. This includes all outside doors, windows, and the roof. These components of the building have a large effect on the insulation value of the building. If they are not insulated or sealed properly, they will allow heat to escape the building and cause for an increased demand on the heating system and in turn an increased heating expense. Because the building envelope is such a large factor on the energy efficiency of a building, we have compiled a list of recommendations to increase its efficiency. In turn, the school will save money and be more environmentally friendly, thus allowing it to serve as a better precedent to the community.

Windows and doors.

Union Hill Elementary School should replace all its exterior doors and windows.

One of our goals is to find areas in which Union Hill Elementary School can upgrade in order to save money on their energy bills and we have identified that replacing windows and doors will not only save money, but it will increase productivity and health of the students. The costs of replacing windows and doors have been found to pay for themselves in energy savings within five to ten years ("Should I Replace", 2010). As noted before in the building envelope section of our results and discussion section, we have found that both the doors and windows in both the 1960 and 1890 building are in need of improvement. We understand that the Worcester Public Schools have their own method for determining replacement windows and doors inside these buildings. Because of this we have consulted both The United States Department of Energy and The Continuing Education Center to compile a list of factors that should be considered in the selection process.

Before these factors are considered, two important coefficients should be understood. First is the U-Factor of a window or door. The U-factor is a unit that relates the amount of non-solar heat flow through a door or window. A low U-factor means that the door or window lets less non solar heat flow through it. The second unit to understand is the Solar Heat Gain Coefficient. This is a unit that measures the rate of solar heat that flows through a door or window. The lower this coefficient is means that less solar heat will flow through this door or window. Below is a list of considerations that should be made when deciding which windows to install in The Union Hill Elementary School. Thus, we recommend to replace windows and doors following these guidelines:

- Choose windows and doors with a low U-Factor.
    - Make sure the U-factor applies to the entire window and not just the glass pane
    - The U-factor should be below .5, and optimally below .4
    - This can be obtained with a Low-Emittance coating on the glass
    - This can also be obtained from using gas fills between glass panes
    - Multiple pane windows will create a lower U-factor
    - Avoid windows and doors with aluminum frames
        - Wood, vinyl, and fiberglass are the best materials for insulation in frames
- Pay attention to the Solar Gain Coefficient

    - South facing windows and doors create solar heat during the heating season, a higher solar heat coefficient will maximize this advantage
    - East and West facing windows and doors create solar heating during the cooling season; these windows should have a lower solar heat gain to minimize this effect. This could also be minimized with blinds or drapes to block the sunlight
    - North facing windows and doors do not have a large effect on solar heat gain. Because of this it is not important to spend money for lower solar heat coefficient windows and doors.
- Windows should be operable if possible
    - This allows for ventilation, improves comfort, and reduces need for air conditioning.
- Blinds or drapes should be considered for windows were possible
    - Can vary solar heat depending on time of day and season
    - Between the glass blinds can reduce solar heat gain by forty-three percent compared to traditional room side blinds
        - Improves air quality by eliminating the dust, dirt, and allergens associated with hard to clean blinds.
        - Provides acoustic insulation from outside noises
- Consider better mounting surfaces for window air conditioners
    - Utilize window manufacturers air conditioner mounts
        - Increases U-factor of window and increases aesthetics
    - Use air conditioner covers in winter or remove air conditioners in winter

These recommendations will allow for the best possible replacement of windows and doors in The Union Hill Elementary School. If replacement of the windows and doors is not feasible, we have compiled a few recommendations to improve the efficiency of the current fixtures.

- Realign or re-hang windows and doors that do not close properly
- Weather-stripping on all exterior doors to eliminate gaps between door and frame
    - Replace current worn and cracking calking and weather-stripping
- Caulking around window and door frames to reduce air passing between the frame and the wall

- Replacing broken glass panes in all windows and doors
- Fixing window panes that are separating from the frame and creating gaps
- Use air conditioner covers in winter or remove air conditioners in winter

Ultimately, this will help The Union Hill Elementary School become a more energy efficient building and will create a better atmosphere for learning. This will have a positive benefit as we discussed in the literature review.

Roofing.

Our recommendation for Union Hill Elementary School is to install a White roof on top of the 1890 building and a Green roof on top of 1960 building.

In our energy assessment, we investigated the roof of The Union Hill Elementary School. Upon initial inspection the roof looks adequate: no tears in the membrane exist and no evidence of leaking was found within the school. However, from our inspection with the FLIR thermal imager, we found that the roof could be insulated better to save the school money on heating costs. Through our research, we have found two options to improve the roof at The Union Hill Elementary School. The two options we have are:

- Install a White roof by using white roofing material over the existing roof
- Install a Green roof by using vegetation to increase the insulation value of the roof
    - Install an Intensive Green Roof with safety precautions to allow students to be involved with the roof
    - Install an Extensive Green Roof and not allow students on top of the roof for safety reasons, but still take advantage of the benefits.

Both of these options would be a great addition to the school because it has the potential to save thousands of dollars and make the school greener. We will speak about the benefits of each option, but because the roofs of the two buildings at the Union Hill Elementary School are both in good condition, we feel that these recommendations are not a huge priority to get completed, but they are certainly something that should be considered because either option would greatly benefit the school.

White roofs.

A white roof can be implemented by using white roofing material instead of the typical black roofing material. This helps by reducing the solar heat gain of the roof because the color white absorbs less heat from the sun compared to black. Also, this creates a stable temperature inside the building and in turn helps create a more comfortable learning environment. In retrofits, the white roofing material is typically applied over the existing roofing material so that it is more cost effective. This adds extra thickness to the roof and in turn further increases the insulation value of the roof and helps reduce heating costs.

A white roof would help create a more energy efficient Union Hill Elementary School because the school would save money and the surrounding community would benefit from the decrease of adverse health risks from smog. One sixth of the energy used in the United States goes into cooling buildings (Rosenfel, Romm, Akbari, & Lloyd, 1997). A white roof will reduce the amount of heat energy absorbed into the building through the roof. According to the Lawrence Beark Leg National Heat Island Group, "switching to a white roof can actually reduce energy use by about 20% in hot sunny weather" (Kimble-Evans, n.d., p. 1). Lower absorption of heat can also help reduce smog levels in the surrounding area because it causes a reduced average temperature of the environment.

Green roofs.

A green roof is another roofing option that will greatly benefit the Union Hill Elementary School. "A green roof system is an extension on the existing roof which involves a high quality water proofing and root repellant system, a drainage system, filter cloth, lightweight growing medium, and plants" ("Green Roofs Benefits," 2011). A green roof involves using vegetation on the roof of a building to allow for better energy efficiency and water management. Below in Figure 46 is a picture of how the 1960 building may look with a green roof.

Figure 46. Rendering of a green roof on top of 1960 building.

Looking at Table 7, the price difference between a conventional roof and green roof is relatively minimal.

Table 7. Conventional vs. green roof pricing.

	Conventional Price/ft^2	Green Roof Price/ft^2
New Construction	3-9	10-15
Re-Roofing	5-50	15-50

On the other hand, for a building as big as the Union Hill Elementary School, these small differences can add up. Fortunately, the benefits of a green roof far outweigh the initial cost. In addition to the ability to decrease energy usage by increasing insulation value, a green roof can decrease the demand on a storm water system by slowing the drain time of the roof which will result in less flooding in the immediate area of the school. A green roof can also clean the air by allowing plants to convert carbon dioxide in the air into oxygen ("Green Roofs Benefits," 2011). There are also school performance benefits: the added vegetation on the roof has been shown to reduce noise in the building by up to forty decibels ("Green Roofs Benefits," 2011). This lowered distraction will allow students to focus better in the classroom. This information is also reiterated in the National Geographic. "Maureen Connelly runs a green-roof lab at the British Columbia Institute of Technology who are studying the practical benefits green roofs offer, helping quantify how they perform and providing an accurate measure of their ability to reduce

storm-water runoff, increase energy efficiency, and enhance the urban soundscape" (Klinkenborg, V., n.d.). Another example of a useable green roof can be seen Figure 47.

Figure 47. The Louisa, Portland, OR. 2007 Green Roof Awards of Excellence winner ("Green Roofs Benefits," 2011).

Two types of green roofs exist: intensive and extensive. Intensive green roof involves elaborate design of plants and walkways. This is best for a roof with a lot of human interaction, but also required much more maintenance and cost. Initial startup cost for an intensive roof is fifteen to twenty-five dollars per square foot. Extensive green roofs are comprised of a thin layer of drought resistant plants such as grasses. This type of roof is not designed for human interaction, but the startup cost is much less and there is no needed maintenance. The initial startup cost of an extensive roof is eight to twenty dollars per square foot.

Students can be brought up to the roof and shown how a Green Roof works as well as maintain the garden themselves ("Green Roofs Benefits," 2011). A green roof is a great teaching tool to show students how they can help the environment. However, after speaking to M. Morse, we have found that the feasibility of putting children on the current roof is not possible. Marie Morse has expressed concern that this is unsafe. This safety concern could be eliminated by adding stairs to the roof and a very reliable fence. As discussed later in this chapter, we also recommend implementing a community garden. Having both an intensive green roof and a community garden would have diminishing return on investment. Because a community garden is easier to implement than an intensive green roof in this situation, we recommend an extensive roof if a green roof is implemented on the top of the 1960 building. Because of this we have created two detailed recommendations:

- Install a white roof on top of the 1890 building and install an extensive green roof on top of the 1960 building.

- A white roof can be installed on top of the 1890 building because the access to this roof is minimal as well as the surface area of insulation that would be added from a green roof is much less than that of the 1960 building.

As we spoke before, these recommendations may not have as much affect for the Union Hill elementary School as other recommendations in this chapter because:

- The roofs are in good shape right now and do not need to be replaced.
- These options should be considered for options when the roof does need to be repaired, or there is an opportunity to invest the money in the roof.
- Installing either a green roof or white roof on the school will help the school save money on their heating costs, keep the temperature lower during the summer, and increase the insulation value of the roof.
    - Most importantly, it will help teach students to become ecological stewards, and show them ways they can to help preserve the environment through daily activities such as gardening.

Heating, ventilation, and cooling.

Currently the boilers in both buildings of Union Hill Elementary School are broken so our recommendation is for Union Hill to invest in two working boilers for the school.

Improving the HVAC system has significant opportunity to save the school money, improve health, and better school performance, and fits in well into our goal of improving the energy efficiency and greenness of Union Hill Elementary. For reference, the relationship between temperature and both health and school performance was discussed in the Health and School Performance section of chapter two. In addition, the current state of the HVAC system was explored in the heating, ventilation, and cooling section of chapter three. This section will focus on the retrofits possible to achieve such financial, health, and educational improvements through 1) the heating system; 2) the cooling system; and 3) an energy management system. Note that retrofits include both infrastructural and behavioral changes, and that some of the behavioral recommendations are not possible until new infrastructure is installed.

Heating.

Because the school does not have a central ventilation system and operates mostly in the colder seasons, improvements to the heating system will be most crucial for the finances, health, and performance of the school. Heating system recommendations include:

- Replace temporary boiler in 1890 building; add boiler to 1960 building, where there is currently no active heating system.
- Develop routine boiler maintenance per manufacturer's instructions.
- Install control to automatically shut down heat generating device when outside air temperature reaches 60ºF.
- If soot and odors are detected in areas where they are not expected:
    - Heat exchanger may have burned out. Replace.
    - Stack draft may be inadequate. Clean and correct as necessary.
    - Perform flue gas analysis to obtain proper air to fuel ration.
    - Check operation of furnace draft controller.
    - Check boiler setting for leaks.
- Clean air inlets or outlets if dirty or obstructed.
- Reduce thermostat settings by a minimum of 10ºF at nights, for weekends and holidays during heating season

The main problem with the current heating system is that a temporary boiler is being used and there are heat distribution problems. Because the temporary boiler costs money to rent in addition to the money for oil, the payback period of a new boiler would be relatively low given the significant startup cost. In addition, such a new system would be able to accommodate better heat distribution. Also, replacing the temporary boiler would allow natural gas, which is to be used and would make the soot a non-issue. In the 1960 building, health and school performance are the primary concerns due to the recent breakdown of the system in that building. Thus, it is very important that new boiler be installed. If this process must wait for the Honeywell system to be implemented in the summer of 2012, consider using a temporary boiler for the upcoming winter season. Once new boilers are installed, it is imperative that maintenance is scheduled regularly to increase the life span of the system.

Cooling.

Health and comfort are the most important factors when considering an upgrade to the cooling system because of the fact that there is currently no central air system. While several offices are conditioned, the classrooms, where students spend most of the time, are not. Several recommendations are to:

- Consider installing a central air system
- Add 29,000 BTUs of cooling to Room 391.
    - Rooms needs approximately 47,000 BTUs total, consider using one large AC unit instead of five small units for efficiency
- Add 34,500 BTUs of cooling to Room 191
- Remove
- Check Principal's office air conditioner for function. Wattage is lower than expected, so it might not function properly.
- Where practical, cover through the wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.
    - Cover Air Conditioners during winter or take them down.
- Turn off pilots during cooling season, if applicable.

It is important to highlight both the optimal and the most practical solutions for cooling to help to identify the best recommendation for Union Hill Elementary. The optimal solution when only paying attention to the health and school performance of the children is to install a large central air system such that both buildings can be cooled properly. As discussed in the literature review, temperature control will improve performance by making students more comfortable. However, a new central air system would be very expensive, and the school is not in everyday use during the warmer seasons. It is important to note that such a system would have very high startup cost and would increase the energy of the building considerably. If a central air system is considered to be too expensive, consider improving conditioned air in targeted locations. Currently, all offices and one computer laboratory are conditioned. Such rooms that are already targeted make sense: the offices are in more use than classrooms during the times that the most cooling is required (i.e. the summer), the additional heat from the computer labs needs to be

handled, and there are too many classrooms to cool. However, these spaces, in addition to the other computer laboratory, should be cooled more.

Energy management system.

Once new boilers and/or a new central air system are installed, it is imperative to:

- Install an automated energy management system that will control all spaces in accordance with usage and temperature (i.e. allow rooms to be controlled separately).
    - Adjust thermostats to 68-70ºF in heating season and to 78ºF during cooling season.
- Experiment with start-up times and duration of operation to determine satisfactory comfort levels for occupants. Reduce or turn off heating and cooling during the last hour of occupancy, allowing the building temperature to 'coast.'

These recommendations are focused on improving the health and performance of the students through distribution of conditioned air. As discussed in the building envelope section of this chapter, more operable windows will also help here.

Health Recommendations

Through our research in the literature review, we have found that the building can have a large impact on the health of the staff and students due to the fact that the students and staff of Union Hill Elementary School spend up to eight hours a day inside the school. In our health assessment we began to identify the areas of the building that could affect health. From this assessment, we have compiled recommendations in regards to 1) air quality; and 2) lead.

Air quality.

Air quality is important to check for in schools for the safety of the students so our recommendation is to have a professional air quality test done at Union Hill Elementary School.

Through our research we have found that the air quality can have a large impact on the health of both the staff and students of The Union Hill Elementary School. Unfortunately, we could not complete air quality testing of the facilities. However, the Massachusetts Department of Public Health offers thorough air quality testing on public buildings on request. This is done through the Emergency Response/ Indoor Air Quality Program. Their testing includes factors including microbial growth, indoor/outdoor sources of respiratory irritants/ vapors/ gases/ particulates, carbon dioxide levels, carbon monoxide levels, humidity, and an analysis of the

current ventilation system ("Overview of Indoor," 2011). We feel that it would be greatly beneficial to determine if there are any factors that are affecting the air quality of the Union Hill Elementary School. For further information on Air Quality Testing, contact the Emergency Response/Indoor Air Quality Program: (617) 624-5757.

Lead.

The lead testing completed in Chapter Five was a preliminary test and further testing by professionals is advised.

Through our research we have found that lead can have a large impact on the development of adolescent's brains and central nervous systems. Because of this, we performed some preliminary tests to find if there are any direct threats of lead in The Union Hill Elementary School. From our tests we did not find any lead, but we feel that further testing should be done to get a more in depth analysis. We have found that The Massachusetts Department of Public Health has a laboratory that will analyze samples for traces of lead. We recommend that The Union Hill Elementary School get in contact with The Environmental Chemistry Laboratory to find out how they can obtain a more in depth analysis of lead in their building.

Energy Consumption Recommendations

In our energy assessment in chapter three, we have identified many areas in which can be improved to decrease the amount of electricity used in The Union Hill Elementary School. If the amount of energy used in the school can be reduced then this will help save money, contribute to the more global effort towards limiting demand on power plants, and increase greenness. Some topics for recommendations include 1) lighting; 2) National Grid; and 3) office equipment.

Lighting.

Our recommendation is to improve the lighting through both behavioral changes and infrastructural improvements.

Improvements to the lighting system are particularly crucial because there is great potential to save money, increase health, and improve school performance. In addition, because less energy can be used to illuminate the school, there is also a potential for the school to become greener. Many claims are made in this section, and they can all be supported with the energy assessment data found in chapter three and in appendices J and K. Note that the health effects

due to improper lighting can be found in the literature review in the lighting section. Lighting recommendations were split up between behavioral and infrastructural improvements.

Behavioral.

Behavioral lighting recommendations focus on habitual changes that have the potential to immediately save money because they have no initial cost. The challenges associated with habitual change can be found in the last section of chapter two. Behavioral recommendations include:

- Establish a regular inspection and cleaning schedule for lamps and luminaires (fixtures). Dust buildup reduces effectiveness.
    - Including windows
    - Replace lens shielding that has turned yellow or hazy with new acrylic lenses which do not discolor.
    - Clean surfaces to increase reflectivity
- Utilize available daylight more effectively for illumination
    - Do not hang posters high on walls (reduces reflectance)
    - Do not hang posters on windows
    - Remove bookshelves and other furniture that blocks sunlight.
    - If half lights are a better option, shut lights off closer to the window
- switch off lights at night and in unoccupied areas during the daytime
    - Post instruction to turn off lights when leaving area.

The important factor to note is how little effort needs to be expended to save a lot of money. For example, if teachers were able to turn off their lights for just one hour during the day by using natural lighting or turning lights off during lunch period, over one thousand dollars could be saved annually.

Infrastructural.

Infrastructural changes do have initial costs, but their potential to save money is often greater than behavioral changes. In addition, these recommendations have the potential to increase school performance and student health by reducing distractions such as light glare and flickering and reducing over and under-illumination which cause headaches and eyestrain, respectively. Such recommendations include:

Controls

- Install switch banks - Rewire switches so that one switch does not control all fixtures in a room.
    - Switch on alternate lights in row of fluorescents for better lighting distribution
- Do not consider dimmers – they are not efficient
- Install photosensors and switching equipment which automatically compensate for varying natural lighting conditions and room use.

Lighting distractions

- Replace North-West HID light that makes noise
- Replace flickering lights

Under-illumination

- Replace lights that do not function (if under-illuminated)
    - Ex) bathroom 347 is under-illuminated
- Increase luminance in all-purpose room. The current luminance is way under the OSHA standard and need to provide much more light.

Over-illumination

- Replace incandescent bulbs with fluorescent where appropriate
    - Example: small bathrooms.
- In the case that there is always over-illumination, remove lights from fixtures (evenly within the room)
- Install drapes to reduce over-illumination when all lights are off.
- Reduce the levels of illumination at selected task locations, and lower them further between or beyond the tasks

Efficiency

- Replace lights “with more efficient light sources”
    - Consider 15 Watt LED T8 bulbs.
- Disconnect ballasts (which still use significant amount of energy even though tubes have been removed) in fixtures where fluorescent lamps have been removed.
- Reduce the losses in power distribution system that serves the lighting system
- Use of Solar Tubes in hallways and classrooms to introduce sunlight and reduce energy cost.

Each recommendation has various initial costs, payback periods, and difficulties to install. Due to the complexity of this project, only a two will be highlighted. Currently, there are approximately 815 32 Watt T8 fluorescent bulbs installed in the school. These could be replaced with 15 Watt LED T8 bulbs. Assuming each LED bulb cost $50 and the price of a kilowatt hour is $0.17, such a retrofit would have a 6.25 year payback period. After this time, approximately $6500 dollars would be saved per year. Although this may seem like a very long time, LED bulbs have a 2.5 times longer lifespan than fluorescent bulbs (which cost approximately $3). Factoring in replacement bulbs and energy consumption over sixteen years, the school could save approximately $88,000.

Solar tubes.

Solar tubes also have a lot of potential to improve the energy efficiency of the school and promote environmental consciousness. A solar tube is a type of tubular skylight that is used to harness the light from the sun on the roof through a clear plastic dome, and reflect it into the building via a mirrored tube and a diffuser. An example of a solar tube can be seen below in Figure 48.

Figure 48. Example of solar tube installation.

These tubes would introduce a significant amount of sunlight into classrooms and the hallway and decrease the need for artificial light. We believe that these solar tubes should be installed at minimum in the hallways because there are currently no sources or sunlight in these hallways. We also feel that they should be installed in each classroom to increase the light from the sun and even out the light that comes in on one side from the windows. If these solar tubes are installed, there will be a significant decrease in electric usage because artificial lights will not

be needed during the day. Below we have compiled a list of companies that install and build solar tubes and specialize on the use of daylight in a building.

- Sunlight Systems of New England (617) 690-3668
- Solatubes http://www.solatube.com/
- Velux Sun Tunnel http://www.veluxusa.com
- ODL Tubular Lighting System http://www.odl.com/skylights.htm

National Grid relationship / incentive programs.

Our recommendation is to utilize National Grid's incentive program to help offset the cost of the improvements to Union Hill Elementary School.

One of our goals is to help save the Union Hill Elementary School as much money as possible. Because of this goal, as part of our recommendations we have investigated ways to help alleviate the high cost of making these renovations. One recommendation we make to help with the cost of these projects is to utilize National Grid's Incentives Program. This is because National Grid will pay for a percentage of the cost to make energy efficient upgrades. We spoke to Scott Farrar from National Grid in order to find out exactly what national grid has to offer the Union Hill Elementary School. He began by telling us that the Union Hill Elementary School is applicable for this type of program. In fact he is already working with the city of Worcester to make energy efficient upgrades in public buildings. He noted that they are looking into performing lighting upgrades to these types of buildings, which would greatly benefit the Union Hill Elementary School. He told us that the amount of money that can be saved depends on the type of project being completed.

Because the electric demand of The Union Hill Elementary School is 79.4 kilowatts and that is less than 300 kilowatts, it falls under the Small Business Program. This means that National Grid will pay for seventy percent of the cost for the upgrades and the school would get to pay the remaining thirty percent interest free on their electric bill for up to two years. This program will cover such upgrades as lighting upgrades, energy efficient time clocks, photo cells for outdoor lighting, occupancy sensors, and programmable thermostats. This means that The Union Hill Elementary School will be able to benefit greatly from such a program, and we recommend getting involved with National Grid before considering the renovations we

recommend. For further questions about the program, contact Scott Farrar at National Grid: (508) 860-6304. The number to contact the laboratory is (617) 983-6657.

Office equipment.

Our recommendation is to install automatic controls such as time clocks or automated management systems to limit Union Hill Elementary School's electricity waste.

One of our goals is to save the Union Hill Elementary School money on their electric usage. As stated before in our energy assessment chapter Office equipment was found to be a large contributor to electric usage in the Union Hill Elementary School. We have compiled a list of recommendations to help reduce the electric demand of the office equipment found in the school.

- Install automatic controls such as time clocks or automated management systems.
    - Example: time clocks for network switches
- Set computers to automatically hibernate after a set period of time
- Utilize program to shut off computers at night.
    - Contact Bob Walton, Worcester Public School IT manager
    - Develop maintenance schedule for this program
- Posters to tell printer operators to put in energy saving mode when not in active use
- Reduce idle time before sleep for smaller laser printers.

If these recommendations are implemented, there will be a significant decrease in electricity usage in The Union Hill Elementary School. If an automatic timer is set up on all network switches there will be savings of thousands of dollars over the course of a year. This is not because the network switches alone use a lot of electricity, but there are so many network switches in the school that the minimal electric usage adds up. A switch could turn of these switches during the night when the computers are not being used and save electricity. The same course of action should be taken for computers and printers, the only difference is that these components can be programmed to shut of which means that there is no need to buy switches: simply programing computers to shut off and reducing the time before a printer goes to into standby mode will save electricity. We have found out that a shut off policy already exists, but is not implemented at Union Hill Elementary School. An automatic shutoff program should be installed. Moreover, we feel that a maintenance schedule would be beneficial to ensure that the

program is always working correctly. In order to do this, we recommend speaking to Bob Walton, he is the IT manager for The Worcester Public Schools.

Outreach Recommendations

In order to facilitate change in the community as well as the school, these recommendations must make an impact on the oak hill community. Throughout our research we have found ways to involve the community into these recommendations. We have also found that there are challenges with creating community change. This community change must be created through educating the residents about the advantages of these changes. If the residents become involved with the efforts, this will greatly increase the probability for these programs to succeed. We will speak about our recommendations including 1) community garden; 2) planting trees; 3) cleaning streets; and 4) teaching.

Community garden.

Our recommendation is to implement a community garden in one of the empty lots currently owned by the Oak Hill CDC.

The Regional Environmental Council of Worcester provides numerous programs that help develop a communities: environmental consciousness, healthier nutritional habits, and overall education, but in particular the Urban Garden Resources of Worcester (UGrow) program will be the most effective to implement in order to improve the environmental awareness and behavioral habits of the Oak Hill Community. "Elementary school and junior high school students gained more positive attitudes about environmental issues after participating in a school garden program" (Waliczek, 1999). Studies have shown that when students are allowed to learn in an outdoor environment, there environmental attitudes have improved. The UGrow program will provide a community garden for the children of Union Hill Elementary to actively interact with and help develop their environmental awareness. The maintenance of the garden will help the students learn more about environment. This will also provide a green space for children to learn more about nutritional habits as well. "Study reports consumption of fruits and vegetables, as a habit in childhood, is an important predictor of higher fruit and vegetable consumption as adults (Heimendinger, 1995)." The UGrow program will provide availability of fresh vegetables for the community directly from their own garden. This will help improve the behavioral habits of the Oak Hill Community because the community garden will increase the interest in fruit and

vegetable consumption; thus, the community will care for the garden in order to maintain that source of fresh produce. Another benefit that comes from this program is that children will start to be more interested in improving the appearance of their neighborhood. To reiterate the importance of green space in a community referenced in our beautification section, the article Youth "Nutrition Garden" in Southwest Detroit, states that, "A study on a youth gardening program in Detroit reports that after gardening, children have an increased interest in eating fruit and vegetables, possess an appreciation for working with neighborhood adults, and have an increased interested for improvement of neighborhood appearance. In addition, they made new friends, and showed increased knowledge about nutrition, plant ecology, and gardening." (Pothukuch, 2004).

As you can see, the implementation of a community garden will bring forth many improvements to the community: beautification, environmental awareness, and nutritional habits. This will happen because of the motivation and drive the children will have after completing the UGrow program. They will feel encouraged to eat more produce and will also feel the obligation of looking out for their own garden that will be only a block away from their school. The community garden can be accomplished through the following process:

- School must go through the REC Application process in order to be chosen for the UGrow program
- Build a committee of Union Hill Staff and Oak Hill Residence who would be interested in the UGrow Program.
- Committee must determine how the garden will be taken care of
- Committee must determine where the garden will go
- Oak Hill CDC has an empty lot on Chaplin Street as an example of a possible area near the school.
- The students of Union Hill Elementary and the Oak Hill Community will have to be involved in the build in order to ensure success of the Community Garden. At least twenty to twenty-five people should be involved.
- The garden build usually happens in the spring time.
- It's good to start as soon as possible to prevent any problems during the spring time when the build would actually happen.
- Once application process and committee is built, a build date has to be determined.

- Once the build is complete, educational programs and after school activities can be set up to utilize the garden.

Planting trees.

Our recommendation is to create a gardening committee that focuses on beautifying the community through planting trees around the community.

A main goal of this project is to provide green outreach material for the Oak Hill Community in order to develop their environmental consciousness and behavioral habits; we believe that a tree planting program would help address this issue. The Oak Hill Community is economically disadvantaged and have a lack of social capital as described in chapter one. By planting trees with the community a communal respect will grow, and there will be more involvement throughout the community. In order to help with this process, we have arranged a list of recommendations to help with planting trees in The Union Hill Elementary School.

The Worcester Tree Initiative provides environmental educational material as well which will be discussed further in our teaching recommendations section. Here are the steps that should be taken in order to get involved with the Worcester Tree Initiative program:

- Contact Peggy Middaugh of the Worcester Tree Initiative program
- President of the organization, her contact information can be found on the Worcester Tree Initiative website.
- Build a committee of Union Hill staff, Oak Hill CDC staff, and community members to push for the program.
- The environmental and educational benefits of the program should get this off the ground very easily.
- Should incorporate members that will care about the well-being of the trees and the program itself.
- Pick out a site for the tree planting
- An Oak Hill property would be the most feasible to use in this case. An example being the Oak Hill Property lot right down the road from the Union Hill Elementary School on Chaplin St.
- Fill out the application form on the Worcester Tree Initiative website.

Planting trees have many benefits for The Union Hill Elementary School and environment. Trees soak up ground water; this water is then "evapotranspired" from the leaves which cools the leaves and environment around them. A single tree can "evapostranspire" up to 40 gallons of water in a day. If trees are planted in the correct location they can help shade the building from the sun in the summer to decrease cooling costs, also if deciduous trees are planted they will lose their leaves in the winter and allow the sun to heat the building in the winter (Rosenfel, 1997,p. 2). Planting trees would be beneficial to the union hill elementary school. It offsets of energy use and students will learn how to garden and care for plants. Also involving the community in planting the trees at the school gives them more connection to the school which then makes more awareness of the school.

A program that we have recommended to use is the Worcester Tree Initiative, here is what the program incorporates, "The program includes intensive outreach, education and training, and long term tracking to realize significant environmental and quality of life improvements with this community based approach" (Middaugh, 2009). They will provide the community with the materials necessary to plant the trees as well as educational material for the community about how trees are helpful to the environment. This is exactly the type of program the students of Union Hill would get excited about.

As noted previously in our literature review section, beautifying a community can have many psychological and physical effects on a community. By initiating this tree planting program these effects will happen with the community. For example, there is an empty lot that the Oak Hill CDC owns and can utilize with this program that is no less than one-hundred yards away from the school. The opportunity to use the Worcester Tree Initiative program is very likely because of the numerous lots the Oak Hill owns in the area. This program will help develop another green space for the community which has been proven to reduce the crime of an area as well as provide a calm and comforting area for the residents. Involving the community in cleaning their environment helps grow pride throughout the community that grows and volunteering will grow.

If trees are planted in and around the Union Hill Elementary School, it will help with flooding problems, decrease the demand on cooling systems, increase the education for students, and help beautify the community which will help improve Oak Hill as well.

Cleaner streets program.

Our recommendation is to have Union Hill Elementary School hold a town cleanup to show the community the importance and benefits of keeping a clean and safe community for their families.

Beautifying a community will help reduce crime rate as well as bring aesthetic appeal to the members of that community; a street cleaning program will help with this goal. The program will consist of parents, students, and teachers from the community. The more involved we keep the community the greater the possibility that our small recommendations can start the change to make the community better.

In the figure below you can see a picture of the street that Union Hill Elementary school is on and how bad the littering is in this area. In Figure 49 below you can see a picture of the street that Union Hill Elementary school is on and how bad the littering is in this area.

Figure 49. Littering on the sidewalk of Dorchester St.

Now when a community has a lack of aesthetic appeal it is proven to cause a neighborhood decline. A recent study in Florida shows that, "litter has been identified as a major indicator of neighborhood decline and disorder. Other indicators of neighborhood decline and disorder include vandalism, abandoned buildings, graffiti, and vacant lots" (Geers, n.d.). In Figure 50 below, you can see a picture at Union Hill where graffiti is evident right on the schools playground.

Figure 50. Graffiti at the Union Hill Elementary School playground.

Addressing this littering problem can help the community save money as a whole because the cost of cleaning up litter has had an added impact of the economy as well. There are many reasons why a street cleaning program will benefit the community, but to help this cause it is necessary that children begin to learn about litter reduction during school. “It is a better investment to educate litterers out of their habit than to go around just picking up after them” (Florida Litter Study, 1998). This idea is to teach people that casual littering can have a serious impact on the issues that I had discussed earlier and others such as: human health and wild life.

Ways to help educate the Oak Hill Community on litter reduction as well as the students and staff at Union Hill Elementary can be done through the following:

- Integration into school curriculum or after school activities.
- Anti-littering messages on buses, billboards, etc.
- Mass media campaigns on the radio, and/or television.
- Cleanup campaigns that also provide information about how litter, or chemicals from litter, can be harmful to human and wildlife health.

Teaching.

Our recommendation is to have Union Hill Elementary School utilize the outreach programs at their disposal in the Worcester area.

Teaching the children about environmental awareness and changing their behavioral habits is one of the most pertinent goals of this project, here we’ll explain a teaching method and

a few activities that could be used to accomplish that. Non-traditional teaching strategies will be most effective for implementing the green outreach campaign. In an inner-city school, such as Union Hill Elementary, "the problem isn't that their education lacks 'rigor' -- in fact, a single-minded focus on 'raising the bar' has served mostly to push more low-income youths out of school -- but that it lacks depth and relevance and the capacity to engage students" (Poor Teaching for Poor Children…in the Name of Reform, 2011). Figure 2 reinforces this fact because approximately less than 15% of teachers use non-traditional education strategies. Therefore, to better Union Hill's students' environmental consciousness it is best for them to learn through alternative methods.

When looking at non-traditional teaching strategies, two-distinct methods were studied: Active, project-centered instruction and discussion-oriented instruction. Project-centered instruction is the idea that the children will work on a long-term project or a problem with no immediate answer, this de-emphasizes individual schoolwork. Discussion-oriented instruction is a great way to wrap up a project by bringing the class together as a whole to go over what they learned from the project and how it benefited their learning process. The goal of this teaching method is to provide "activities that allow for alternative responses and solutions all contribute to learning" for the children of Union Hill Elementary ("The Pedagogy of Poverty Versus Good Teaching", 1991). We believe non-traditional teaching strategies are the most efficient way to effectively teach the students about environmental consciousness; the Worcester Tree Initiative and Regional Environmental Council are a few of the programs we recommend that will provide this type of education for the students.

As stated previously, part of our recommendations is to implement a community garden and tree planting program for the students at Union Hill Elementary and for the general community. The Worcester Tree Initiative program as well as the Regional Environmental Council provide environmental educational material with each of their programs and are willing to help the Oak Hill Community. When we spoke with S. Brimmage of the REC and P. Middaugh of the Worcester Tree Initiative, they both expressed great interest in the garden and tree build but even more interest in helping educating the community. For example, the REC provides a "Cooking for Youth Program" where they help teach the children about nutritional habits and gardening skills by providing a cooking class that utilizes the produce from the community garden. This can be a perfect afterschool activity for the students at Union Hill

Elementary school, the children will learn about life skills as well as the environment. Another benefit that comes from gardening activities is that students will begin to learn more about science and the environment; thus, they will score higher on science achievement tests. "Third, fourth, and fifth grade students that participated in school gardening activities scored significantly higher on science achievement tests compared to students that did not experience any garden-based learning activities" (Klemmer, 2005). These informal educational methods are exactly what can help Union Hill Elementary get out of being a level 4 school, which is our main concern when it comes to education. We hope that by utilizing these programs that the REC and Worcester Tree Initiative provide we can help improve the environmental consciousness and behavioral habits of the Oak Hill Community; in addition, we believe these programs will help develop students overall education in science as well

Here are more recommendations that are worth looking into adding into the Union Hill Elementary curriculum or to implement in the Oak Hill Community.

- Utilize Worcester Tree Initiative curriculum
  - Follow Initial Instructions in Planting Tree section
  - Educational material and classes about the significance of planting trees
- Utilize Regional Environmental Council curriculum
  - Follow Initial instructions in Community Garden section
- Cooking For Youth Program
- Utilize National Grid Media Learning
  - Energy World Program
    - Found at http://www.ngridenergyworld.com/
    - Multitudes of topics for students to learn about at Union Hill
    - Electrical and Natural Gas Safety
    - Energy Efficiency
    - Energy and Your Environment
- Make available Health Homes homeowner educational material in main office
- After school activities
  - Maintenance of community garden

Longitudinal Studies

Many of our recommendations are based on trying to change the behaviors of the Union Hill Elementary School and the community that surrounds them. In order to see how our changes affect the school and community, longitudinal studies of their behaviors must be conducted. According to the Webster dictionary, a longitudinal study is a research study that involves repeated observations of the same variables over long periods of time. As part of our project, surveys have been completed by our project group on the students, teachers, and families as described in our behavioral audit section. Through these surveys we have created a baseline of the behaviors of the community that can be used to base further longitudinal studies off of, as well as created a pretest to find out which information is important.

With the limited time that we have to complete and collect these surveys, our surveys had to be very basic and with the Oak Hill CDC's help we can compile the information that we collect with theirs to make a better baseline. Mullen Sawyer added to this when he told us, "After your baseline research is completed we can then compile that information with the information that we have collected" (M. Sawyer, Interview, 2011). M. Johnson, an employee of the Oak Hill CDC added to this by saying, "After your project ends we [the Oak Hill CDC] can take over your surveys and track how the recommendations that you made affects the community" (M. Johnson, Interview, 2011). Ultimately, due to the time limits of the project the longitudinal studies cannot be completed by our group so The Oak Hill CDC must have a group to complete these studies for the next few years.

The information gathered from these surveys can prove to be very valuable. From this information gathered in the next few years the Oak Hill CDC can make a decision whether our recommendations were affectively changing the community's behaviors and determine if changes need to be made. Also, the Oak Hill CDC is funded through grants from congress, in order to receive money the Oak Hill CDC needs to show that what they are doing is creating improvement. These longitudinal studies will show qualitatively how effective these recommendations are and ultimately allow the Oak Hill CDC to receive more grant money to help the community. In conclusion, the longitudinal study gives our project meaning. Because of the study our recommendations can be evaluated based on their criteria. If proven to be ineffective the other recommendations that we have listed for the Oak Hill CDC can be looked at

and implemented if they believe their effects will be greater than the ones that our group has chosen. This information helps our project grow and change with the community.

Recommended Implementation Strategy

Through our research and analysis, we have compiled a list of recommendations from our health, behavioral, and energy audit findings. The recommendations above may seem a bit confusing because it is not clear where to start. Because of this, we have split the most important recommendations into three stages. The *first level* recommendations are most feasible to the Oak Hill Community, this is composed of recommendations that are simple, have a low cost, has community involvement, and energy saving opportunities. The *second level* recommendations are higher costing recommendations but have a large payback and opportunity to save money for the school, these recommendations are important to improve Union Hill School. The *third level* are idealistic recommendations, these are recommendations that would be ideal but are unrealistic to implement at Union Hill Elementary School without making major changes.

Table 8. Recommendation implementation strategy.

First Level Recommendations	• Building Envelope
	  ○ Windows and Doors
	  ▪ Repair Broken Panes
	  ▪ Replace old caulking
	  ▪ Install weather-stripping in gaps on doors
	  ▪ Use air conditioner covers in the winter
	  ▪ Utilize natural sunlight whenever possible
	• Outreach
	  ○ Create an environmental council to organize with pre-existing organizations
	  ▪ Worcester Tree Initiative
	  ▪ Regional environmental Council
	  ○ Integration of environmentalism into curriculum
	  ○ Cleaner streets program.
	• Energy Consumption
	  ○ Office Equipment
	  ▪ Reduce time to standby for all office equipment
	  ▪ Utilize pre-existing program to shut off computers at night
	  ○ Lighting
	  ▪ Use signs to inform occupants to
	  • Turn off lights when they leave the room
	  • Use half lights whenever possible
	• Green
	  ○ Recycling
	  ▪ Create an environmental council to organize a recycling campaign
	  • Utilize pre-existing organizations
	  ○ Recycle Now
	  ○ Earth 911
	  ○ Go Green Initiative
	  • Provide educations to students about importance
	  • Create signs to remind people to recycle
	  • Material to send home to importance
	• Water Conservation
	  ▪ Create an environmental council to organize a water conservation plan
	  • Use of signs by sinks to educate
	  • Education in class
	  • Material to send home to parents
	• Health
	  ○ Air Quality Testing
	  ▪ Massachusetts Department of Public Health
	  ○ Further Lead Testing

Second Level Recommendations	• Building Envelope
	  ○ Windows and Doors
	  ▪ Replace all windows and doors
	  • Following our criteria as described in windows and door recommendation section
	• Energy Consumption
	  ○ Lighting
	  ▪ Install Switch banks to allow for lights to be turned on in groups
	  ▪ Install Occupancy Sensors
	  ▪ Install Photo sensors to automatically switch off lights when sunlight is adequate
	  ▪ Increase luminescence of all purpose room
	  • Install florescent lights instead of High Intensity Discharge
	  ▪ Consider fifteen watt LED T8 bulbs
	  ○ Office Equipment
	  ▪ Install automatic switches to shut off network switches at night
	  ○ HVAC
	  ▪ Install Programmable thermostats in the rooms
	  ▪ Reduce temperature by at least ten degrees Fahrenheit at night and on weekends
	  ▪ Replace Boilers in 1890 and 1960 building
	  ▪ Add cooling to all computer labs
	  ▪ Install an Energy Management System
	  • Control all spaces from one local area
	  • Rooms can be controlled separately
	• Water Conservation
	  ○ Install reduced flow nozzles in sinks
	  ○ Install motion detection faucets

Third Level Recommendations	• Energy Consumption
	  ○ Lighting
	  ▪ Install solar tubes in the hallways and classrooms to introduce sunlight
	• Green
	  ○ Solar Power
	  ▪ Install a solar array on the roof to harvest energy from the sun
	  • Make them visible from the ground to promote and inspire environmentalism
	• Building Envelope
	  ○ Roofing
	  ▪ Install a Green Roof
	  ▪ Install a White Roof
	  ▪ Install a combination of both a Green and White Roof

If any of the recommendations above are implemented, they will have a large impact on the Union Hill Elementary School. We believe that the recommendations with no cost should be implemented as soon as possible and the recommendations with cost can be evaluated to determine the financial feasibility of performing them. The implementation of the National Grid Incentives Program helps offset the cost for these recommendations to allow for them to be implemented faster and with more ease therefore this is our greatest recommendation for Union Hill Elementary School. We do not expect these recommendations to solve all of the problems in The Union Hill Elementary School and Oak Hill Community, but we believe that they are stepping stones to introduce the ideas of environmentalism and ultimately begin a movement towards becoming more environmentally conscious.

Chapter Seven
Conclusion

The Oak Hill Community suffers from a number of economic and community challenges, which manifest themselves in a high poverty rate, high mobility rate, and low employment. These issues cause residents to struggle every day; thus, they may not have time to pay attention to all of the health and environmental advantages that are possible. The residents of the Oak Hill Community are not aware of the benefits of being 'greener' and conserving energy because they do not partake in efforts to become greener and conserve energy in their daily life, because they are focused on their daily financial, health, and crime problems. The goal of this project is to begin to show the students of the Union Hill Elementary School how to be environmentally conscious and ultimately have the students begin to show the residents of the community how they can be environmentally conscious as well. This project is simply a stepping stone towards fixing these problems, it will help focus the school and community in the correct direction.

In order for this to happen we performed an energy, health assessment, and behavioral assessment. We took the data collected from these assessments to help formulate recommendations in order to increase the environmental consciousness of the students and ultimately the community as a whole. The energy assessment helped us find areas of the school which needed the most improvement to save money on heating and electric bills. Not only to save money but to reduce the demand for electricity of the school to help limit the demand on power plants to produce more energy. We used the health assessment to evaluate the current condition of health in the Union Hill Elementary School. This is important because students and staff spend up to 8 hours a day in the building. The buildings effects can have a large impact on the health of the staff and students. We then created recommendations in order to help improve the areas in the school that could have a negative effect on the health. Finally the behavioral audit was helpful by allowing us to create a profile in which we found areas where the staff, students, and parents were lacking knowledge. We created recommendations in order to help educate the staff, students, and parents on ways that they can be environmentally friendly. These recommendations will not be able to explicitly solve these problems, but they will form a foundation to begin working on these issues.

The next step for the Union Hill Elementary School to take is to form and environmental council in the Union Hill School comprised of staff, students, and parents in order to facilitate

these changes and to interact with the outreach programs that we have identified in our recommendations section. The council should have defined meeting times at least twice a month. This council will allow the teachers, parents, and students to address environmental problems as they arise in the school. This council will also allow the people involved to have a sense of pride in their school and community. This is what will ultimately give these recommendations the backing that they need to become implemented.

The next step for the Oak Hill Community Development Corporation to take is to continue the longitudinal study which is comprised of constantly interacting with the staff, students, and teachers in order to report the areas of improvement. This can be done through surveys that are given to the staff, students, and teachers. This information will make it easier to show improvement within the school and this will ultimately make it easier to apply for grants as well as identify areas in which more improvements can be made.

We hope our recommendations help the Union Hill Elementary School to become a role model for the community. In order to show the Oak Hill Community ways that they too can help preserve the environment by being environmentally conscious. We also hope that when the Union Hill Elementary School makes the effort to become a more environmentally conscious environment, that this will facilitate a better learning environment for both teachers and students.

We have found many areas in which the Union Hill Elementary School could use improvement. Unfortunately, due to the time constraints and the complexity of our project, we were not able to study these areas in as much detail that we wanted to. We would like to suggest these topics to be used for future Interactive Qualifying Projects.

- Research into the feasibility of installing a Green Roof on top of the Union Hill Building
- Perform a study to decide the best ways to utilize sunlight inside the school
- Create teaching material that increases the science education of the students in the Union Hill Elementary School
- Focus on continuing the longitudinal study that we have begun
- Perform further research into other outreach programs that could help Union Hill
- Create education material that will incorporate environmentalism into the curriculum

From the scope of these suggested projects, it can be seen that there are still many areas that could be worked on within the Union Hill Elementary School and Oak Hill Community. We hope that through our recommendations and extension projects, the quality of life for the Oak Hill Community will be improved.

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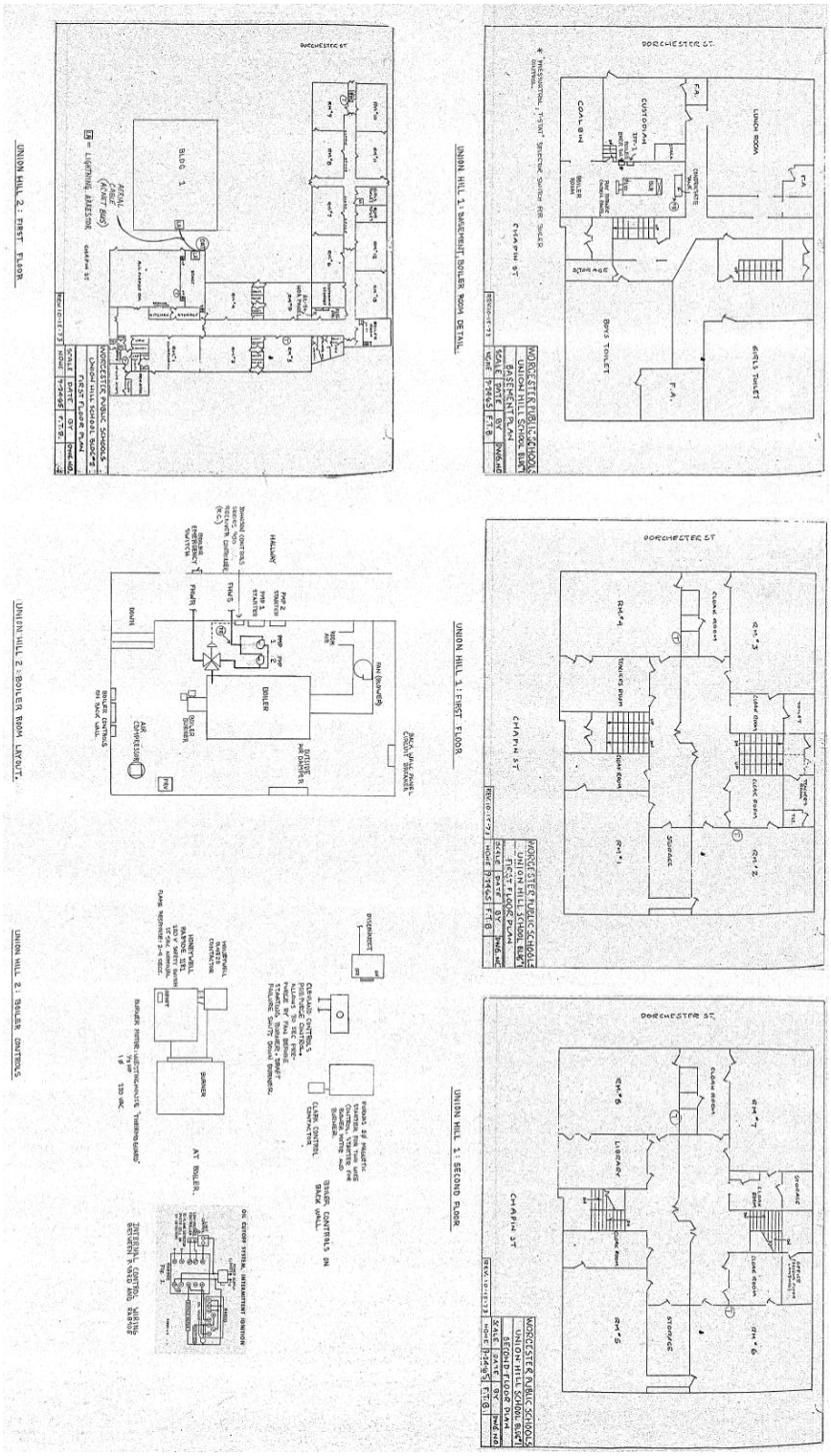
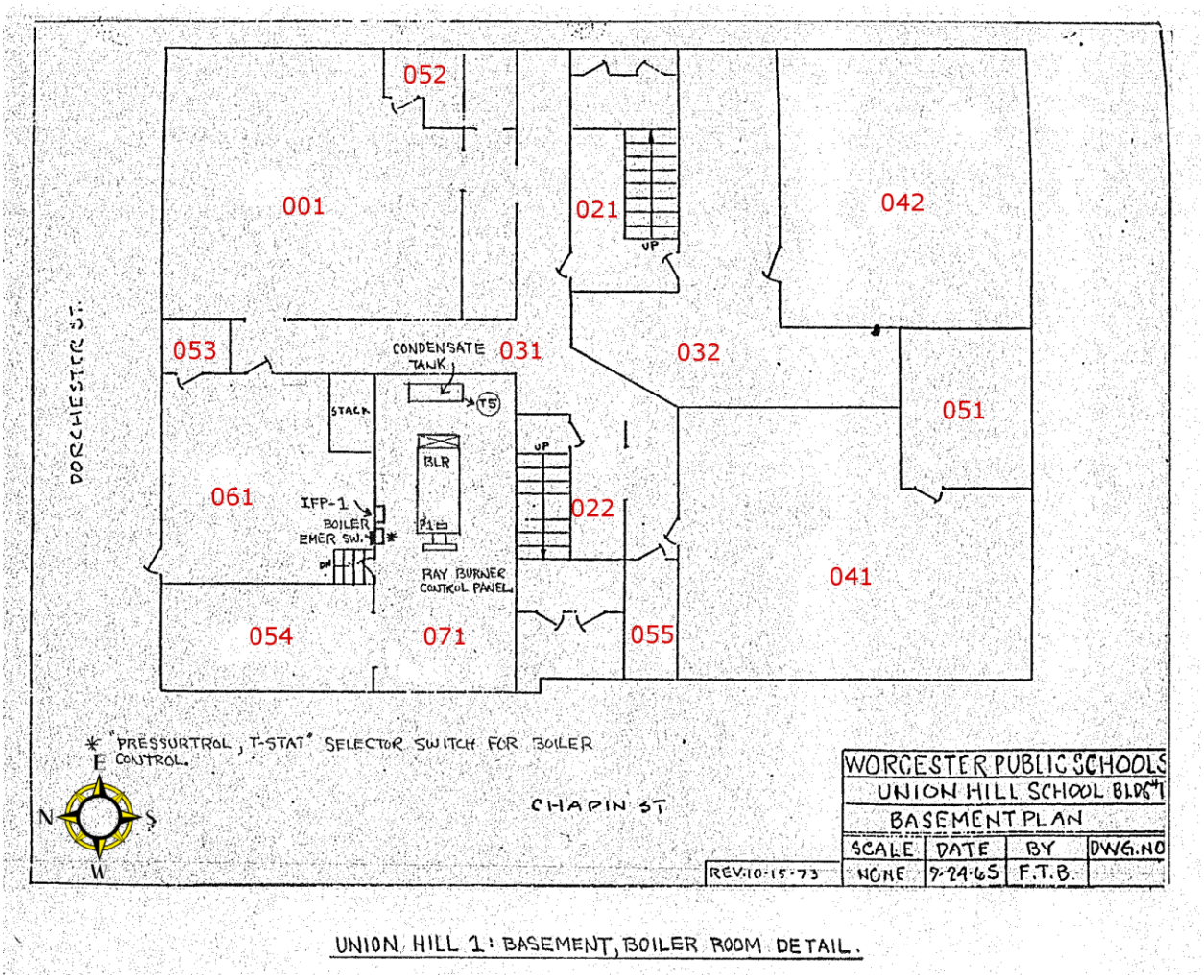
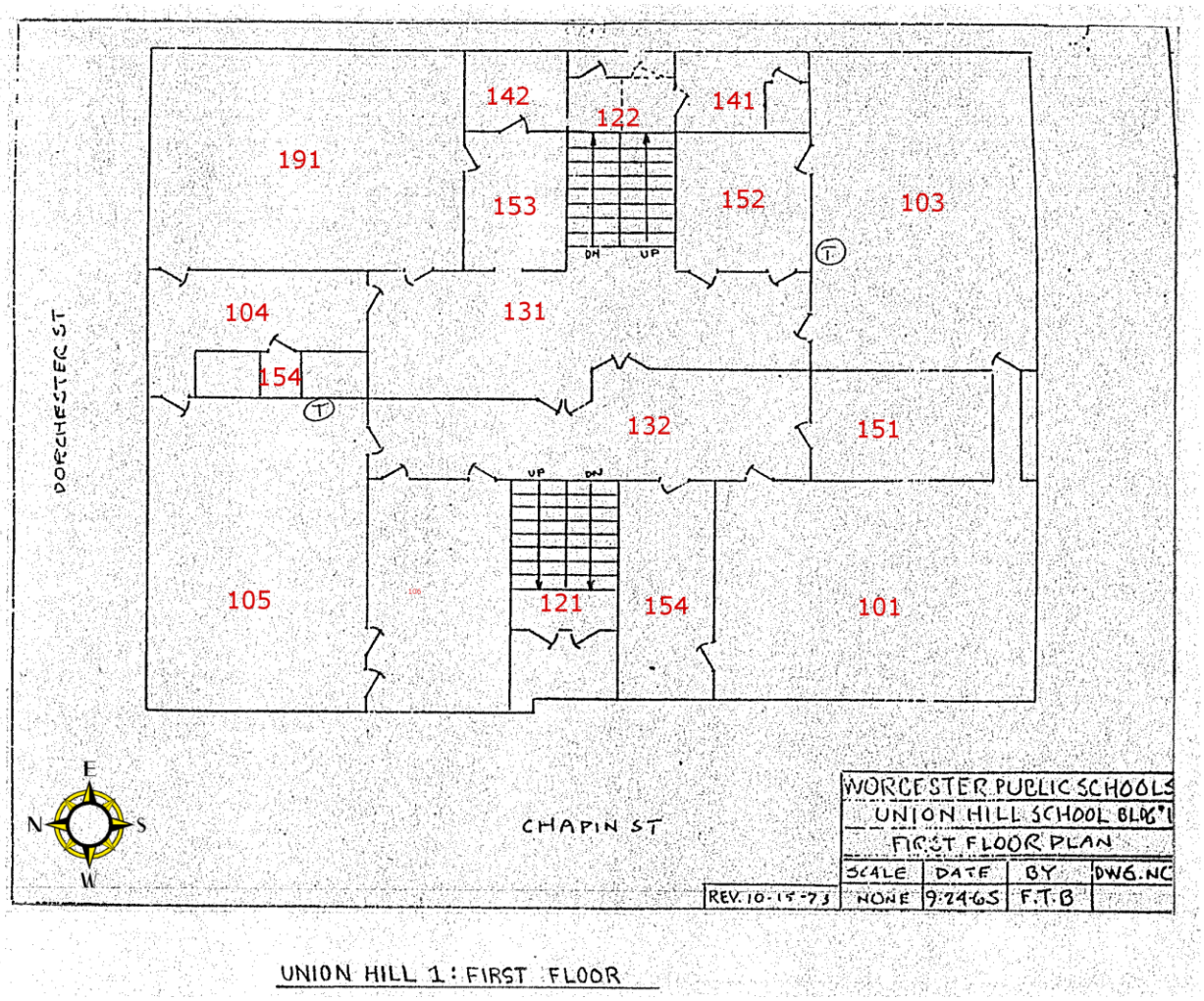
Appendix

APPENDIX A – Union Hill Elementary Building Schematics

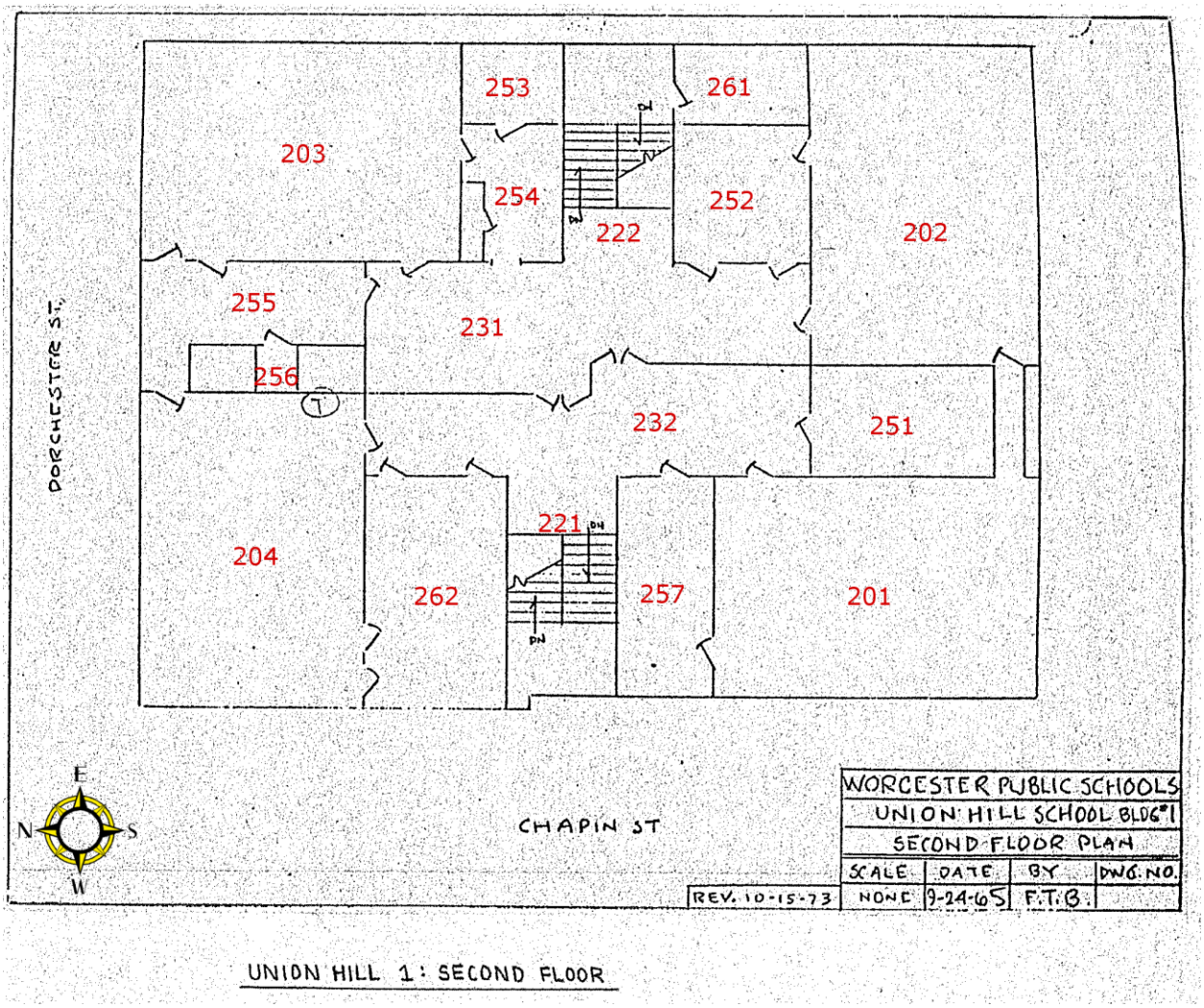




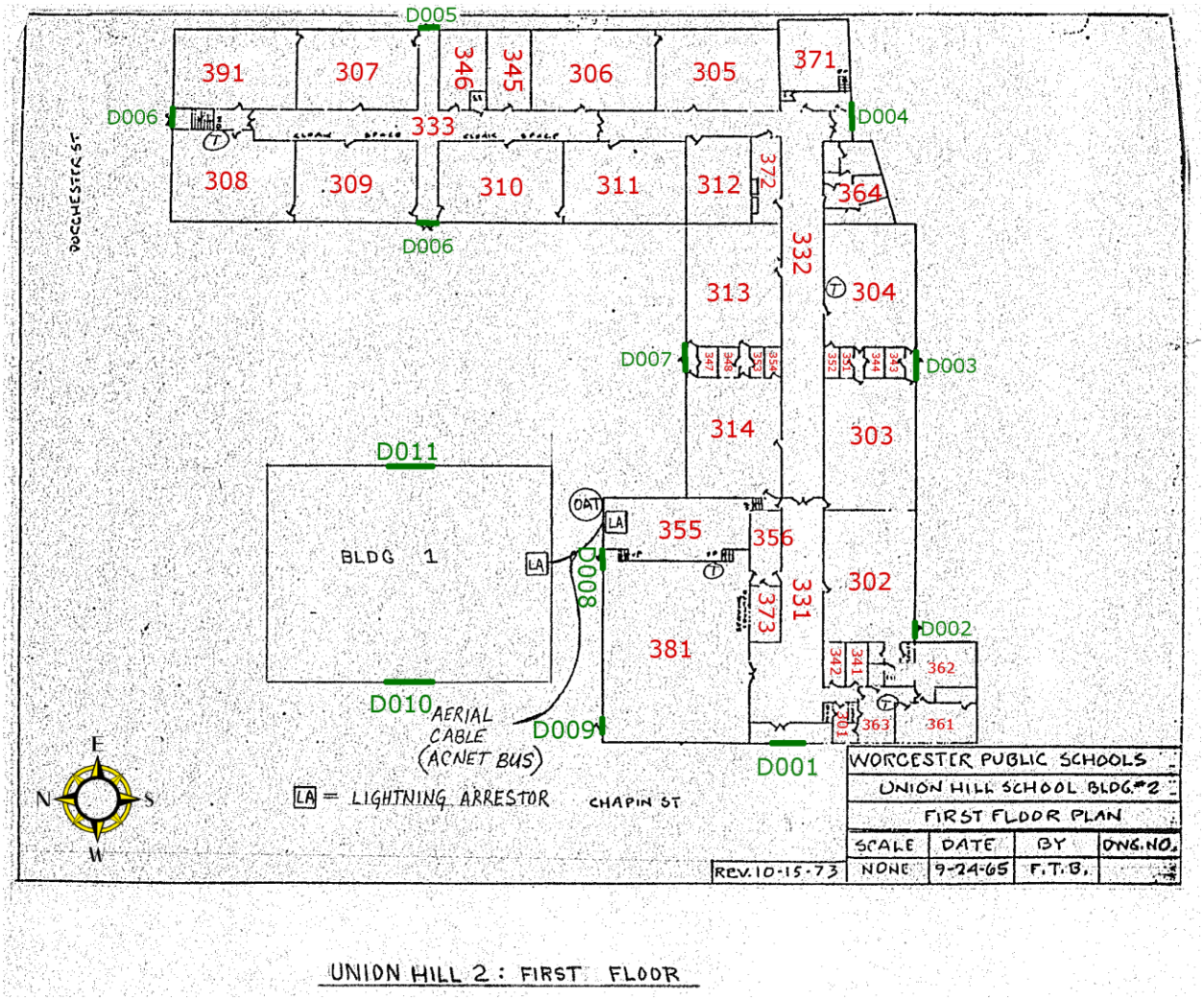
UNION HILL 1: BASEMENT, BOILER ROOM DETAIL.



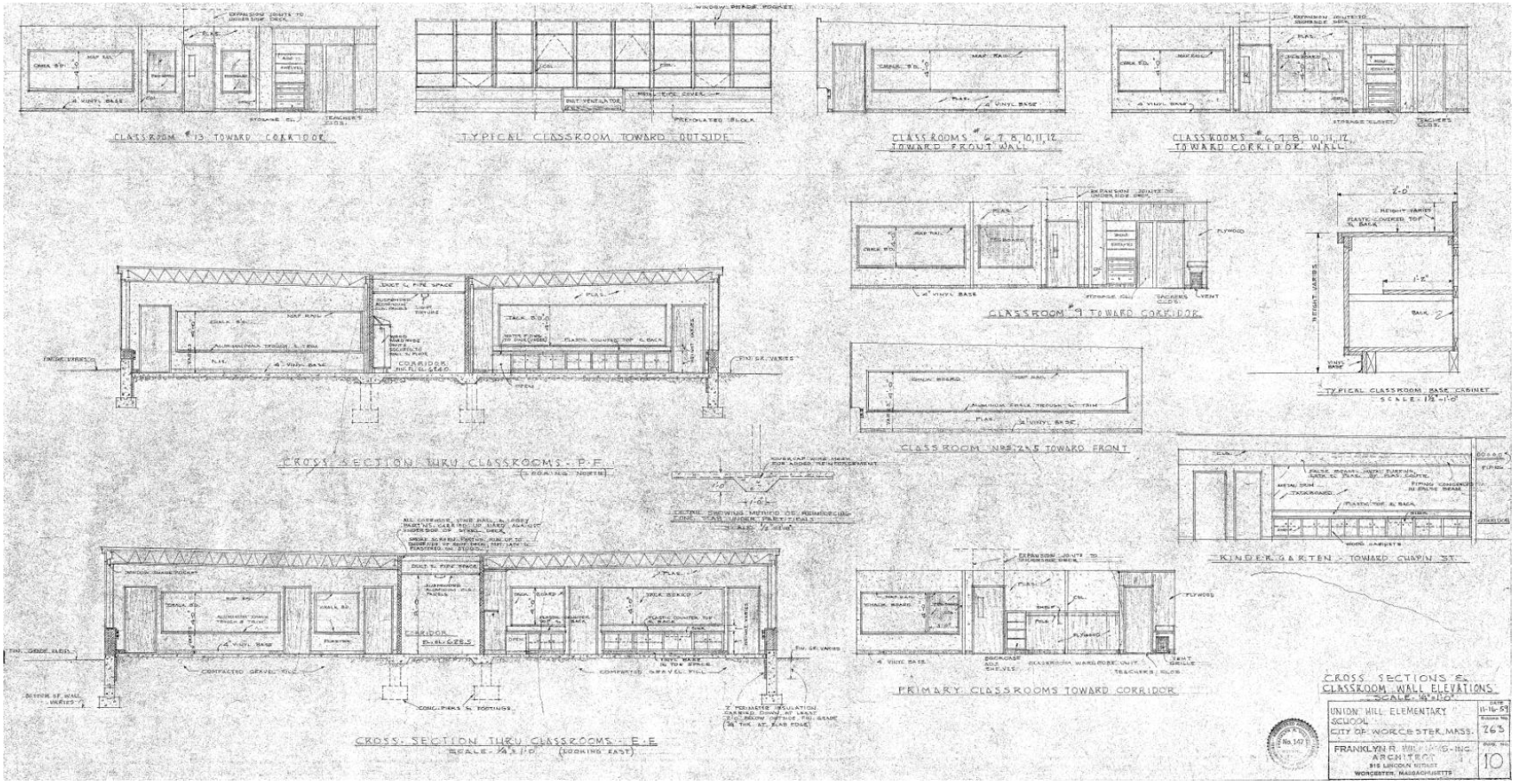
UNION HILL 1: FIRST FLOOR

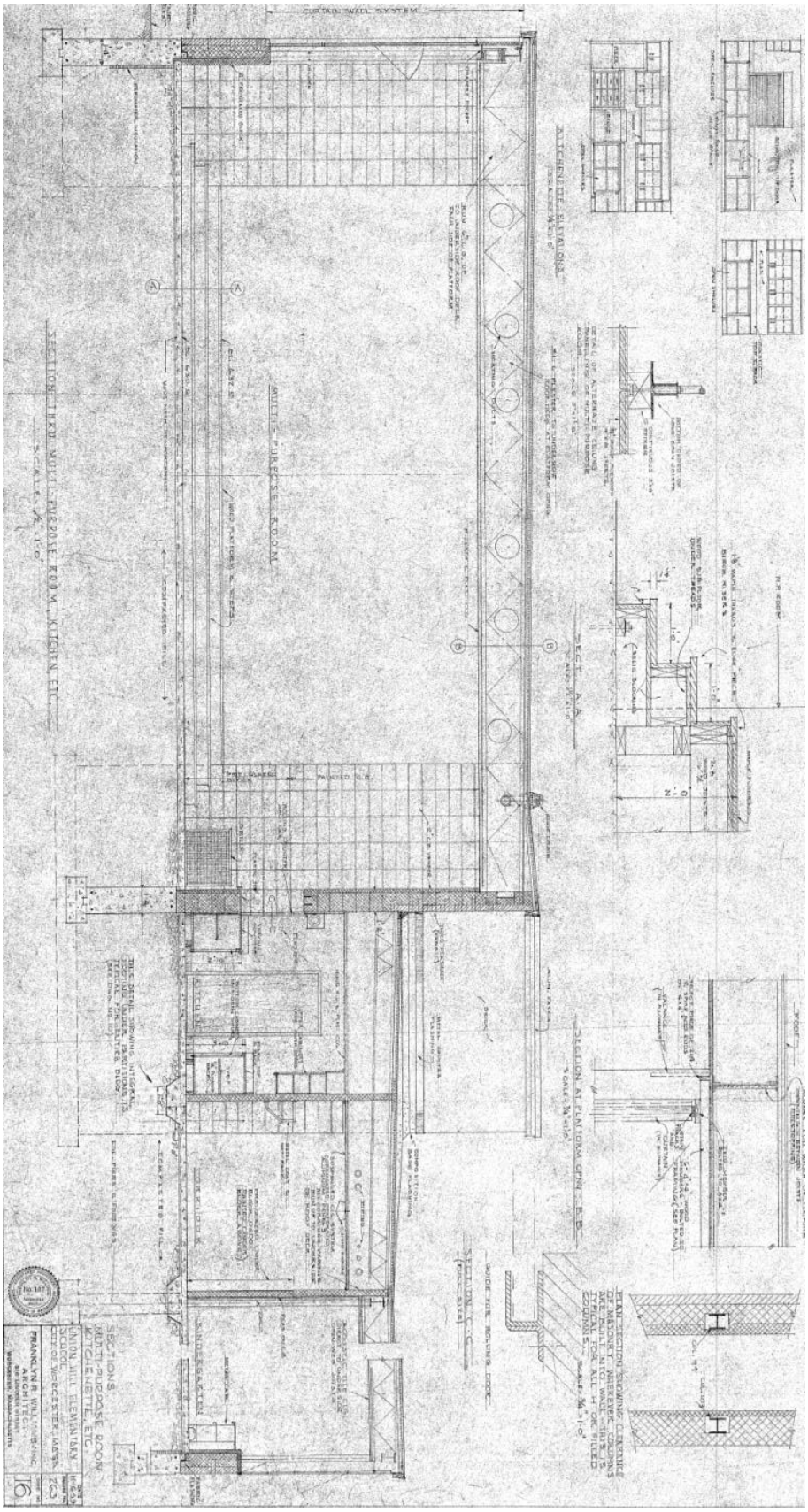


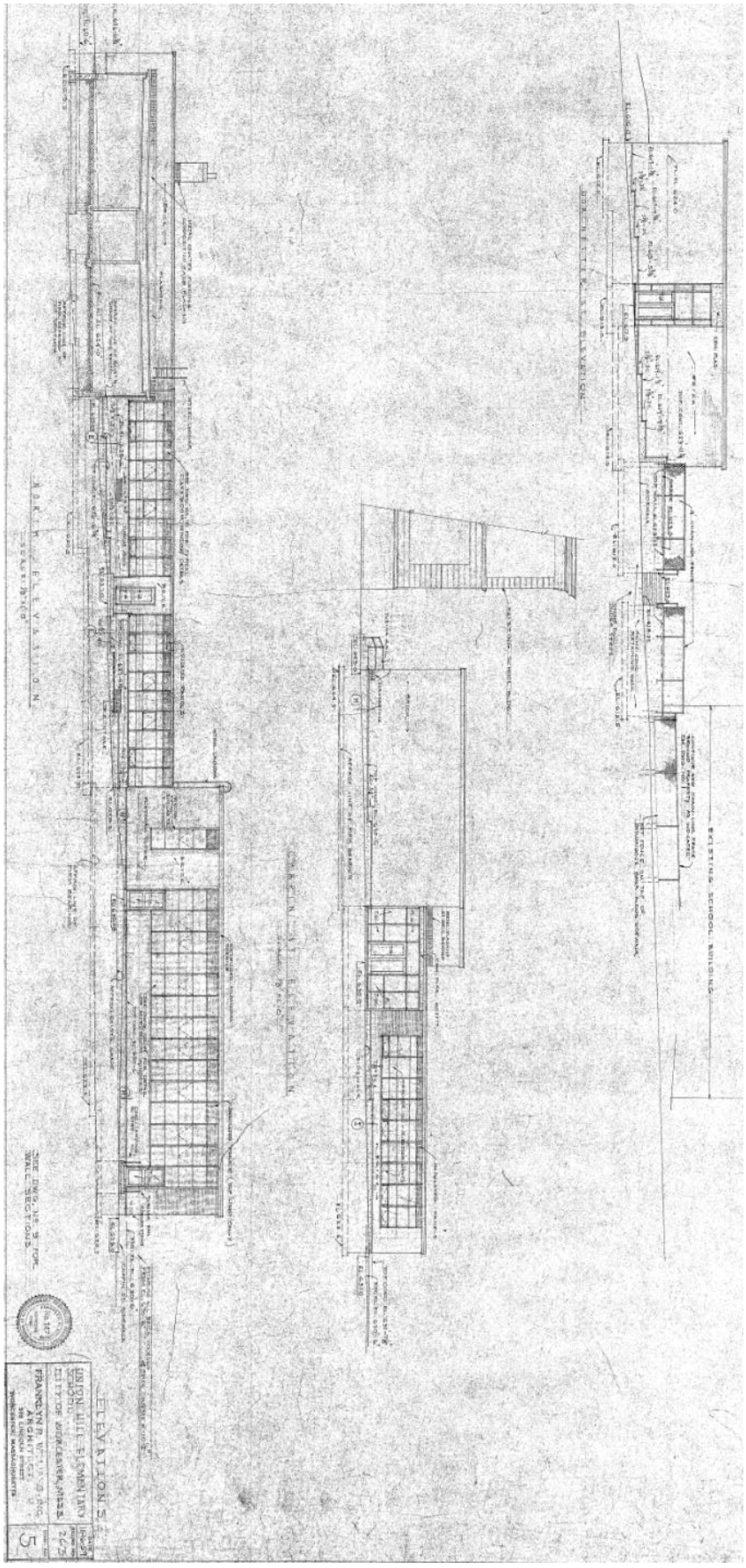
UNION HILL 1: SECOND FLOOR

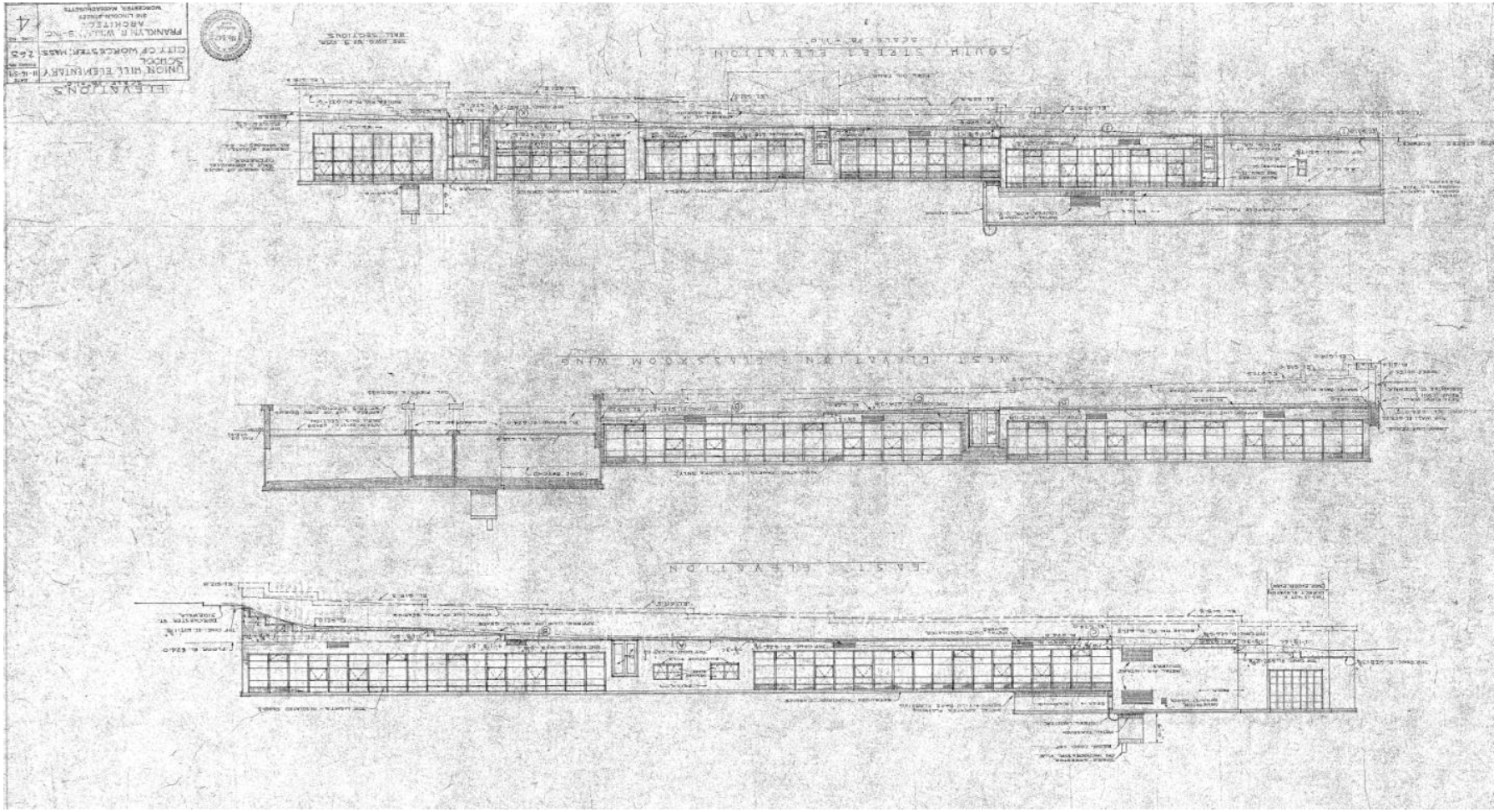


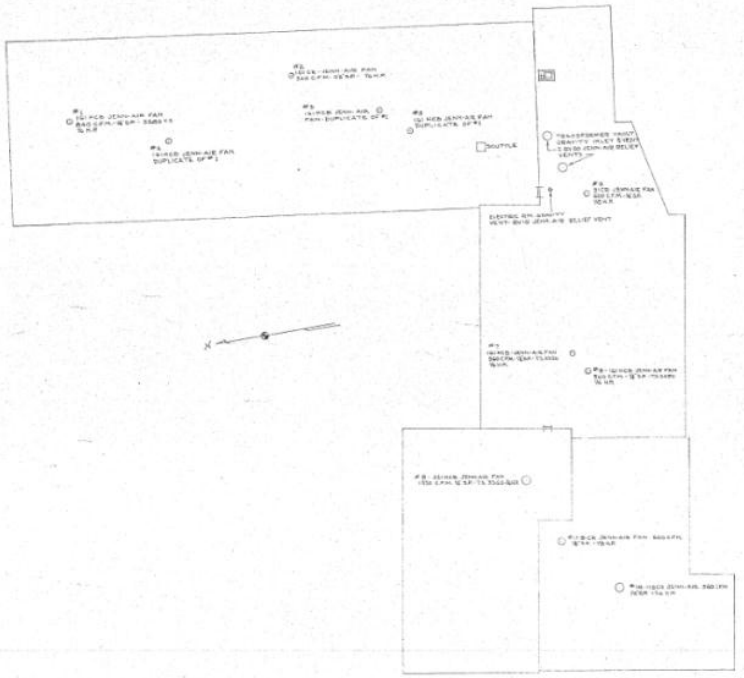
UNION HILL 2 : FIRST FLOOR


CLASSROOM #13 TOWARD CORRIDOR
TYPICAL CLASSROOM TOWARD OUTSIDE
CLASSROOMS #6, 7, 8, 10, 11, 12 TOWARD FRONT WALL
CLASSROOMS #6, 7, 8, 10, 11, 12 TOWARD CORRIDOR WALL
CLASSROOM #9 TOWARD CORRIDOR
TYPICAL CLASSROOM BASE CABINET
SCALE: 1½"=1'-0"
CROSS SECTION THRU CLASSROOMS - P-F
CLASSROOMS #2, 4, 5 TOWARD FRONT
KINDERGARTEN - TOWARD CHAPIN ST.
CROSS SECTION THRU CLASSROOMS - E-E
SCALE: 1/8"=1'-0" (LOOKING EAST)
PRIMARY CLASSROOMS TOWARD CORRIDOR
CROSS SECTIONS & CLASSROOM WALL ELEVATIONS
SCALE: AS NOTED
UNION HILL ELEMENTARY SCHOOL
CITY OF WORCESTER, MASS.
11-14-57
763
10
FRANKLYN R. WILKINS-ING. ARCHITECT
515 LINCOLN SQUARE
WORCESTER, MASSACHUSETTS

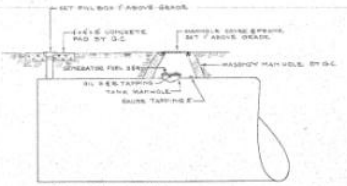

SECTION THRU MULTI-PURPOSE ROOM, KITCHEN, ETC.
SCALE 1/4"=1'0"
MULTI-PURPOSE ROOM
CURTAIN WALL SYSTEM
ALTERNATE ELEVATIONS
SECT. A-A
SECTION AT PLATFORM OPEN - B-B
SECTION C-C
SECTIONS
MULTI-PURPOSE ROOM
KITCHENETTE, ETC.
UNION HILL ELEMENTARY
SCHOOL
WORCESTER, MASS.
FRANKLYN R. WILLIAMS INC
ARCHITECT
WORCESTER, MASSACHUSETTS
16


ELEVATIONS
UNION HILL ELEMENTARY SCHOOL
CITY OF WORCESTER, MASS.
FRANKLYN R. WILLIAMS, INC.
ARCHITECT
5
EXISTING SCHOOL BUILDING

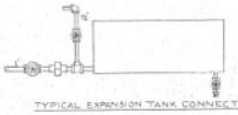




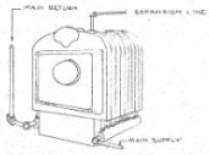
ROOF PLAN
SCALE: 1/8" = 1'-0"



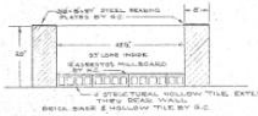
OIL TANK DETAIL
3/4" = 1'-0"



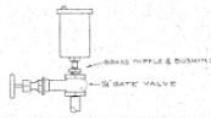
TYPICAL EXPANSION TANK CONNECTION



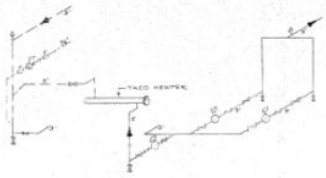
BOILER CONNECTION DETAIL



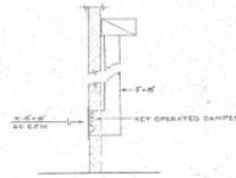
BASE DETAIL FOR "MILLS" BOILER
3/4" = 1'-0"



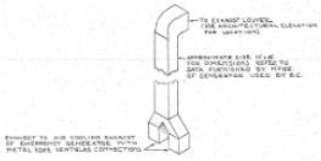
TYPICAL AUTOMATIC VENT DETAIL



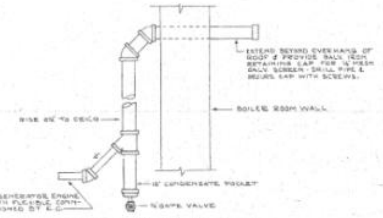
BOILER ROOM PIPING DETAIL



TYPICAL TOILET EXHAUST DETAIL
3/4" = 1'-0"



DETAIL OF GENERATOR AIR COOLING EXHAUST DUCT



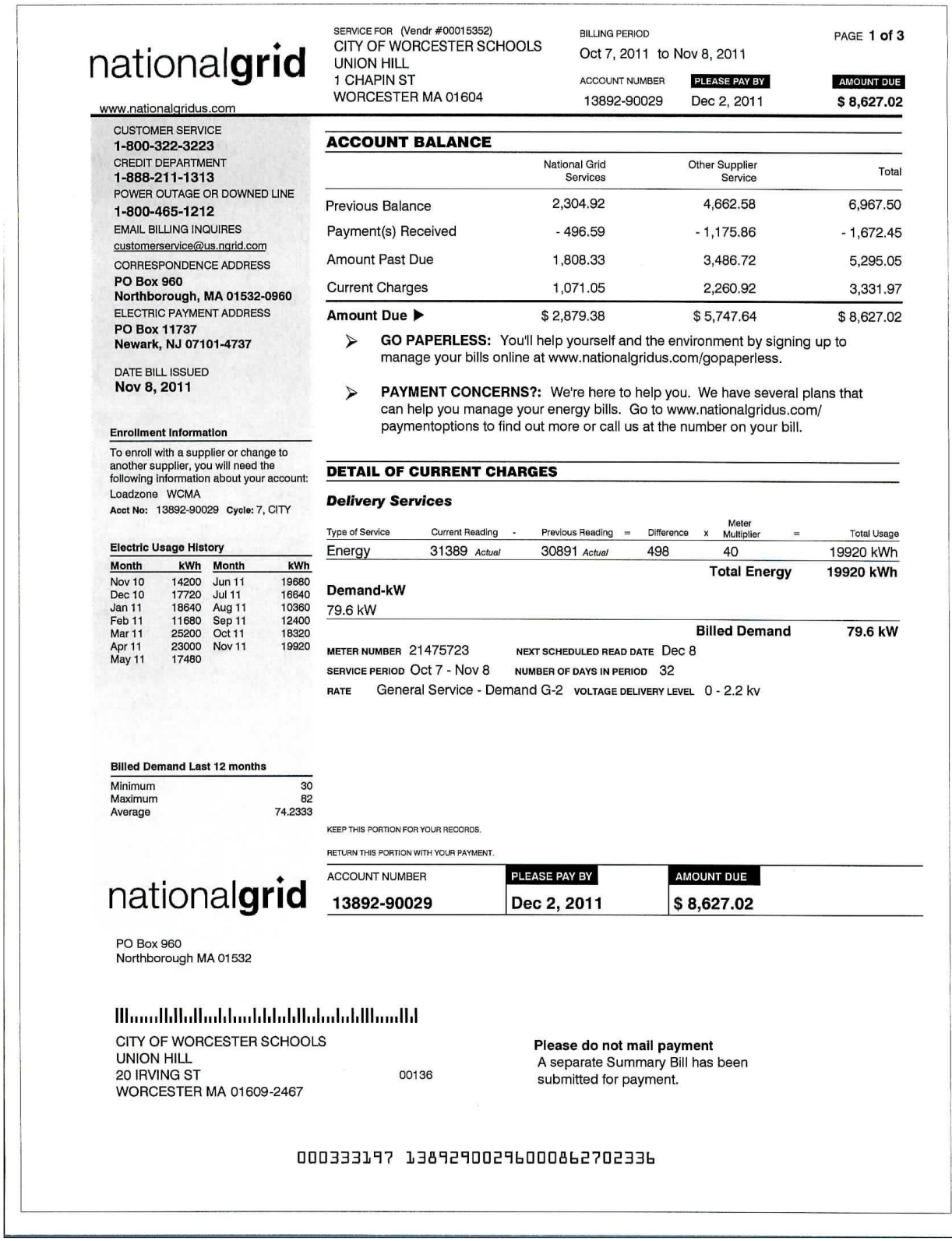
EMERGENCY GENERATOR ENGINE EXHAUST DETAIL

APPENDIX B – Utility Assessment - Energy Usage

Electricity Usage By Kilowatt for Union Hill School

AcctNum	School	Fiscal Yr	Month	ReadDate	ReadDays	TotalkWh	UtilityCharges	SupplierCharges	TotalCharges	MeteredPeakkW	MeteredOnPeakkW
1389290029	Union Hill	2012	September	9/8/2011	31	12400	$795.63	$1,407.40	$2,203.03	70	70
1389290029	Union Hill	2012	August	8/8/2011	32	10360	$496.59	$1,175.86	$1,672.45	30	30
1389290029	Union Hill	2012	July	7/7/2011	31	16640	$961.65	$1,888.64	$2,850.29	77.2	77.2
1389290029	Union Hill	2011	June	6/6/2011	31	19680	$1,064.10	$2,233.68	$3,297.78	79.6	79.6
1389290029	Union Hill	2011	May	5/6/2011	28	17480	$941.33	$1,983.98	$2,925.31	78	78
1389290029	Union Hill	2011	April	4/8/2011	31	23000	$1,084.64	$2,610.50	$3,695.14	80.8	80.8
1389290029	Union Hill	2011	March	3/8/2011	33	25200	$1,131.38	$2,860.20	$3,991.58	78.4	78.4
1389290029	Union Hill	2011	February	2/3/2011	27	11680	$788.84	$1,325.68	$2,114.52	78.8	78.8
1389290029	Union Hill	2011	January	1/7/2011	30	18640	$1,021.92	$2,115.64	$3,137.56	82	82
1389290029	Union Hill	2011	December	12/8/2010	33	17720	$987.65	$2,011.22	$2,998.87	78.8	78.8
1389290029	Union Hill	2011	November	11/5/2010	28	14200	$907.53	$1,611.70	$2,519.23	82	82
1389290029	Union Hill	2011	October	10/8/2010	30	15200	$918.74	$1,741.67	$2,660.41	79.2	79.2
1389290029	Union Hill	2011	September	9/8/2010	29	9040	$647.29	$1,066.72	$1,714.01	62.8	62.8
1389290029	Union Hill	2011	August	8/10/2010	33	6680	$381.81	$788.24	$1,170.05	29.6	29.6
1389290029	Union Hill	2011	July	7/8/2010	31	8840	$636.87	$1,043.12	$1,679.99	62	62
1389290029	Union Hill	2010	June	6/7/2010	28	10600	$743.91	$1,250.80	$1,994.71	71.6	71.6
1389290029	Union Hill	2010	May	5/10/2010	31	11640	$739.90	$1,373.52	$2,113.42	68.4	68.4
1389290029	Union Hill	2010	April	4/9/2010	29	12160	$761.29	$1,434.88	$2,196.17	70.8	70.8
1389290029	Union Hill	2010	March	3/11/2010	34	12600	$777.74	$1,486.80	$2,264.54	74.4	74.4
1389290029	Union Hill	2010	February	2/5/2010	28	12120	$746.14	$1,430.16	$2,176.30	78.8	78.8
1389290029	Union Hill	2010	January	1/8/2010	31	11600	$717.87	$1,368.80	$2,086.67	74.4	74.4
1389290029	Union Hill	2010	December	12/8/2009	33	11800	$727.72	$1,392.40	$2,120.12	74.4	74.4
1389290029	Union Hill	2010	November	11/5/2009	29	10720	$707.05	$1,264.96	$1,972.01	74.4	74.4
1389290029	Union Hill	2010	October	10/7/2009	29	10120	$672.08	$1,194.16	$1,866.24	70.8	70.8

APPENDIX C – Utility Assessment - Sample Energy Bill



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www.nationalgridus.com

SERVICE FOR (Vendr #00015352)
CITY OF WORCESTER SCHOOLS
UNION HILL
1 CHAPIN ST
WORCESTER MA 01604

BILLING PERIOD
Oct 7, 2011 to Nov 8, 2011

PAGE 1 of 3

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
13892-90029	Dec 2, 2011	$ 8,627.02

CUSTOMER SERVICE
1-800-322-3223
CREDIT DEPARTMENT
1-888-211-1313
POWER OUTAGE OR DOWNED LINE
1-800-465-1212
EMAIL BILLING INQUIRES
customerservice@us.ngrid.com
CORRESPONDENCE ADDRESS
PO Box 960
Northborough, MA 01532-0960
ELECTRIC PAYMENT ADDRESS
PO Box 11737
Newark, NJ 07101-4737

DATE BILL ISSUED
Nov 8, 2011

Enrollment Information

To enroll with a supplier or change to another supplier, you will need the following information about your account:
Loadzone WCMA
Acct No: 13892-90029 **Cycle:** 7, CITY

Electric Usage History

Month	kWh	Month	kWh
Nov 10	14200	Jun 11	19680
Dec 10	17720	Jul 11	16640
Jan 11	18640	Aug 11	10360
Feb 11	11680	Sep 11	12400
Mar 11	25200	Oct 11	18320
Apr 11	23000	Nov 11	19920
May 11	17480		

Billed Demand Last 12 months

Minimum	30
Maximum	82
Average	74.2333

ACCOUNT BALANCE

	National Grid Services	Other Supplier Service	Total
Previous Balance	2,304.92	4,662.58	6,967.50
Payment(s) Received	- 496.59	- 1,175.86	- 1,672.45
Amount Past Due	1,808.33	3,486.72	5,295.05
Current Charges	1,071.05	2,260.92	3,331.97
Amount Due ▶	$ 2,879.38	$ 5,747.64	$ 8,627.02

➢ **GO PAPERLESS:** You'll help yourself and the environment by signing up to manage your bills online at www.nationalgridus.com/gopaperless.

➢ **PAYMENT CONCERNS?:** We're here to help you. We have several plans that can help you manage your energy bills. Go to www.nationalgridus.com/paymentoptions to find out more or call us at the number on your bill.

DETAIL OF CURRENT CHARGES

Delivery Services

Type of Service	Current Reading	-	Previous Reading	=	Difference	x	Meter Multiplier	=	Total Usage
Energy	31389 *Actual*		30891 *Actual*		498		40		19920 kWh
							Total Energy		**19920 kWh**

Demand-kW
79.6 kW

Billed Demand **79.6 kW**

METER NUMBER 21475723 NEXT SCHEDULED READ DATE Dec 8
SERVICE PERIOD Oct 7 - Nov 8 NUMBER OF DAYS IN PERIOD 32
RATE General Service - Demand G-2 VOLTAGE DELIVERY LEVEL 0 - 2.2 kv

KEEP THIS PORTION FOR YOUR RECORDS.

RETURN THIS PORTION WITH YOUR PAYMENT.

nationalgrid

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
13892-90029	**Dec 2, 2011**	**$ 8,627.02**

PO Box 960
Northborough MA 01532

CITY OF WORCESTER SCHOOLS
UNION HILL
20 IRVING ST
WORCESTER MA 01609-2467

00136

Please do not mail payment
A separate Summary Bill has been submitted for payment.

000333197 13892900296000862702336

nationalgrid

SERVICE FOR (Vendr #00015352)
CITY OF WORCESTER SCHOOLS
UNION HILL
1 CHAPIN ST
WORCESTER MA 01604

BILLING PERIOD
Oct 7, 2011 to Nov 8, 2011

ACCOUNT NUMBER	PLEASE PAY BY	AMOUNT DUE
13892-90029	Dec 2, 2011	$ 8,627.02

Customer Charge		16.56
Distribution Charge	0.00451 x 19920 kWh	89.85
Transition Charge	0.00006 x 19920 kWh	1.19
Transmission Charge	0.01609 x 19920 kWh	320.51
Distribution Demand Chg	6 x 79.6 kW	477.60
Energy Efficiency Chg	0.0078 x 19920 kWh	155.38
Renewable Energy Chg	0.0005 x 19920 kWh	9.96
	Total Delivery Services	**$ 1,071.05**

Explanation of General Billing Terms

KWH: Kilowatt-hour, a basic unit of electricity used.
Off-Peak: Period of time when the need or demand for electricity on the Company's system is low, such as late evenings, weekends and holidays.
Peak: Period of time when the need or demand for electricity on the Company's system is high, normally during the day, Monday through Friday, excluding holidays.
Estimated Bill: A bill which is calculated based on your typical monthly usage rather than on an actual meter reading. It is usually rendered when we are unable to read your meter.
Meter Multiplier: A number by which the usage on certain meters must be multiplied by to obtain the total usage.
Demand Charge: The cost of providing electrical transmission and distribution equipment to accommodate your largest electrical load.

Supplier Service Charges are comprised of:

Generation Charge: The charge(s) to provide electricity and other services to the customer by a supplier.

Delivery Service Charges are comprised of:

Customer Charge: The cost of providing customer related service such as metering, meter reading and billing. These fixed costs are unaffected by the actual amount of electricity you use.
Distribution Charge: The cost of delivering electricity from the beginning of the Company's distribution system to your home or business.
Transition Charge: Company payments to its wholesale supplier for terminating its wholesale arrangements.
Transmission Charge: The cost of delivering electricity from the generation company to the beginning of the Company's distribution system.

Energy Efficiency Charge: The cost of energy efficiency program services offered by the Company.
Renewable Energy Charge: A charge to fund initiatives for communicating the benefits of renewable energy and fostering formation, growth, expansion and retention of renewable energy and related enterprises.

Questions:
If you have questions or complaints regarding this bill or National Grid's service quality, please contact Customer Service at 1-800-322-3223. You may also contact the Massachusetts Department of Public Utilities, Consumer Division at 617-737-2836 or toll free at 1-877-886-5066 or web site www.mass.gov/dpu.

nationalgrid

www.nationalgridus.com

SERVICE FOR (Vendr #00015352)
CITY OF WORCESTER SCHOOLS
UNION HILL
1 CHAPIN ST
WORCESTER MA 01604

BILLING PERIOD
Oct 7, 2011 to Nov 8, 2011

ACCOUNT NUMBER
13892-90029

PLEASE PAY BY
Dec 2, 2011

AMOUNT DUE
$ 8,627.02

Supply Services

SUPPLIER ConEdison Solutions
100 Summit Lake Drive
Valhalla, NY 10595

PHONE 1-866-469-4362 ACCOUNT NO 438050

Electricity Supply	0.1135 x 19920 kWh	2,260.92

Please be advised that your local municipality may require ConEdision Solutions to apply and collect a Gross Receipts Tax for our electric supply charges. If so, your next invoice will contain a line item for this charge.

Total Supply Services **$ 2,260.92**

APPENDIX D – Utility Assessment - Oil Usage

Heating Fuel Oil Usage By Gallons for Union Hill School

Fiscal Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total Gallons	Avg Price	Est. Cost
2010						8,949.4	3,000.2	3,020.1					14,969.7	$2.16	$32,335
2011					7,511.5	7,000.5	3,999.6	2,996.0	4,533.7	2,509.8	1,064.0		29,615.1	$2.94	$87,068

APPENDIX E – Utility Assessment - sample oil bill

Dennis K Burke, Inc

P.O.Box 3639
Boston, Ma 02241-3639
Ph (800) 289 2875 * Fx (617) 884 7638

Original Invoice
Page 1

Invoice No: 000973788
Order No: 094767500
Purchase Order No: 0
Bill of Lading No: 1036779

Invoice Date: 04/11/2011
Load Date: 04/11/2011
Reference No: 0
Shipped Via: CUSTOMER PICKUP

Bill To: WORC20
WORCESTER PUBLIC SCHOOLS
BUSINESS OFFICE
20 IRVING ST.
WORCESTER, MA 01608

Ship To: WORC20
UNION HILL 1
1 CHAPIN
WORCESTER, MA 000000000

Product	Description	Price	Order Qty	Ship Qty	Extended Price
01H BK	#2 HEATING OIL	3.4797	60.00	60.00	$208.78
	DYED UNMARKED HEATING OIL:NOT FOR USE IN HIGHWAY, LOCOMOTIVEOR MARINE ENGINES				
FDDSE	EXEMPT FED. DIESEL TAX	0.000		60.00	$0.00
FDSFE	NO FEDERAL OIL SPILL TAX	0.000		60.00	$0.00
MADSE	EXEMPT MASS. DIESEL TAX	0.000		60.00	$0.00
MASTE	EXEMPT MASS SALES TAX	0.000 %		208.78	$0.00
MAURPE	MA UNIFORM RESP & PREV EXEMPT	0.000		60.00	$0.00
MAUSTE	MA. CLEAN-UP FEE EXEMPT	0.000		60.00	$0.00
NORAE	EXEMPT NORA ASSOC FEE	0.000		60.00	$0.00

Date Due: 04/26/2011 — Invoice Total: $208.78

APPENDIX F – Case Study Methodology and Table

First, we organized every room into a category based upon its use. A numbering system was used for all of the rooms to define their location and use shown below.

Room Classification	Room Numbers 1890	Room Numbers 1960	Minimum Ft-Candles
Auditorium		381	30
Classroom	001, 101, 102, 103, 104, 105, 201, 202, 203, 204	301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314	30
Laboratory	191	391	30
Office	061, 261, 262	361, 362, 363, 364	30-50
Hallway	031, 032, 131, 132, 231, 232	331, 332, 333, 334	10
Bathroom	041, 042, 141, 142	341, 342, 343, 344, 345, 346, 347, 348	10
Closet or Storage Room	051, 052, 053, 054, 055, 151, 152, 153, 154, 251, 252, 253, 254, 255, 256, 257	351, 352, 353, 354, 355, 356	10
Stairwell	021, 022, 121, 122, 221, 222		10
Utilities	071	371, 372, 373	10

black: significant energy use
red: negligible energy use

Total Rooms: **86**
Audited Rooms: **19**

The first number indicates the building, zero, one, and two are the basement, first, and second floors of the 1890 building, and three is the entire single story 1960 building. The second number indicates its use, zero and one indicate a classroom, two indicates a stairwell, three indicates a hallway, four indicates a bathroom, five indicates a storage room, six indicates an office, seven indicates a utility room, eight indicates a multipurpose room, and nine indicates a computer lab.

We wanted to perform our assessments on one room from each category as well as from each building. This is how we decided what rooms to use to test for in each case study. This method gives us the ability to limit the amount of testing that needs to be done, but we are still able to scale the results to get a total overview of the school's energy usage. We completed testing in 18 rooms out of 86 and from this technique we were able to gather all the information needed for our assessments.

APPENDIX G – Room Audit Checklist

Room Number	Type of Room	Kill-A-Watt	Lux Meter	Thermal	Temperature	Water Analysis
001	Classroom					
041	Large Bathroom					
131/132	Hallways					
141	Single Bathroom					
151	Storage					
191	Computer Lab					
203	Classroom					
261	Office					
305	Classroom					
312	ESL Room					
331-333	Hallways					
334	Lobby					
345	Large Bathroom					
347	Single Bathroom					
363	Front Office					
364	Principal Office					
381	Multi-Purpouse Room					
391	Computer Lab					
Building Envalope						
Roof						

APPENDIX H – Utility Meter Readings – Electricity

Electric Utility Meter Readings

Date	Time	Current Demand (KW)	Current Usage (KW h)	Change In Usage (KW h)
Wednesday 11/2/2011	1:12 PM	1.95	1251480	N/A
Thursday 11/3/2011	12:22 PM	1.95	1252320	840
Friday 11/4/2011	12:15 PM	1.99	1253160	840
Monday 11/7/2011	12:14 PM	1.99	1254880	1720
Tuesday 11/8/2011	12:16 PM	1.83	1256560	1680
Wednesday 11/9/2011	11:15 AM	1.88	1257360	800

APPENDIX I – Utility Meter Readings – Water

Water Utility Meter Readings

Date	Time	Meter Reading	Water Useage (ft^3)	Change In Useage (ft3)
Wednesday 11/2/2011	1:14 PM	588440	58844000	N/A
Thursday 11/3/2011	12:23 PM	588610	58861000	17000
Friday 11/4/2011	12:17 PM	588800	58880000	19000
Monday 11/7/2011	12:15 PM	589000	58900000	20000
Tuesday 11/8/2011	12:18 PM	589410	58941000	41000
Wednesday 11/9/2011	11:14 AM	589570	58957000	16000

APPENDIX J – Light Meter Readings

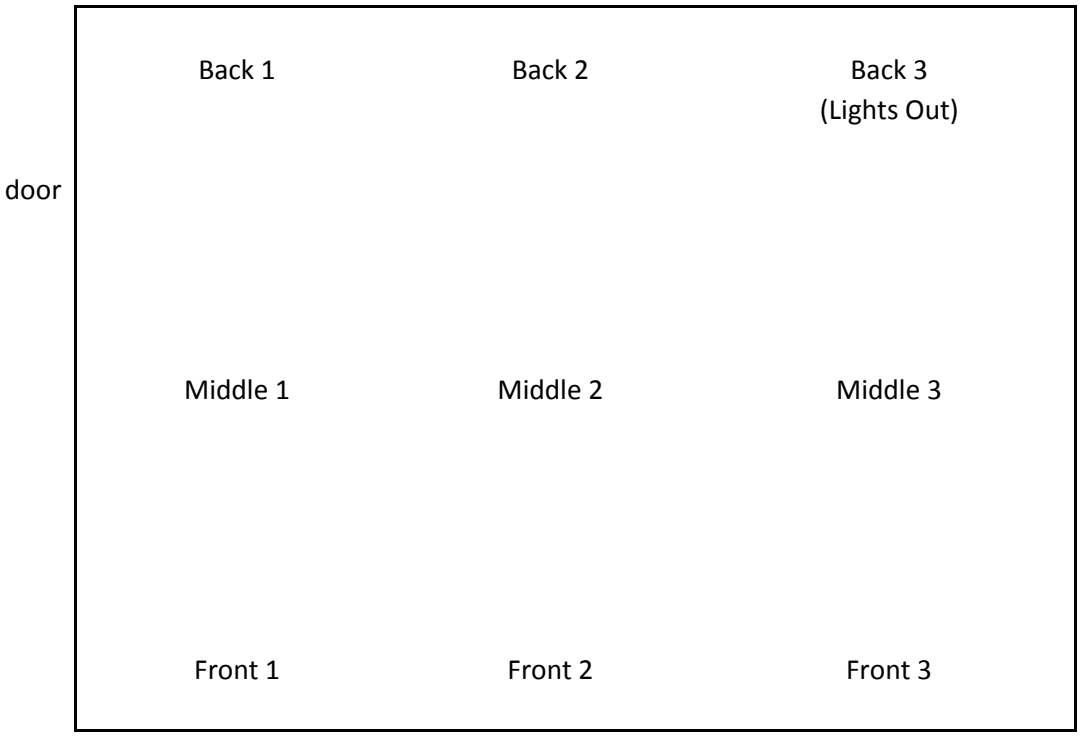
All light reading values below refer to lux. 10.764 lux converts to approximately one ft-candle.

Outside readings.

Outside Lighting Condition	Light Reading
Sunny Day	69000
Cloudy Day	12000
Night	0

Room 001.

Classroom



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	406	N/A	10
Front 2	151	N/A	7
Front 3	385	N/A	15
Middle 1	419	N/A	17
Middle 2	170	N/A	18
Middle 3	132	N/A	22
Back 1	372	N/A	54
Back 2	227	N/A	79
Back 3	336	N/A	331
Average	288.6666667	N/A	61.44444444

Cloudy Day

Position	Full Lights	Half Lights	No Lights
Front 1	300	N/A	0
Front 2	184	N/A	0
Front 3	368	N/A	0
Middle 1	180	N/A	0
Middle 2	281	N/A	0
Middle 3	388	N/A	0
Back 1	330	N/A	0
Back 2	122	N/A	0
Back 3	6	N/A	0
Average	239.8888889	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	300	N/A	0
Front 2	184	N/A	0
Front 3	368	N/A	0
Middle 1	180	N/A	0
Middle 2	281	N/A	0
Middle 3	388	N/A	0
Back 1	330	N/A	0
Back 2	122	N/A	0
Back 3	6	N/A	0
Average	239.8888889	N/A	0

Room 041.

Large Bathroom

Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	729	N/A	0
Front 2	287	N/A	0
Middle 1	1032	N/A	0
Middle 2	350	N/A	0
Back 1	1005	N/A	0
Back 2	171	N/A	0
Average	595.6666667	N/A	0

Cloudy Day

Position	Full Lights	Half Lights	No Lights
Front 1	450	N/A	0
Front 2	233	N/A	0
Middle 1	390	N/A	0
Middle 2	660	N/A	0
Back 1	520	N/A	0
Back 2	115	N/A	0
Average	394.6666667	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	450	N/A	0
Front 2	233	N/A	0
Middle 1	390	N/A	0
Middle 2	660	N/A	0
Back 1	520	N/A	0
Back 2	115	N/A	0
Average	394.6666667	N/A	0

Room 131/132.

Hallway

1	2	**132**	3	4
1	2	**131**	3	4

Sunny Day

Position	Full Lights	Half Lights	No Lights
132-1	162	N/A	17
132-2	267	N/A	5
132-3	214	N/A	22
132-4	225	N/A	36
131-1	163	N/A	8
131-2	88	N/A	23
131-3	118	N/A	3
131-4	225	N/A	65
Average	182.75	N/A	22.375

Cloudy Day

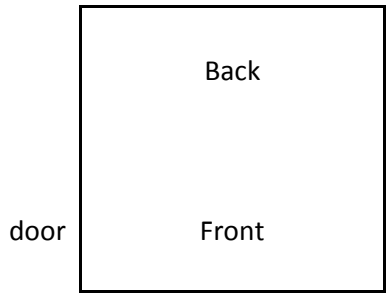
Position	Full Lights	Half Lights	No Lights
132-1	142	N/A	0
132-2	138	N/A	0
132-3	37	N/A	0
132-4	143	N/A	0
131-1	199	N/A	0
131-2	258	N/A	0
131-3	253	N/A	0
131-4	132	N/A	0
Average	162.75	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
132-1	142	N/A	0
132-2	138	N/A	0
132-3	37	N/A	0
132-4	143	N/A	0
131-1	199	N/A	0
131-2	258	N/A	0
131-3	253	N/A	0
131-4	132	N/A	0
Average	162.75	N/A	0

Room 141.

Single Bathroom



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front	334	N/A	222
Front	364	N/A	235
Average	349	N/A	228.5

Cloudy Day

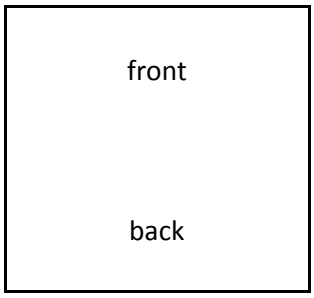
Position	Full Lights	Half Lights	No Lights
Front	130	N/A	0
Front	130	N/A	0
Average	130	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front	130	N/A	0
Front	130	N/A	0
Average	130	N/A	0

Room 151.

Storage



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front	77	N/A	0
Back	65	N/A	0
Average	71	N/A	0

Cloudy Day

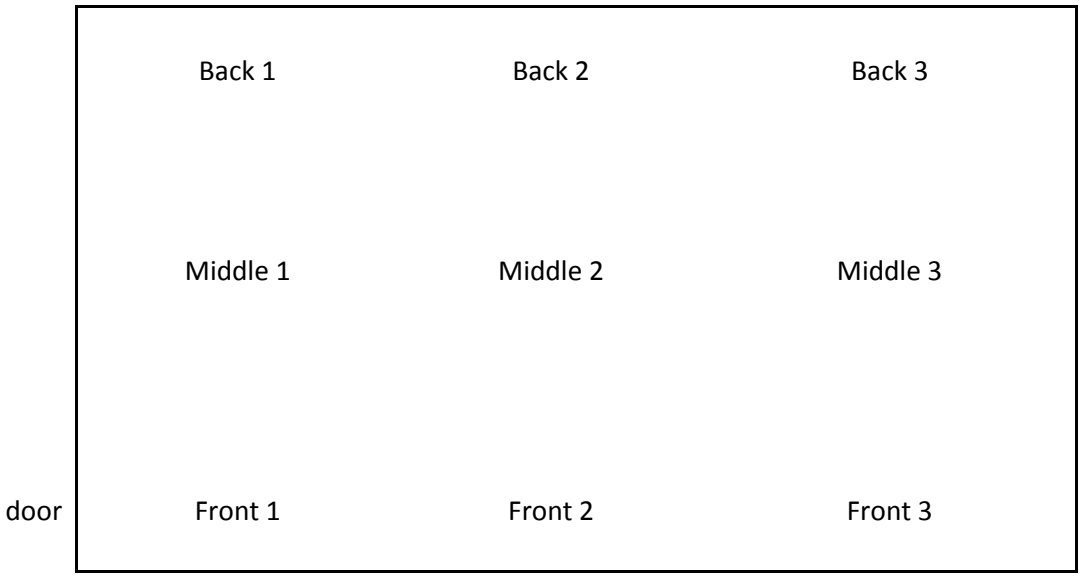
Position	Full Lights	Half Lights	No Lights
Front	69	N/A	0
Back	54	N/A	0
Average	61.5	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front	69	N/A	0
Back	54	N/A	0
Average	61.5	N/A	0

Room 191.

Computer Lab/Library



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	465	307	287
Front 2	841	510	451
Front 3	862	709	545
Middle 1	763	405	379
Middle 2	1070	536	474
Middle 3	1398	1243	884
Back 1	979	504	484
Back 2	1299	928	844
Back 3	1259	1107	812
Average	992.8888889	694.3333333	573.3333333

Cloudy Day

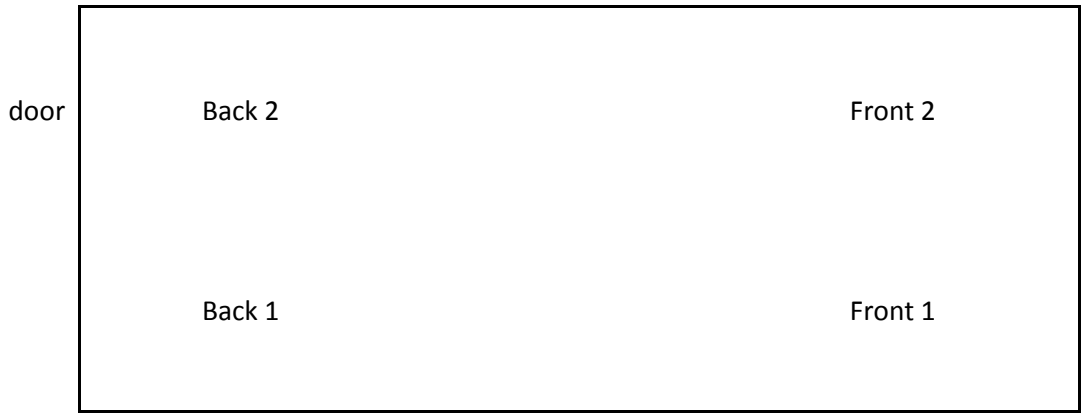
Position	Full Lights	Half Lights	No Lights
Front 1	145	108	0
Front 2	319	250	0
Front 3	253	100	0
Middle 1	390	390	0
Middle 2	548	430	0
Middle 3	420	82	0
Back 1	360	360	0
Back 2	366	330	0
Back 3	368	134	0
Average	352.1111111	242.6666667	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	145	108	0
Front 2	319	250	0
Front 3	253	100	0
Middle 1	390	390	0
Middle 2	548	430	0
Middle 3	420	82	0
Back 1	360	360	0
Back 2	366	330	0
Back 3	368	134	0
Average	352.1111111	242.6666667	0

Room 261.

Guidance Office



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	562	N/A	175
Front 2	522	N/A	191
Back 1	526	N/A	163
Back 2	594	N/A	174
Average	551	N/A	175.75

Cloudy Day

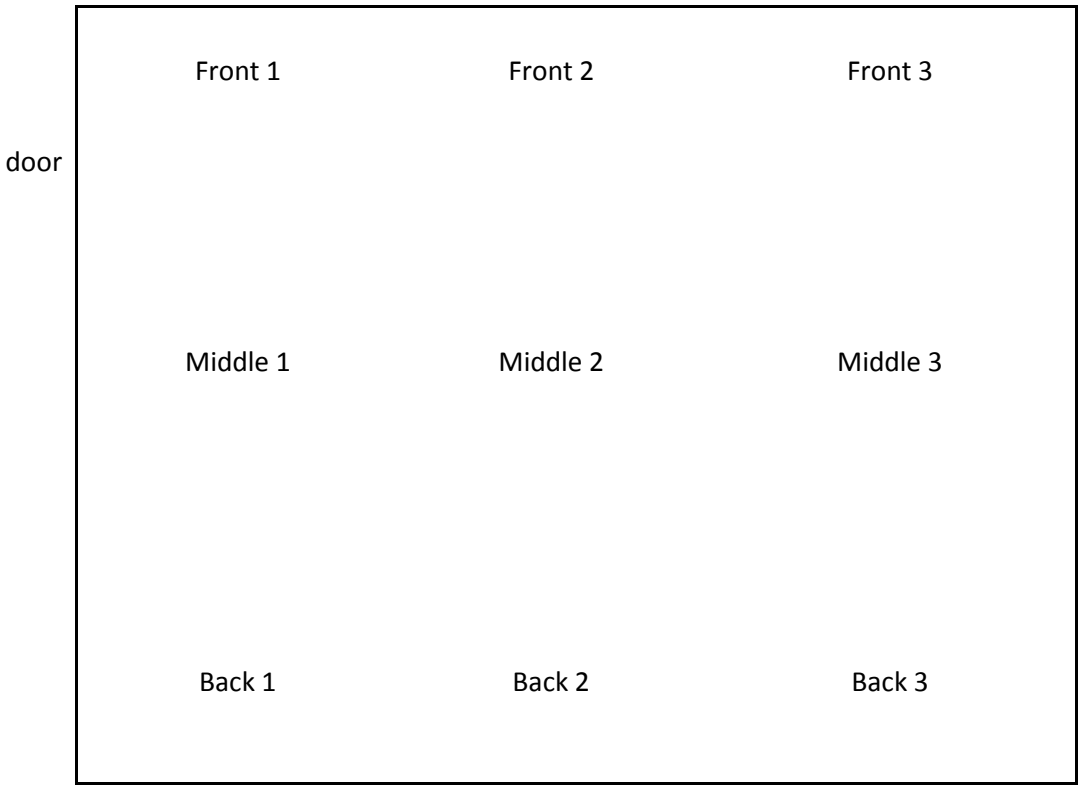
Position	Full Lights	Half Lights	No Lights
Front 1	197	N/A	0
Front 2	250	N/A	0
Back 1	248	N/A	0
Back 2	250	N/A	9
Average	236.25	N/A	2.25

Night

Position	Full Lights	Half Lights	No Lights
Front 1	197	N/A	0
Front 2	250	N/A	0
Back 1	248	N/A	0
Back 2	250	N/A	9
Average	236.25	N/A	2.25

Room 305.

Classroom



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	1064	839	19
Front 2	288	131	25
Front 3	771	216	210
Middle 1	1131	1086	37
Middle 2	357	115	60
Middle 3	672	478	443
Back 1	1056	956	23
Back 2	291	134	31
Back 3	443	176	133
Average	674.7777778	459	109

Cloudy Day

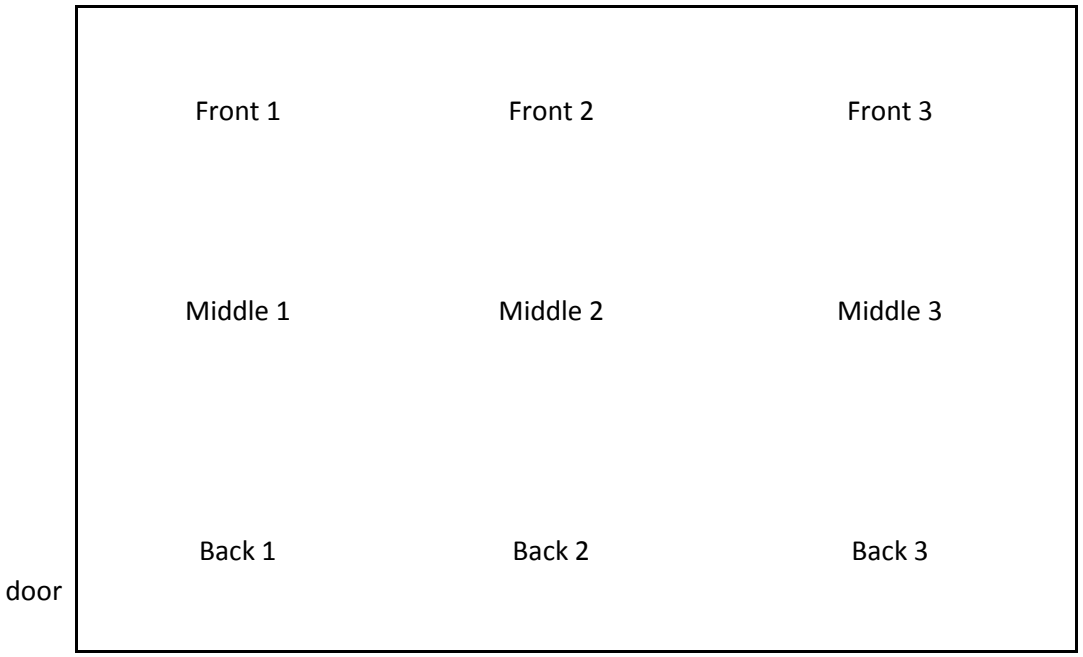
Position	Full Lights	Half Lights	No Lights
Front 1	927	846	0
Front 2	201	106	0
Front 3	739	30	0
Middle 1	824	45	0
Middle 2	272	212	0
Middle 3	746	620	0
Back 1	624	590	0
Back 2	194	64	0
Back 3	666	15	0
Average	577	280.8888889	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	927	846	0
Front 2	201	106	0
Front 3	739	30	0
Middle 1	824	45	0
Middle 2	272	212	0
Middle 3	746	620	0
Back 1	624	590	0
Back 2	194	64	0
Back 3	666	15	0
Average	577	280.8888889	0

Room 312.

ELS Room



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	93	N/A	0
Front 2	122	N/A	0
Front 3	149	N/A	0
Middle 1	131	N/A	0
Middle 2	148	N/A	0
Middle 3	160	N/A	0
Back 1	49	N/A	0
Back 2	73	N/A	0
Back 3	55	N/A	0
Average	108.8888889	N/A	0

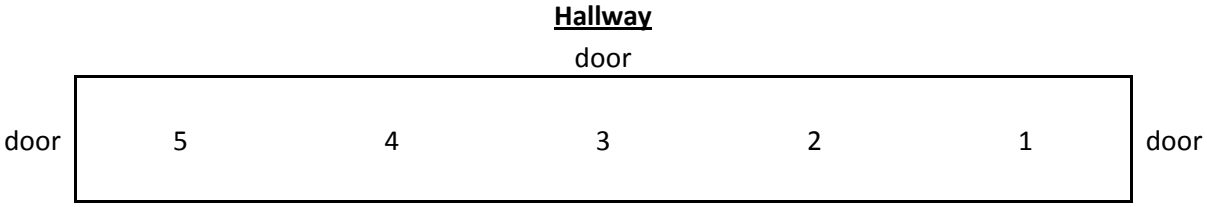
Cloudy Day

Position	Full Lights	Half Lights	No Lights
Front 1	80	N/A	0
Front 2	106	N/A	0
Front 3	110	N/A	0
Middle 1	119	N/A	0
Middle 2	133	N/A	0
Middle 3	112	N/A	0
Back 1	100	N/A	0
Back 2	103	N/A	0
Back 3	71	N/A	0
Average	103.7777778	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	80	N/A	0
Front 2	106	N/A	0
Front 3	110	N/A	0
Middle 1	119	N/A	0
Middle 2	133	N/A	0
Middle 3	112	N/A	0
Back 1	100	N/A	0
Back 2	103	N/A	0
Back 3	71	N/A	0
Average	103.7777778	N/A	0

Room 333.



Sunny Day

Position	Full Lights	Half Lights	No Lights
1	244	67	1
2	192	53	13
3	610	30	16
4	479	25	2
5	287	33	16
Average	362.4	41.6	9.6

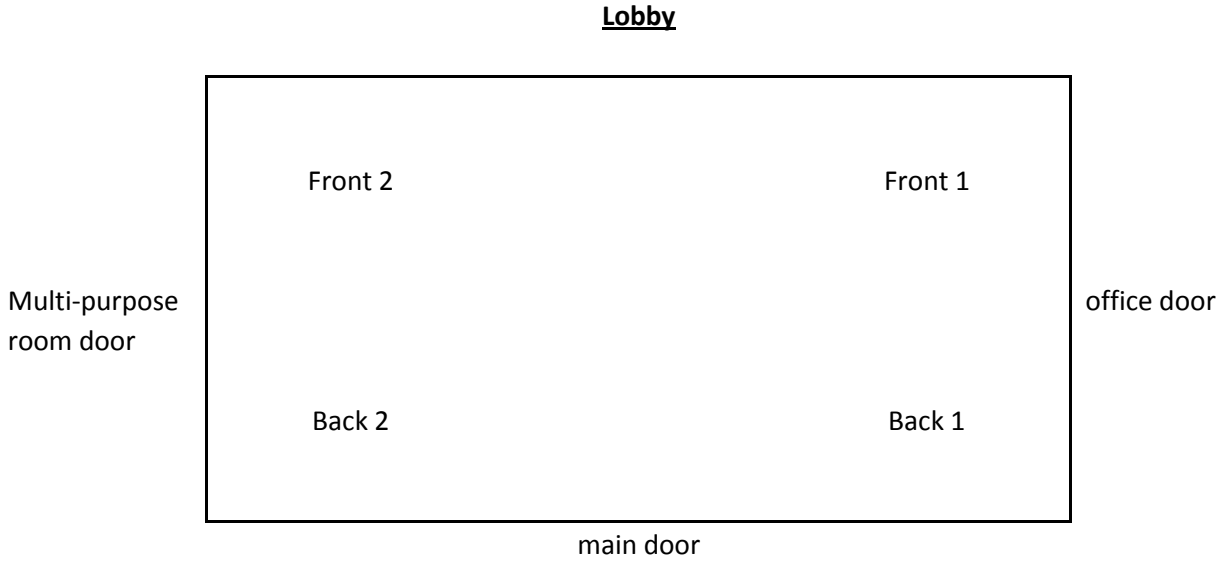
Cloudy Day

Position	Full Lights	Half Lights	No Lights
1	253	33	0
2	435	41	0
3	570	55	0
4	358	63	0
5	285	30	0
Average	380.2	44.4	0

Night

Position	Full Lights	Half Lights	No Lights
1	253	33	0
2	435	41	0
3	570	55	0
4	358	63	0
5	285	30	0
Average	380.2	44.4	0

Room 334.


Lobby
Front 2
Front 1
Multi-purpose room door
office door
Back 2
Back 1
main door

Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	242	200	109
Front 2	278	235	108
Back 1	502	451	304
Back 2	517	468	359
Average	384.75	338.5	220

Cloudy Day

Position	Full Lights	Half Lights	No Lights
Front 1	138	132	0
Front 2	134	130	0
Back 1	228	215	0
Back 2	260	140	0
Average	190	154.25	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	138	132	0
Front 2	134	130	0
Back 1	228	215	0
Back 2	260	140	0
Average	190	154.25	0

Room 345.

Large Bathroom

Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	338	N/A	2
Front 2	303	N/A	1
Middle 1	312	N/A	5
Middle 2	370	N/A	6
Back 1	414	N/A	13
Back 2	431	N/A	36
Average	361.3333333	N/A	10.5

Cloudy Day

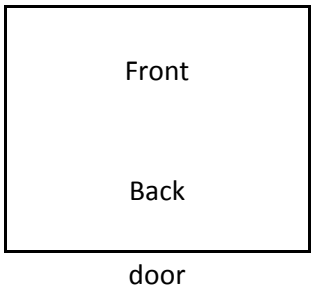
Position	Full Lights	Half Lights	No Lights
Front 1	482	N/A	0
Front 2	520	N/A	0
Middle 1	525	N/A	0
Middle 2	440	N/A	0
Back 1	340	N/A	0
Back 2	269	N/A	0
Average	429.3333333	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	482	N/A	0
Front 2	520	N/A	0
Middle 1	525	N/A	0
Middle 2	440	N/A	0
Back 1	340	N/A	0
Back 2	269	N/A	0
Average	429.3333333	N/A	0

Room 347.

Single Bathroom



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front	67	N/A	0
Back	87	N/A	0
Average	77	N/A	0

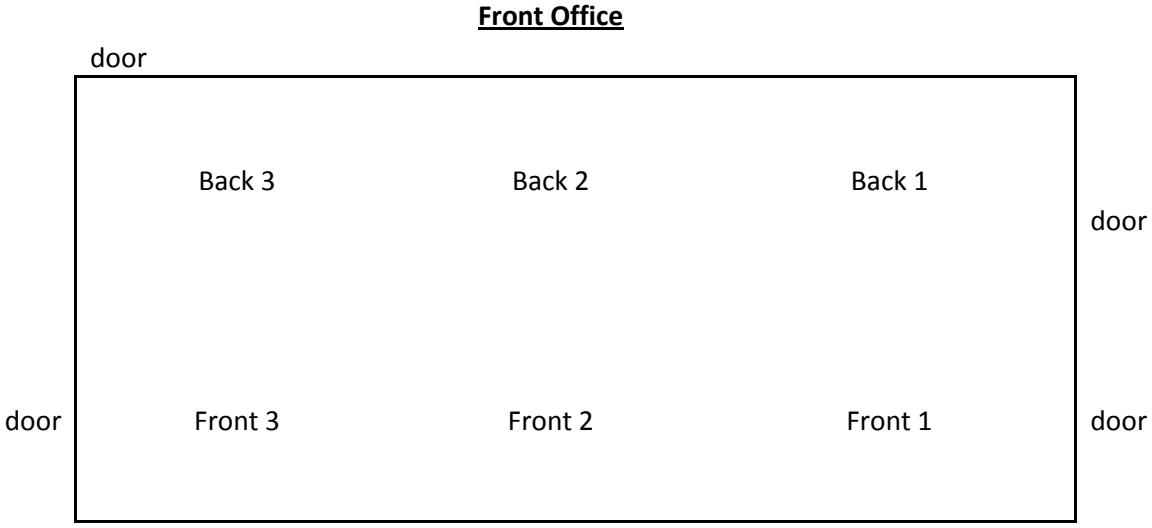
Cloudy Day

Position	Full Lights	Half Lights	No Lights
Front	69	N/A	0
Back	90	N/A	0
Average	79.5	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front	68	N/A	0
Back	85	N/A	0
Average	76.5	N/A	0

Room 363.


Front Office
door
Back 3
Back 2
Back 1
door
door
Front 3
Front 2
Front 1
door

Sunny Day

Position	Full Lights	Half Lights	No Lights
Front	789	N/A	114
Front	1246	N/A	128
Front	1015	N/A	105
Back	1282	N/A	1169
Back	1913	N/A	1113
Back	1820	N/A	760
Average	1344.166667	N/A	564.8333333

Cloudy Day

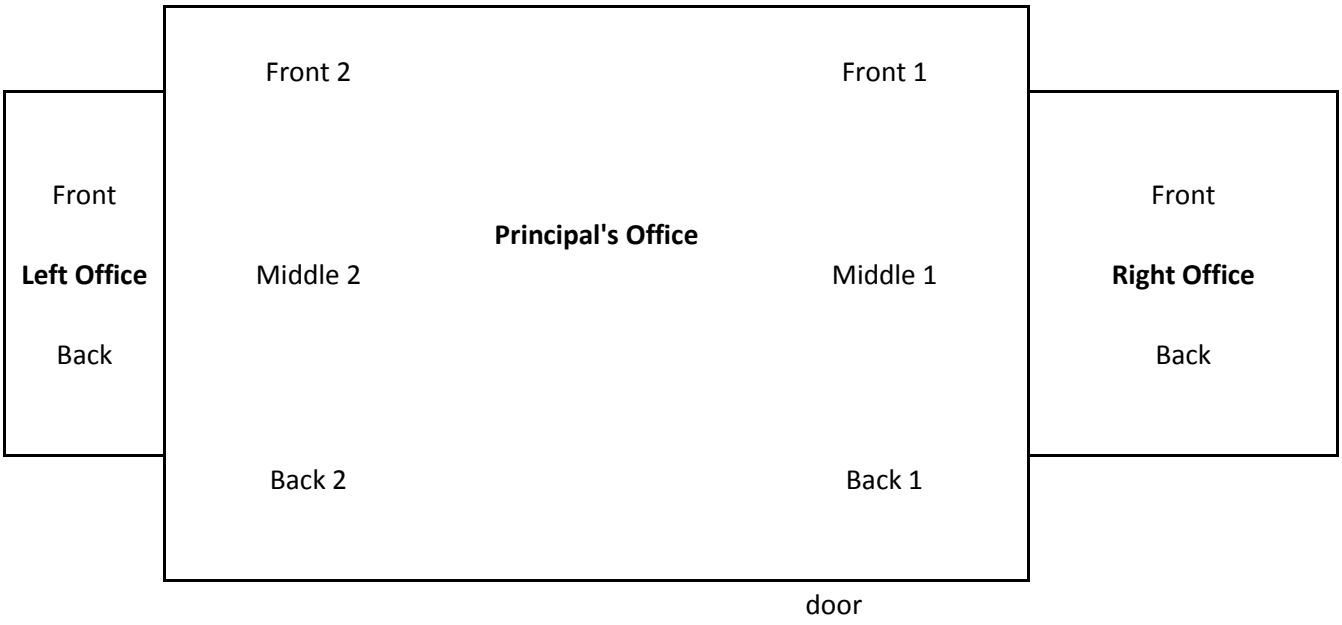
Position	Full Lights	Half Lights	No Lights
Front	607	N/A	0
Front	1150	N/A	0
Front	1140	N/A	0
Back	127	N/A	0
Back	360	N/A	0
Back	818	N/A	0
Average	700.3333333	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front	607	N/A	0
Front	1150	N/A	0
Front	1140	N/A	0
Back	127	N/A	0
Back	360	N/A	0
Back	818	N/A	0
Average	700.3333333	N/A	0

Room 364.

Offices



Sunny Day Principal's Office

Position	Full Lights	Half Lights	No Lights
Front 1	4100	N/A	4000
Front 2	4300	N/A	4000
Middle 1	1080	N/A	1045
Middle 2	798	N/A	699
Back 1	863	N/A	517
Back 2	640	N/A	411
Average	1963.5	N/A	1778.666667

Sunny Day Left Office

Position	Full Lights	Half Lights	No Lights
Front	759	N/A	570
Back	542	N/A	314
Average	650.5	N/A	442

Sunny Day Left Office

Position	Full Lights	Half Lights	No Lights
Front	604	N/A	429
Back	344	N/A	195
Average	474	N/A	312

Cloudy Day Principal's Office

Position	Full Lights	Half Lights	No Lights
Front 1	282	N/A	0
Front 2	232	N/A	0
Middle 1	130	N/A	0
Middle 2	225	N/A	0
Back 1	219	N/A	0
Back 2	265	N/A	0
Average	225.5	N/A	0

Cloudy Day Left Office

Position	Full Lights	Half Lights	No Lights
Front	152	N/A	0
Back	138	N/A	0
Average	145	N/A	0

Cloudy Day Left Office

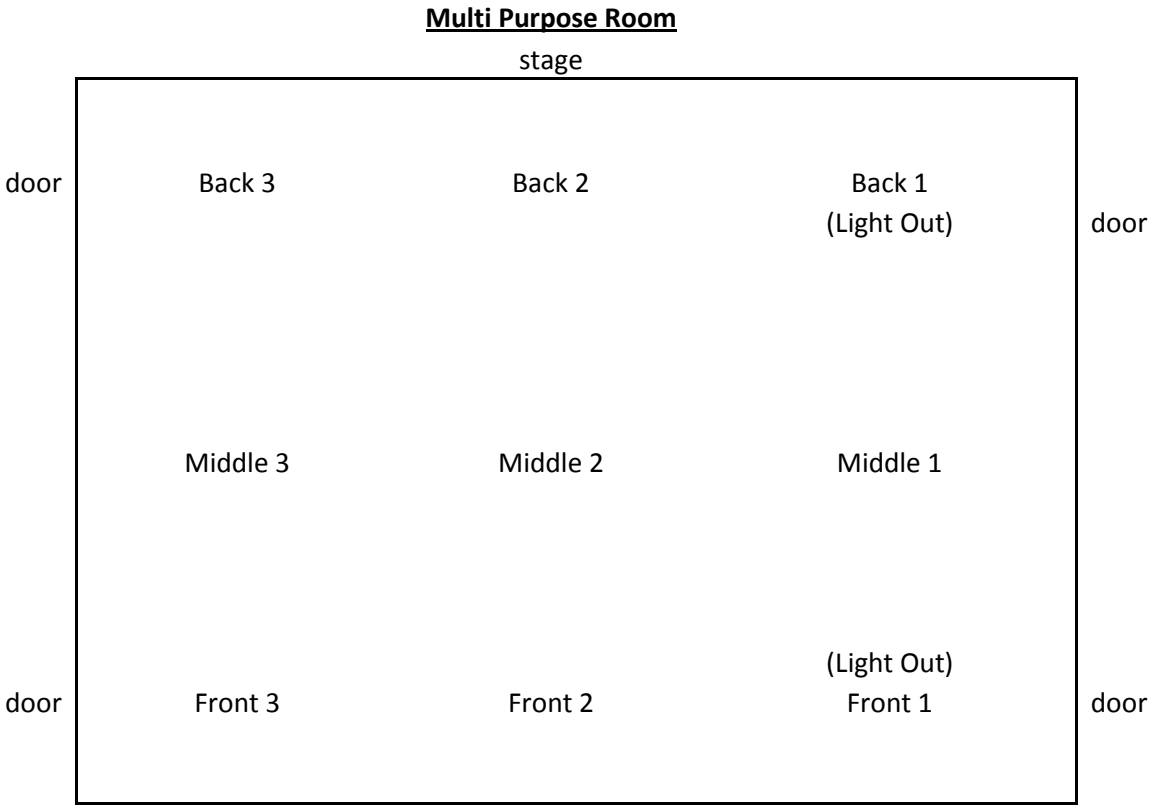
Position	Full Lights	Half Lights	No Lights
Front	126	N/A	0
Back	161	N/A	0
Average	143.5	N/A	0

Night	Principal's Office		
Position	Full Lights	Half Lights	No Lights
Front 1	282	N/A	0
Front 2	232	N/A	0
Middle 1	130	N/A	0
Middle 2	225	N/A	0
Back 1	219	N/A	0
Back 2	265	N/A	0
Average	225.5	N/A	0

Night	Left Office		
Position	Full Lights	Half Lights	No Lights
Front	152	N/A	0
Back	138	N/A	0
Average	145	N/A	0

Night	Left Office		
Position	Full Lights	Half Lights	No Lights
Front	126	N/A	0
Back	161	N/A	0
Average	143.5	N/A	0

Room 381.


Multi Purpose Room
stage
door
Back 3
Back 2
Back 1
(Light Out)
door
Middle 3
Middle 2
Middle 1
(Light Out)
door
Front 3
Front 2
Front 1
door

Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	195	N/A	181
Front 2	304	N/A	319
Front 3	910	N/A	830
Middle 1	366	N/A	243
Middle 2	437	N/A	474
Middle 3	1105	N/A	1070
Back 1	198	N/A	207
Back 2	265	N/A	250
Back 3	1205	N/A	1047
Average	553.8888889	N/A	513.4444444

Cloudy Day

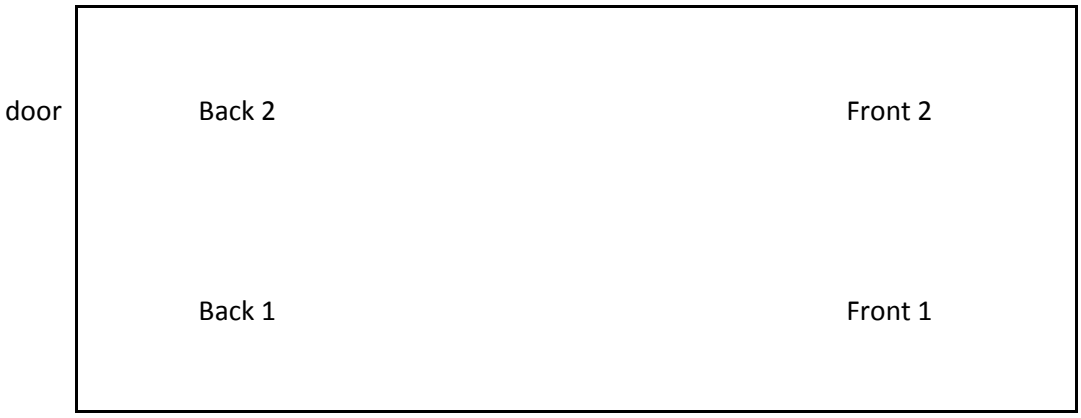
Position	Full Lights	Half Lights	No Lights
Front 1	19	N/A	0
Front 2	31	N/A	0
Front 3	144	N/A	0
Middle 1	83	N/A	0
Middle 2	63	N/A	0
Middle 3	72	N/A	0
Back 1	16	N/A	0
Back 2	28	N/A	0
Back 3	94	N/A	0
Average	61.11111111	N/A	0

Night

Position	Full Lights	Half Lights	No Lights
Front 1	19	N/A	0
Front 2	31	N/A	0
Front 3	144	N/A	0
Middle 1	83	N/A	0
Middle 2	63	N/A	0
Middle 3	72	N/A	0
Back 1	16	N/A	0
Back 2	28	N/A	0
Back 3	94	N/A	0
Average	61.11111111	N/A	0

Room 391.

Guidance Office



Sunny Day

Position	Full Lights	Half Lights	No Lights
Front 1	562	N/A	175
Front 2	522	N/A	191
Back 1	526	N/A	163
Back 2	594	N/A	174
Average	551	N/A	175.75

Cloudy Day

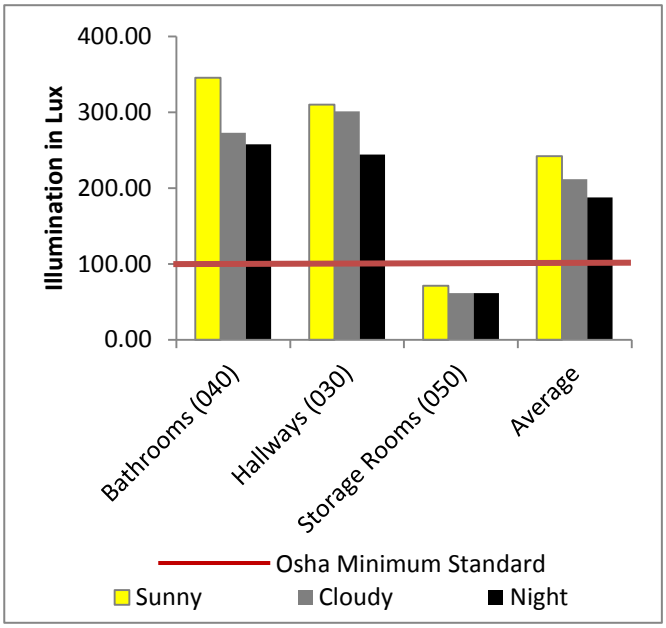
Position	Full Lights	Half Lights	No Lights
Front 1	197	N/A	0
Front 2	250	N/A	0
Back 1	248	N/A	0
Back 2	250	N/A	9
Average	236.25	N/A	2.25

Night

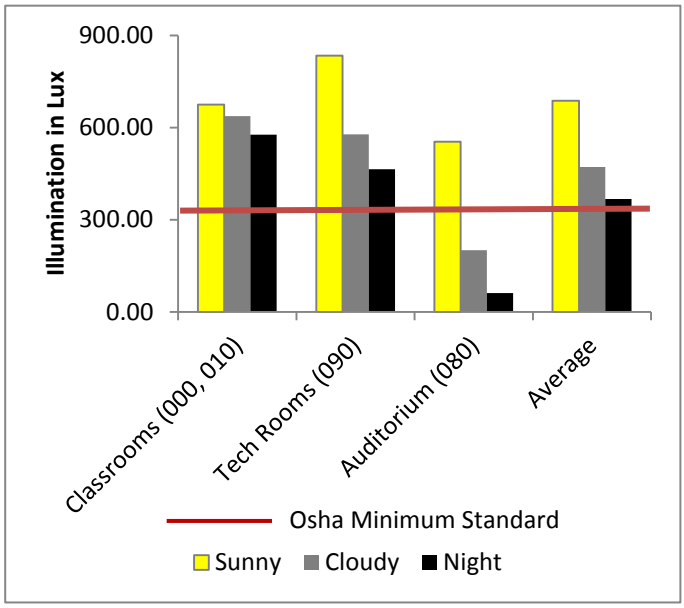
Position	Full Lights	Half Lights	No Lights
Front 1	197	N/A	0
Front 2	250	N/A	0
Back 1	248	N/A	0
Back 2	250	N/A	9
Average	236.25	N/A	2.25

Graphs.

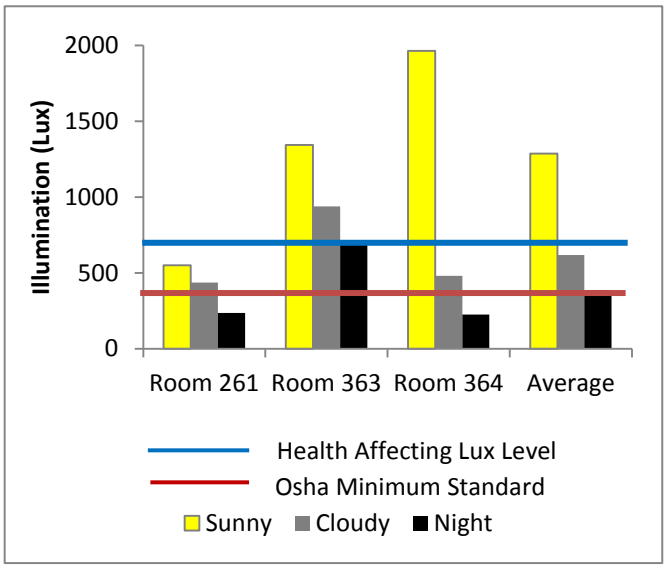
10 ft-candle OSHA Standard Rooms			
	Sunny	Cloudy	Night
Bathrooms (040)	345.75	273.00	257.75
Hallways (030)	309.97	301.37	244.32
Storage Rooms (050)	71.00	61.50	61.50
Average	242.24	211.96	187.86



30 ft-candle OSHA Standard Rooms			
	Sunny	Cloudy	Night
Classrooms (000, 010)	674.78	636.67	577.00
Tech Rooms (090)	833.83	577.67	464.56
Auditorium (080)	553.89	201.22	61.11
Average	687.50	471.85	367.56

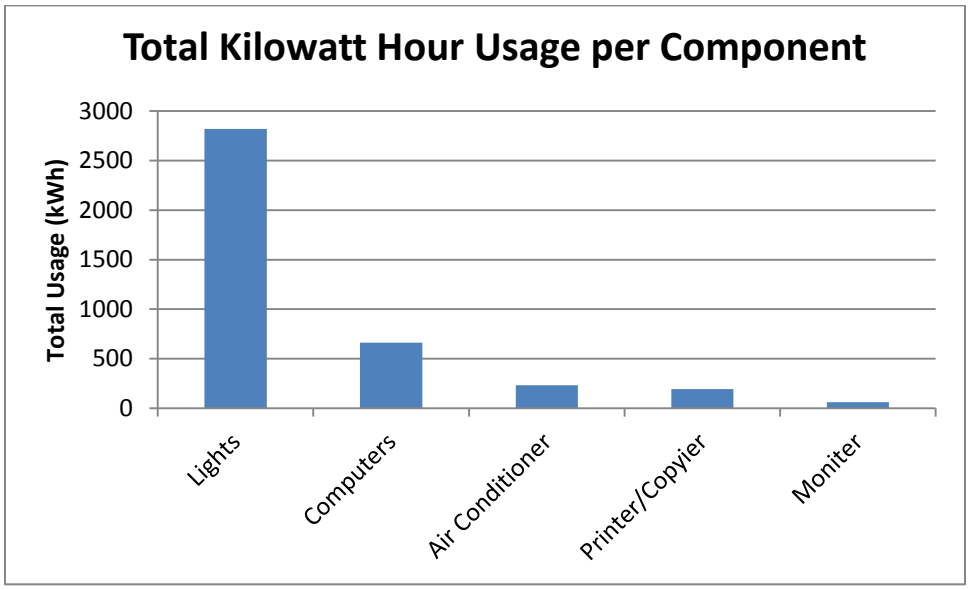


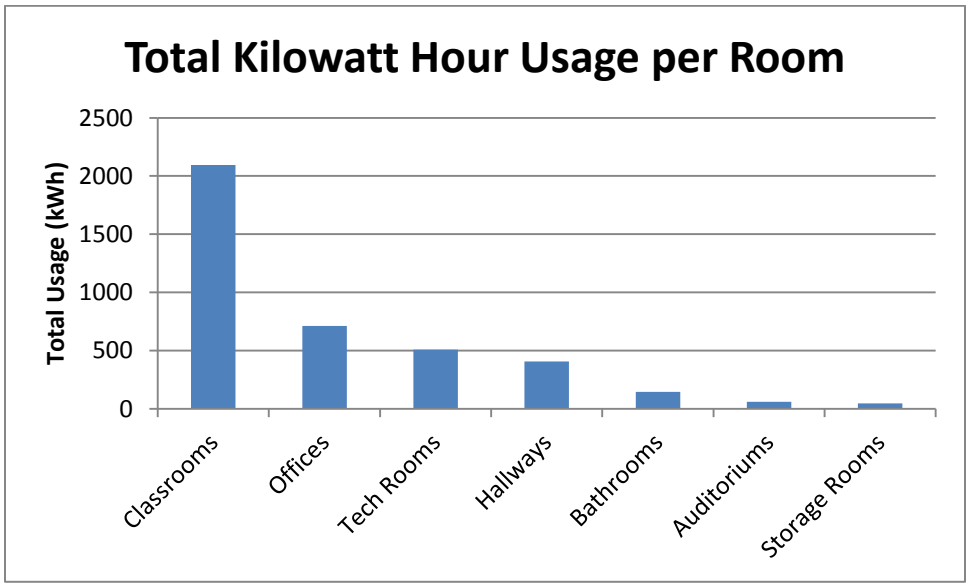
30-50 ft-candle OSHA Standard Rooms			
	Sunny	Cloudy	Night
Room 261	551	437	236
Room 363	1344	939	700
Room 364	1964	481	226
Average	1286	619	387



APPENDIX K – Office Equipment Readings

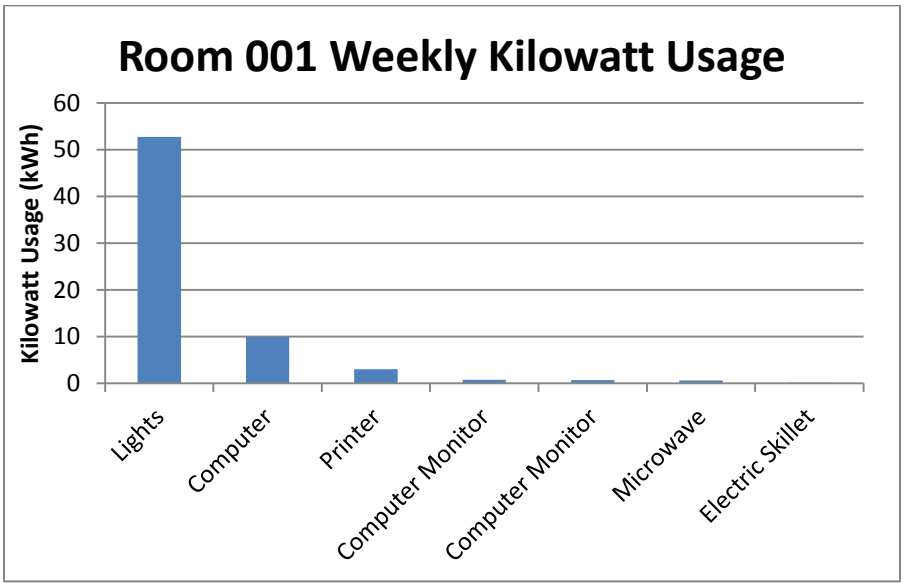
Overall





Room 001.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	26	32	1	60	52.728
Computer	2	100	20	20	9.92
Printer	1	18	18	15	3.024
Computer Monitor	1	28	2	16	0.752
Computer Monitor	1	35	1	16	0.712
Microwave	1	1000	2	0.33	0.66534
Electric Skillet	1	1	1	168	0.168



Room 041.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	20	32	1	60	40.56

Room 131/132.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	20	32	1	60	40.56

Room 141.

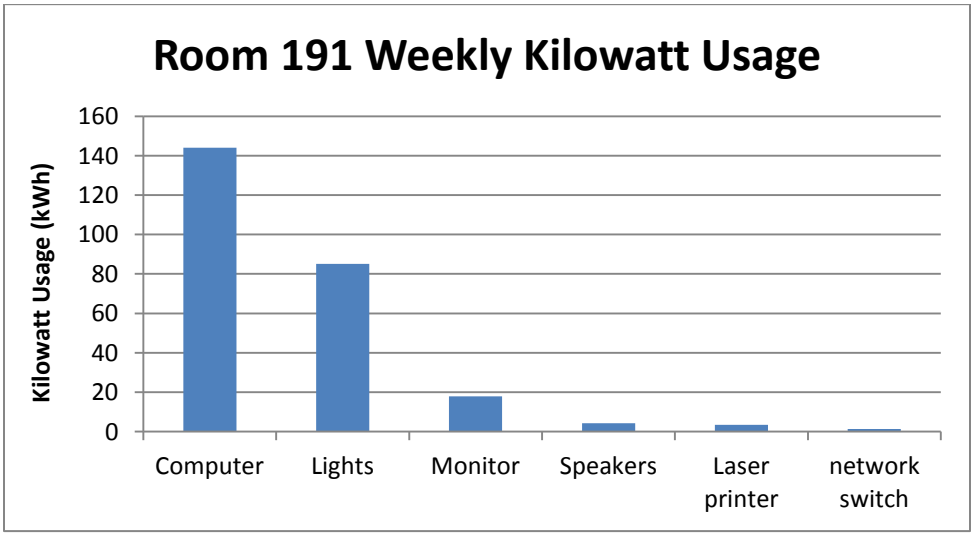
Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	4	32	1	60	8.112

Room 151.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	1	65	1	30	2.088

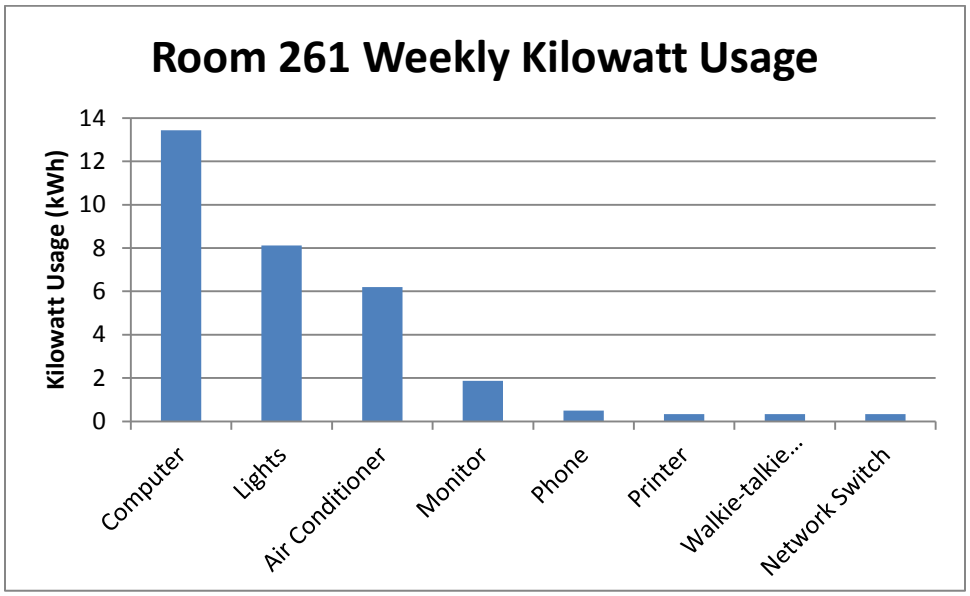
Room 191.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Computer	25	100	20	30	144
Lights	42	32	1	60	85.176
Monitor	25	23	1	25	17.95
Speakers	25	2	1	2.5	4.2625
Laser printer	1	22	20	25	3.41
network switch	4	2	2	168	1.344



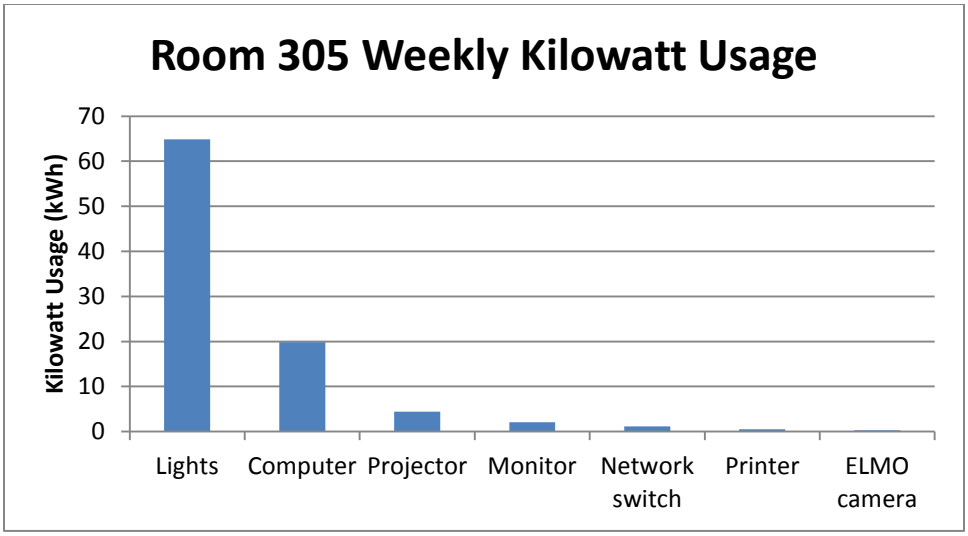
Room 261.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Computer	2	100	20	42	13.44
Lights	4	32	1	60	8.112
Air Conditioner	1	588	2	10	6.196
Monitor	2	23	1	35	1.876
Phone	1	3	3	168	0.504
Printer	1	2	2	15	0.336
Walkie-talkie charger	1	2	2	168	0.336
Network Switch	1	2	2	168	0.336



Room 305.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	32	32	1	60	64.896
Computer	4	100	20	20	19.84
Projector	1	242	5	15	4.395
Monitor	4	23	1	16	2.08
Network switch	1	7	7	168	1.176
Printer	1	10	3	0.33	0.50631
ELMO camera	1	10	1	15	0.303



Room 312.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	7	32	1	60	14.196
clock	1	2	2	168	0.336

Room 333.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	??	32	1	60	#VALUE!

Room 334.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	6	32	1	60	12.168

Room 345.

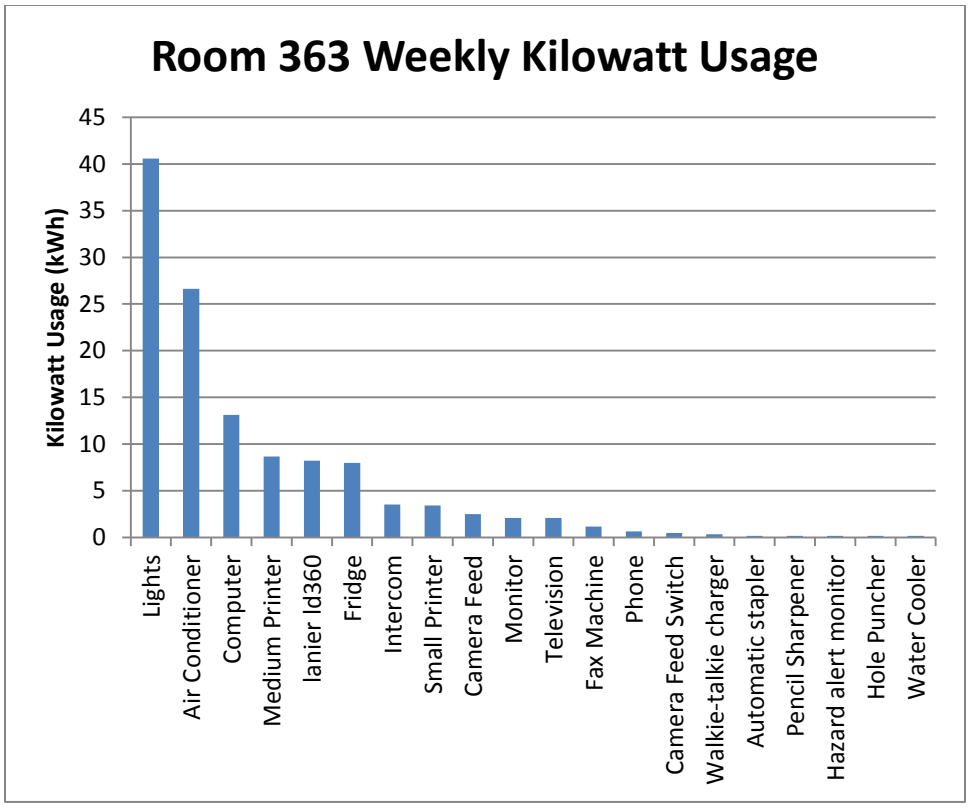
Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	6	32	1	60	12.168

Room 347.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	1	32	1	60	2.028

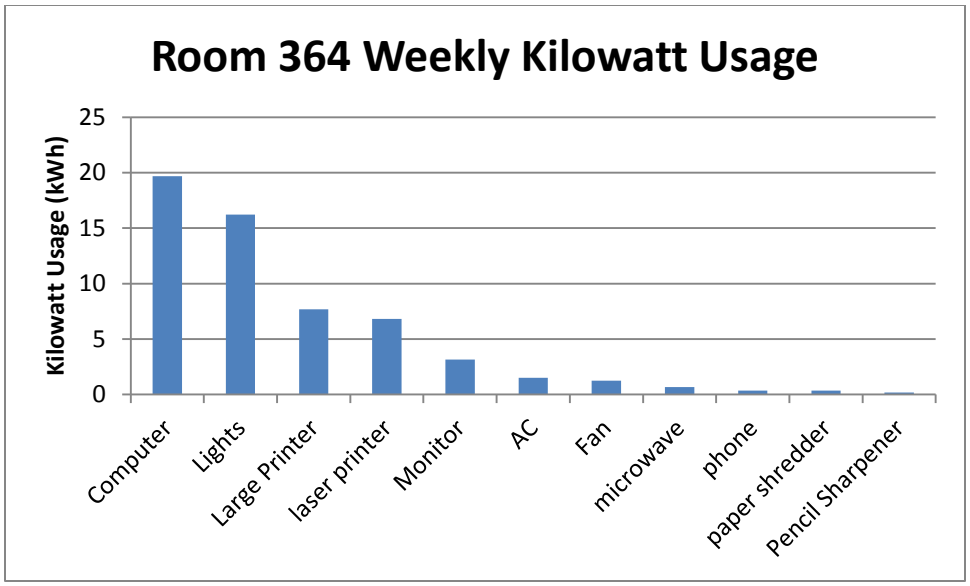
Room 363.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	20	32	1	60	40.56
Air Conditioner	4	650	1	10	26.632
Computer	2	100	20	40	13.12
Medium Printer	1	68	48	30	8.664
lanier ld360	1	90	40	30	8.22
Fridge	1	63	22	105	8.001
Intercom	1	23	21	10	3.548
Small Printer	1	22	20	30	3.42
Camera Feed	1	15	15	168	2.52
Monitor	2	23	1	40	2.096
Television	1	27	2	70	2.086
Fax Machine	1	7	7	168	1.176
Phone	2	2	2	168	0.672
Camera Feed Switch	1	3	3	168	0.504
Walkie-talkie charger	1	2	2	168	0.336
Automatic stapler	1	1	1	168	0.168
Pencil Sharpener	1	1	1	168	0.168
Hazard alert monitor	1	1	1	168	0.168
Hole Puncher	1	1	1	168	0.168
Water Cooler	1	1	1	168	0.168



Room 364.

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Computer	3	100	20	40	19.68
Lights	8	32	1	60	16.224
Large Printer	1	65	43	20	7.664
laser printer	2	22	20	20	6.8
Monitor	3	23	1	40	3.144
AC	1	120	2	10	1.516
Fan	2	33	1	14	1.232
microwave	1	1000	2	0.33	0.66534
phone	1	2	2	168	0.336
paper shredder	1	2	2	168	0.336
Pencil Sharpener	1	1	1	168	0.168

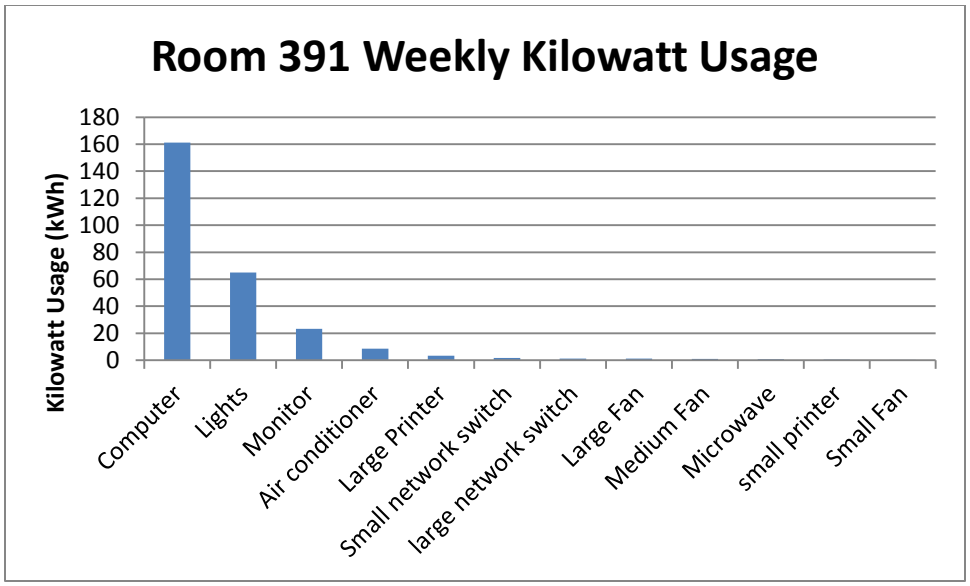


Room 381.

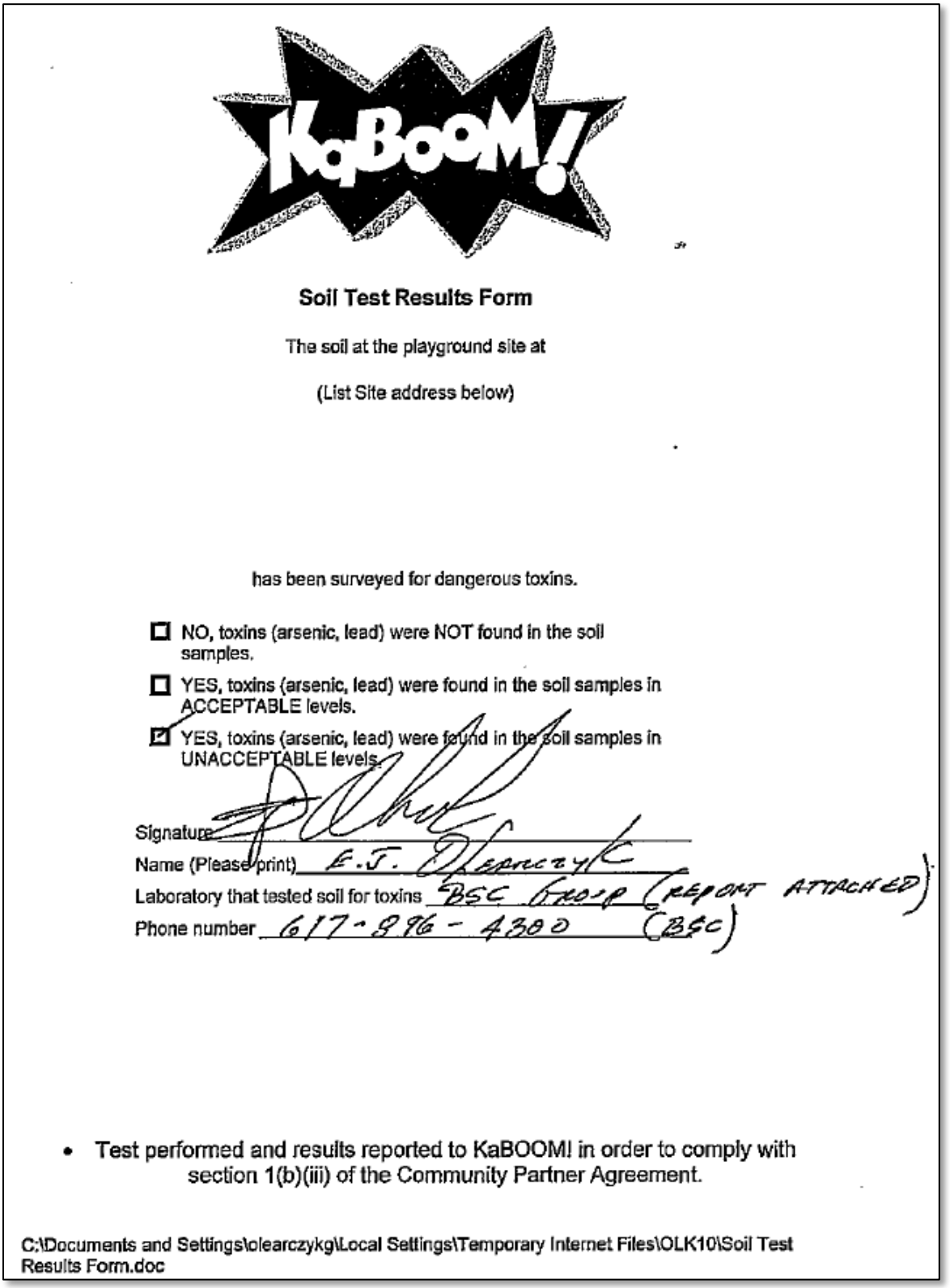
Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Lights	8	120	1	60	58.464

Room 391

Component	Number of Components	Watt Consumption (on)	Watt Consumption (standby)	Typical Weekly Usage (hrs)	Typical Weekly Energy Consuption (kW-hrs)
Computer	28	100	20	30	161.28
Lights	32	32	1	60	64.896
Monitor	28	23	1	30	23.184
Air conditioner	2	415	1	10	8.616
Large Printer	1	22	20	25	3.41
Small network switch	5	2	2	168	1.68
large network switch	1	7	7	168	1.176
Large Fan	1	80	1	12	1.116
Medium Fan	1	75	0	12	0.9
Microwave	1	1000	2	0.33	0.66534
small printer	1	3	3	25	0.504
Small Fan	1	28	0	12	0.336


Room 391 Weekly Kilowatt Usage
Kilowatt Usage (kWh)
180
160
140
120
100
80
60
40
20
0
Computer
Lights
Monitor
Air conditioner
Large Printer
Small network switch
large network switch
Large Fan
Medium Fan
Microwave
small printer
Small Fan

APPENDIX L – KaBOOM! Lead/Arsenic Soil Testing



Soil Test Results Form

The soil at the playground site at

(List Site address below)

has been surveyed for dangerous toxins.

- ☐ NO, toxins (arsenic, lead) were NOT found in the soil samples.
- ☐ YES, toxins (arsenic, lead) were found in the soil samples in ACCEPTABLE levels.
- ☑ YES, toxins (arsenic, lead) were found in the soil samples in UNACCEPTABLE levels.

Signature

Name (Please print) E.J. Olearczyk

Laboratory that tested soil for toxins BSC Group (REPORT ATTACHED)

Phone number 617-896-4300 (BSC)

- Test performed and results reported to KaBOOM! in order to comply with section 1(b)(iii) of the Community Partner Agreement.

C:\Documents and Settings\olearczykg\Local Settings\Temporary Internet Files\OLK10\Soil Test Results Form.doc

BSC GROUP

15 Elkins Street
Boston, MA 02127

Tel: 617-896-4300
800-288-8123
Fax: 617-896-4301

www.bscgroup.com

August 4, 2011

City of Worcester School Dept.
Attn: Gene Olearczyk, Facilities Manager
20 Irving Street
Worcester, MA 01609

RE: Union Hill Elementary School
Environmental Soil Evaluation

Dear Gene,

BSC Group, Inc. (BSC) submits this report on the environmental evaluation of the subsurface soils at the proposed court yard improvements at the Union Hill Elementary School located at 1 Chapin Street, Worcester, Massachusetts.

Area subject to this investigation is located in a 9,000+/- ft.² courtyard located in the center of the existing school building complex that is proposed to be redeveloped. The entire courtyard is paved with bituminous pavement and drains to one catch basin at the eastern end of the site. There was no evidence of any fills for underground tanks or other utilities in the courtyard. Other than soil sampling and analysis no study or historic investigation of the locus has occurred.

- BSC hand excavated the following test pits, which logged as follows :

  Test Pits 1 and 4:

  0-2 inches pavement
  2 to 12 inches gravel base
  12 to 18 inches silty sandy gravel moist tannish gray,
  No odor, no staining

  Test Pits 2 & 3

  0-2 inches pavement
  2 to 10 inches course gravel base
  10 to 12 inches silty sandy gravel moist tannish gray
  No odor, no staining.

In order to screen the soils for potential contamination, a sample from each of the test pits was analyzed for the eight RCRA metals and test pits 1&4 and test pits 2&3 were composited for EPH analysis and target poly aromatic hydrocarbons.

The results are shown in the attached tabulation Table 1.

The results indicate trace (non-reportable) levels of petroleum hydrocarbons, although they are likely to have stemmed from broken bituminous concrete during the excavation.

Concentrations of chromium also appear to be reportable. However, the test completed (total chromium) does not detail chromium (6) AKA Hex Chromium, and I have requested that the laboratory run additional tests on this to rule out hex chromium. (If there is no hex chromium, the reportable concentration rises from 30 to 1,000 mg per kilogram.) Due to lab demands, results should be available mid next week.

Of most important note are the significant elevated levels of arsenic in the soil. Although they are technically naturally occurring concentrations and are exempt from regulation under the Massachusetts Contingency Plan (MCP), they are nonetheless significant and warrant attention.

310 CMR 40.0321 (a) of the MCP indicates that "releases" of arsenic (note this is not classified as a release) could pose an Imminent Hazard to human at concentrations of arsenic equal to or greater than the concentrations of 40 mg/kg at the ground surface or within a depth of twelve inches below the ground surface, at any location within 500 feet of a residential dwelling, school, playground, recreation area or park, unless access by children is controlled or prevented by means of bituminous pavement, concrete, fence, or other physical barrier. A barrier may also consist of a geofabric and a foot or so of clean soil.

Again, while this provision is not precisely applicable because the concentration of naturally occurring arsenic is not regulated under the MCP, it clearly indicates that precautions to prevent contact with the soil by children should be taken. Such protections typically include either a paved surface as currently exists or 3 feet of clean soil to isolate people from the soil with a high concentrations of arsenic.

Further, due to the elevated concentration of arsenic, no soil should be taking off-site without a full chemical characterization and Bill of Lading MCP. It is also advised that you notify the contractor this information because his workers must be OSHA trained to safely work on the site.

Sincerely,
BSC GROUP, INC.

David J Crispin PE PLS
Sr. Associate

U:\BSC\Letter Proposals\2011\Worcester Schools Soil review Union Elemetary\7-28-11 Union Elementary soil eval report djc draft .doc

TABLE 1
SOIL ANALYTICAL DATA

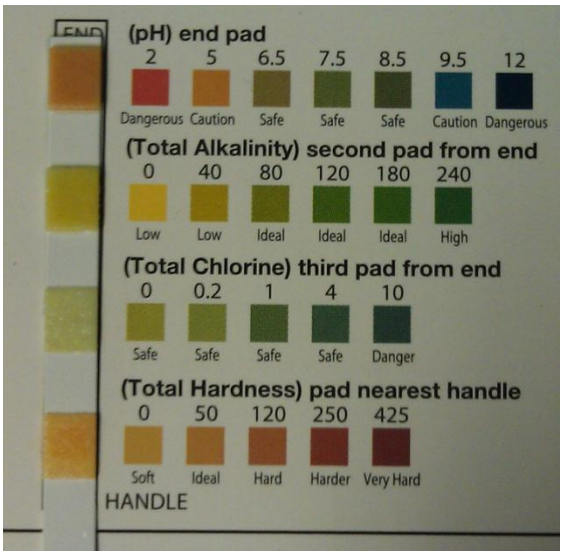
Sample I.D. No	Reportable	Imminenet	Pit-1	Pit -2	Pit-3	Pit-4	Pit 1&4 comp	Pit 2&3 comp
Date Sampled	Concentratio	Hazard	07/22/11	07/22/11	07/22/11	07/22/11	07/22/11	07/22/11
Matrix	RC-S1	Concentration	soil	soil	soil	soil		
Depth (inches)			12	18	12	18		
Arsenic	20	40	33.5	48.5	64.5	31.5		
Barium	1000		70.1	38.4	44.7	83.4		
Cadmium	2		<1.07	<1.08	<1.14	<1.17		
Chromium	30		31.2	23.8	36	34	- (*Retest for Hex Chromium (then 1000 mg/kk RC-S1)	
Lead	300		22	14.1	40	113		
Selenium	400		<5.26	<5.38	5.83	<5.84		
Silver	100		<5.36	<5.38	<5.68	<5.84		
Mercury	20		<0.0943	<0.0922	<0.0943	<.0976		
EPH (MG/KG)								
C9-C18 ALIPHATICS	1000						<15	<15
C19-C36 ALIPHATICS	3000						<15	<15
C11-C22 AROMATICS	1000						<15	<15
TARGET PAH'S (MG/KG)								
NAPTHALENE	4						<0.1	<0.1
2-METHYNAPTHALENE	0.7						<0.1	<0.1
PHENANTHRENE	10						0.451	0.372
ACENAPHTHENE	4						<0.1	<.1
ACENAPHTHALENE	1						<0.1	<0.1
ANTHRACENE	1000						0.149	<0.1
BENZO(a)ANTRACENE	7						0.626	0.193
BENZO(a)PYRENE	50						0.679	0.146
BENZO(b)FLUORANTHENE	7						0.39	<.1
BENZO(g,h,i)PERYLENE	1000						0.355	<.1
BENZO(k)FLUORANTHENE	70						0.645	0.138
CHRYSENE	70						0.679	0.257
DIBENZO(a,h)ANTHRACENE	0.7						0.124	<.1
FLUORANTHENE	1000						1.28	0.525
FLUORENE	1000						<.1	<.1
INDENO(1,2,3-cd)PYRENE	7						0.243	0.14
PYRENE	1000						1	0.5

APPENDIX M – Sample Temperature Data

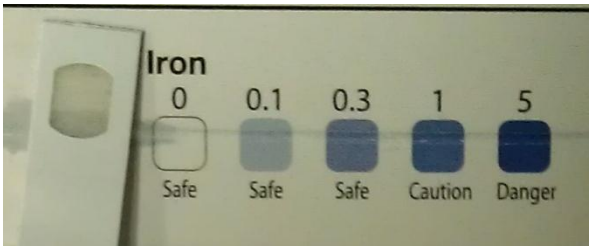
		Room 001			Room 191			Room 203		
Index	Time	Fahrenheit(°F)	Humidity(%rh)	dew point(°F)	Fahrenheit(°F)	Humidity(%rh)	dew point(°F)	Fahrenheit(°F)	Humidity(%rh)	dew point(°F)
1	7/11/2011 17:00	71	34	41.2						
41	7/11/2011 17:40	66	37	39						
81	7/11/2011 18:20	65	37	38.1						
121	7/11/2011 19:00	65	37.5	38.5	67	47	47	70	46	48.3
161	7/11/2011 19:40	65	38	38.8	67	47	47	69	45.5	47.1
201	7/11/2011 20:20	65	38	38.8	67	47.5	47.3	69	46	47.4
241	7/11/2011 21:00	65	38	38.8	67	48	47.6	69	46	47.4
281	7/11/2011 21:40	65	38	38.8	66	48	46.7	68	46	46.5
321	7/11/2011 22:20	64	38.5	38.3	66	48	46.7	68	46.5	46.8
361	7/11/2011 23:00	64	38.5	38.3	66	48	46.7	68	46.5	46.8
401	7/11/2011 23:40	64	39.5	38.9	66	48.5	47	68	47	47
441	8/11/2011 0:20	64	39.5	38.9	66	48.5	47	67	47	46.1
481	8/11/2011 1:00	64	39	38.6	66	48.5	47	67	47	46.1
521	8/11/2011 1:40	64	39	38.6	65	48.5	46	67	47	46.1
561	8/11/2011 2:20	64	40	39.2	65	48	45.8	67	46.5	45.8
601	8/11/2011 3:00	63	40	38.3	65	48	45.8	66	46.5	44.9
641	8/11/2011 3:40	63	40.5	38.6	65	47.5	45.5	66	47	45.2
681	8/11/2011 4:20	63	40.5	38.6	65	47.5	45.5	66	47	45.2
721	8/11/2011 5:00	63	40.5	38.6	64	46.5	44	66	46.5	44.9
761	8/11/2011 5:40	63	40.5	38.6	64	46.5	44	65	46.5	44
801	8/11/2011 6:20	63	42	39.6	64	47	44.3	65	48	44.9
841	8/11/2011 7:00	71	38.5	44.5	68	47	47	71	46	49.2
881	8/11/2011 7:40	72	38.5	45.4	73	42.5	48.9	74	43	50.1
921	8/11/2011 8:20	70	39.5	44.3	73	44	49.8	77	41.5	51.8
961	8/11/2011 9:00	71	40.5	45.8	75	44	51.6	79	40.5	53
1001	8/11/2011 9:40	72	41.5	47.4	77	43	52.8	80	40	53.5
1041	8/11/2011 10:20	71	43	47.4	78	40.5	52.1	82	38	53.9
1081	8/11/2011 11:00	70	43.5	46.8	76	41	50.6	80	38	52.1
1121	8/11/2011 11:40	70	45	47.7	74	43	50.1	78	40	51.7
1161	8/11/2011 12:20	70	45	47.7	74	44	50.7	77	41	51.5
1201	8/11/2011 13:00	69	44.5	46.5	73	44.5	50.1	76	42	51.3
1241	8/11/2011 13:40	70	45.5	48	73	45	50.4	76	43	51.9
1281	8/11/2011 14:20	69	45	46.8	72	45.5	49.8	76	43.5	52.2
1321	8/11/2011 15:00	69	46	47.4	72	43.5	48.6	75	43	51
1361	8/11/2011 15:40	69	45.5	47.1	71	37	43.4	75	39.5	48.7
1401	8/11/2011 16:20	69	45.5	47.1	70	35.5	41.5	74	36.5	45.7
1441	8/11/2011 17:00	69	45.5	47.1	69	39	43	74	38	46.8
1481	8/11/2011 17:40	68	45.5	46.2	68	44	45.3	73	38.5	46.3
1521	8/11/2011 18:20	68	45.5	46.2						
1546	8/11/2011 18:45	68	49	48.1						

APPENDIX N – Water Test

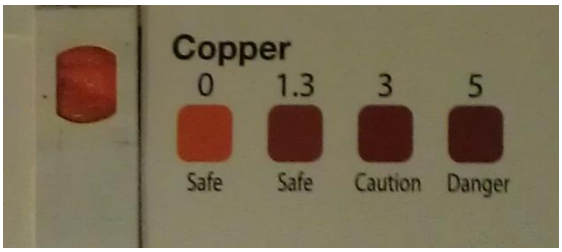
1890 building water test.



1890 building PH test results.



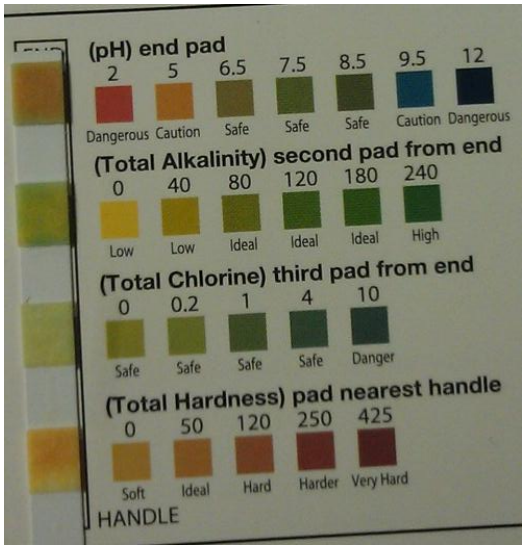
1890 building Iron test results.



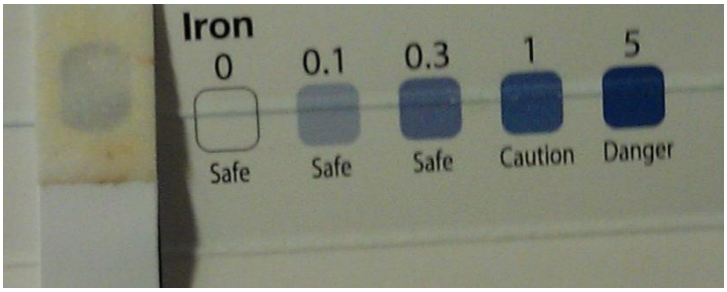
1890 building Copper test results.

1890 building Nitrate and Nitrite test results.

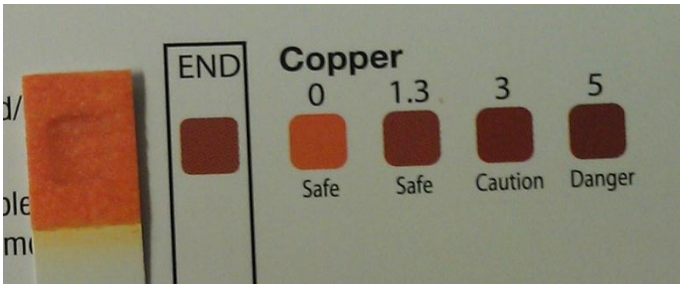
1960 building water test.



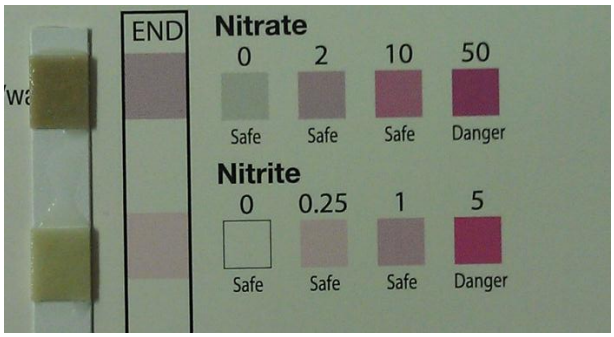
1960 building PH test results.



1960 building iron test results.



1960 building copper test results.



1960 building nitrate test results.

APPENDIX O – Teacher Survey

We are a group of Worcester Polytechnic Institute students who are working with the Oak Hill CDC to perform an energy audit on the Union Hill Elementary School. To begin this we must conduct a survey on the staff and students to create a baseline of how environmentally conscious the school is. We would appreciate it if you could complete this survey. Thank you for your help. We hope to use this information to create a better environment in the Union Hill Elementary School.

Questions:

1. What is the grade level of your class?

2. Do you recycle at home?

3. Do you recycle in the classroom?

4. Do you put your computer on standby when it is not in use?

5. How much do you use your computer/how many hours a day approximately are you using your computer?

6. How much do students use your computer/how many hours a day approximately are they using your computer

7. Do you turn the lights off when you leave the room?

8. How do you get to work?

9. How long is your commute?

10. Have you considered any of the following commute alternatives (circle all that apply)

    Public Transportation, Biking, Walking, Carpool, Other: _____

11. In your opinion, do the students learn better from traditional education methods (Pen/paper exercise, teacher lectures, etc.) or informal education methods (Media assisted instruction, long term projects, etc.)

APPENDIX P – Teacher Survey Results

Question 1: What is the grade level of your class? Even distribution

Answer	Number of Teachers	Percentage
Question 2: Do you recycle at home?		
Yes	31	91%
No	3	9%
Question 3: Do you recycle in the classroom?		
Yes	17	50%
No	17	50%
Question 4: Do you put your computer on standby when it is not in use?		
Yes	15	44%
No	18	53%
Negligible	1	3%
Question 5: How much do you use your computer/how many hours a day approximately are you using your computer?		
0-2 Hours	19	56%
3-5 Hours	10	29%
6+ Hours	4	12%
Negligible	1	3%
Question 6: How much do students use your computer/how many hours a day approximately are they using your computer?		
0-2 Hours	32	94%
3-5 Hours	1	3%
6+ Hours	1	3%
Question 7: Do you turn the lights off when you leave the room?		
Yes	30	88%
No	4	12%

Answer	Number of Teachers	Percentage
Question 8: How do you get to work?		
Drive	34	100%
Walk	0	0%
Public Transportation	0	0%
Question 9: How long is your commute?		
0-15 Minutes	22	64%
15-30 Minutes	8	24%
30-60 Minutes	3	9%
60+ Minutes	1	1%
Question 10: Have you considered any of the following commute alternatives?		
Public Transportation	0	0%
Biking	1	3%
Walking	2	6%
Carpool	3	9%
Other	0	0%
None	29	82%
Question 11: In your opinion do the students learn better from traditional education methods (Pen/Paper exercise, teacher lectures, etc.) or informal education methods (media assisted instruction, long term projects, etc.)?		
Traditional	8	24%
Informal	2	6%
Both	24	70%

APPENDIX Q – Student Survey

Student Questions

1. Do you recycle at home?
   - ◯ Yes
   - ◯ No

2. Do you turn lights off when you leave the room?
   - ◯ Yes
   - ◯ No

3. How do you get to school? (Check all that apply)
   - ◯ I ride the Bus
   - ◯ My parent/guardian drives me
   - ◯ I drive with someone else (more than one student per car)

4. Do you shut the water off while you brush your teeth?
   - ◯ Yes
   - ◯ No

5. How do you learn best? (Pick **two**)
   - ◯ Teacher presentation
   - ◯ Work at your desk
   - ◯ Computer activity
   - ◯ Week-long project
   - ◯ Month-long project
   - ◯ Science experiments

APPENDIX R – Student Survey Results

Answer	Number of Students	Percentage
Do you recycle at home?		
Yes	19	90%
No	2	10%
Do you turn lights off when you leave the room?		
Yes	17	81%
No	4	19%
How do you get to school" (Check all that apply)		
Ride the bus	5	24%
Parents drive you	10	47%
Carpool	2	10%
Walk	4	19%
Do you shut the water off while you brush your teeth		
Yes	17	81%
No	4	19%
How do you learn best? (Check two)		
Teacher Presentation	9	29%
Work at desk	10	32%
Computer Activity	4	13%
Week-long Project	1	3%
Month-long Project	2	6%
Science Experiments	5	17%

APPENDIX S – Parent Survey

Parent Questions

1. Do you recycle at home?
   - ◯ Yes
   - ◯ No
2. Do you turn the lights off when you leave the room?
   - ◯ Yes
   - ◯ No
3. Do you turn the television/radio off when you leave the room?
   - ◯ Yes
   - ◯ No
4. Do you turn the computer off when you leave the room?
   - ◯ Yes
   - ◯ No
5. Do you shut the water off while you brush your teeth?
   - ◯ Yes
   - ◯ No
6. Is your thermostat on a timer that automatically controls it at night or during the day when no one is home?
   - ◯ Yes
   - ◯ No
   - ◯ Not sure
7. Are there any energy efficient bulbs installed in your residence?
   - ◯ Yes
   - ◯ No

Energy Efficient

NOT Energy Efficient

APPENDIX T – Parent Survey Results

Answer	Number of Students	Percentage
Do you recycle at home?		
Yes	22	85%
No	4	15%
Do you turn lights off when you leave the room?		
Yes	25	96%
No	1	4%
Do you turn the television/radio off when you leave the room?		
Yes	22	85%
No	4	15%
Do you turn the computer off when you leave the room?		
Yes	20	77%
No	3	11.5%
N/A	3	11.5%
Do you shut the water off while you brush your teeth?		
Yes	18	69%
No	8	31%
Is your thermostat on a timer that automatically controls it at night or during the day when no one is home?		
Yes	10	38%
No	7	27%
Not Sure	9	35%
Are there any energy efficient bulbs installed in you residence?		
Yes	18	69%
No	8	31%

APPENDIX U – Complete List of Recommendations

Category	Sub-Category	Recommendations
Green Recommendations	Wind Energy	• Not Applicable
	Solar Power	• Install solar panel array on roof for energy harvesting; install solar panel visible in main office to promote and inspire environmental consciousness.
	Water Conservation	• Install reduced flow nozzles on bathroom sinks. • Instruct school chefs to only use dishwasher if full. • Domestic Hot Water: Schedule setbacks to reduce water temperatures during unoccupied periods. • Install motion detection faucets.
	Recycling	• Look into any of the following programs and decide which is best for the Union Hill Elementary School • RecycleNow is a program guide that provides a five step approach to developing and implementing a school recycling program. (http://www.recyclenow.com/what_can_i_do_today/start_recycling_at.html) • Earth 911 is a national organization that offers a lot of assistance and knowledge about environmental issues, specifically recycling. Tips from Earth 911 can be found at this link (http://earth911.com/recycling/paper/paper-recycling-at-school/) and provide a great educational value for students and their families. Using the links contained on the website allows educators and students to find a variety of standards-based activities that highlight the opportunities for increased paper recovery in their own schools and homes. Furthermore, there are video and case study highlights of the difference students can make for their school, their community and their environment. • The Go Green Initiative is a simple, comprehensive program designed to create a culture of environmental responsibility on school campuses across the nation. Founded in 2002, the Go Green Initiative unites parents, students, teachers and school administrators in an effort to make real and lasting changes in their campus communities that will protect children and the environment for years to come. http://www.gogreeninitiative.org/ • Put up recycling posters around the school to remind students the importance of recycling.
	Transportation Organization	• organize transportation to/from school every day for teachers and students.

Building Envelope	Windows and Doors	• Choose windows and doors with a low U-Factor.
		  ○ Make sure the U-factor applies to the entire window and not just the glass pane
		  ○ The U-factor should be below .5, and optimally below .4
		  ○ This can be obtained with a Low- Emittance coating on the glass
		  ○ This can also be obtained from using gas fills between glass panes
		  ○ Multiple pane windows will create a lower U-factor
		  ○ Avoid windows and doors with aluminum frames
		▪ Wood, vinyl, and fiberglass are the best materials for insulation in frames
		• Pay attention to the Solar Gain Coefficient
		  ○ South facing windows and doors create solar heat during the heating season, a higher solar heat coefficient will maximize this advantage
		  ○ East and West facing windows and doors create solar heating during the cooling season; these windows should have a lower solar heat gain to minimize this effect. This could also be minimized with blinds or drapes to block the sunlight
		  ○ North facing windows and doors do not have a large effect on solar heat gain. Because of this it is not important to spend money for lower solar heat coefficient windows and doors.
		• Windows should be operable if possible
		  ○ This allows for ventilation, improves comfort, and reduces need for air conditioning.
		• Blinds or drapes should be considered for windows were possible
		  ○ Can vary solar heat depending on time of day and season
		  ○ Between the glass blinds can reduce solar heat gain by forty-three percent compared to traditional room side blinds
		▪ Improves air quality by eliminating the dust, dirt, and allergens associated with hard to clean blinds.
		▪ Provides acoustic insulation from outside noises
		• Consider better mounting surfaces for window air conditioners
		  ○ Utilize window manufacturers air conditioner mounts
		▪ Increases U-factor of window and increases aesthetics
		  ○ Use air conditioner covers in winter or remove air conditioners in winter
		• Realign or re-hang windows and doors that do not close properly
		• Weather-stripping on all exterior doors to eliminate gaps between door and frame
		  ○ Replace current worn and cracking calking and weather-stripping
		• Caulking around window and door frames to reduce air passing between the frame and the wall
		• Replacing broken glass panes in all windows and doors
		• Fixing window panes that are separating from the frame and creating gaps
		• Use air conditioner covers in winter or remove air conditioners in winter

<table>
<tr><td rowspan="2">Building Envelope</td><td>Roofing</td><td>

Install a White roof by using white roofing material over the existing roof
Install a Green roof by using vegetation to increase the insulation value of the roofo Install an Intensive Green Roof with safety precautions to allow students to be involved with the roofo Install an Extensive Green Roof and not allow students on top of the roof for safety reasons, but still take advantage of the benefits.
Install a White roof on top of the 1890 building and a Green roof on top of 1960 building

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<tr><td>HVAC</td><td>
Heating

Replace temporary boiler in 1890 building; add boiler to 1960 building, where there is currently no active heating system.
Develop routine boiler maintenance per manufacturer’s instructions.
Install control to automatically shut down heat generating device when outside air temperature reaches 60ºF.
If soot and odors are detected in areas where they are not expected:

Heat exchanger may have burned out. Replace.
Stack draft may be inadequate. Clean and correct as necessary.
Perform flue gas analysis to obtain proper air to fuel ration.
Check operation of furnace draft controller.
Check boiler setting for leaks.
Clean air inlets or outlets if dirty or obstructed.
Reduce thermostat settings by a minimum of 10ºF at nights, for weekends and holidays during heating season

Cooling

Consider installing a central air system
Add 29,000 BTUs of cooling to Room 391.

Rooms needs approximately 47,000 BTUs total, consider using one large AC unit instead of five small units for efficiency

Add 34,500 BTUs of cooling to Room 191
Check Principal’s office air conditioner for function. Wattage is lower than expected, so it might not function properly.
Where practical, cover through the wall cooling units when not in use. Specially designed covers can be obtained at relatively low cost.

Cover Air Conditioners during winter or take them down.

Turn off pilots during cooling season, if applicable.

Energy Management System

Install an automated energy management system that will control all spaces in accordance with usage and temperature (i.e. allow rooms to be controlled separately).

Adjust thermostats to 68-70ºF in heating season and to 78ºF during cooling season.

Experiment with start-up times and duration of operation to determine satisfactory comfort levels for occupants. Reduce or turn off heating and cooling during the last hour of occupancy, allowing the building temperature to ‘coast.’

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Health Recommendations	Air Quality	• For further information on Air Quality Testing, contact the Emergency Response/Indoor Air Quality Program: (617) 624-5757.
	Lead	• We recommend that The Union Hill Elementary School get in contact with The Environmental Chemistry Laboratory to find out how they can obtain a more in depth analysis of lead in their building. ○ The number to contact the laboratory is (617) 983-6657.

Electricity Consumption	Lighting	**Behavioral**
		• Establish a regular inspection and cleaning schedule for lamps and luminaires (fixtures). Dust buildup reduces effectiveness.
		  o Including windows
		  o Replace lens shielding that has turned yellow or hazy with new acrylic lenses which do not discolor.
		  o Clean surfaces to increase reflectivity
		• Utilize available daylight more effectively for illumination
		  o Do not hang posters high on walls (reduces reflectance)
		  o Do not hang posters on windows
		  o Remove bookshelves and other furniture that blocks sunlight.
		  o If half lights are a better option, shut lights off closer to the window
		• switch off lights at night and in unoccupied areas during the daytime
		  o Post instruction to turn off lights when leaving area.
		
		Infrastructural
		• Install switch banks - Rewire switches so that one switch does not control all fixtures in a room.
		  o Switch on alternate lights in row of fluorescents for better lighting distribution
		• Do not consider dimmers – they are not efficient
		• Replace North-West HID light that makes noise
		• Replace flickering lights
		• Replace incandescent bulbs with fluorescent where appropriate
		  o Example: small bathrooms.
		• Replace lights that do not function (if under-illuminated)
		  o Ex) bathroom 347 is under-illuminated
		• In the case that there is always over-illumination, remove lights from fixtures (evenly within the room)
		• Install drapes to reduce over-illumination when all lights are off.
		• Install photosensors and switching equipment which automatically compensate for varying natural lighting conditions and room use.
		• Disconnect ballasts (which still use significant amount of energy even though tubes have been removed) in fixtures where fluorescent lamps have been removed.
		• reduce the levels of illumination at selected task locations, and lower them further between or beyond the tasks
		• Replace lights “with more efficient light sources”
		  o Consider 15 Watt LED T8 bulbs.
		• Increase luminance in all-purpose room. The current luminance is way under the OSHA standard and need to provide much more light.
		• Reduce the losses in power distribution system that serves the lighting system
		• Use of Solar Tubes in Hallway and classroom to introduce sunlight

Electricity Consumption	Office Equipment	• Install automatic controls such as time clocks or automated management systems.
		  o Example: time clocks for network switches
		• Set computers to automatically hibernate after a set period of time
		• Utilize program to shut off computers at night.
		  o Contact Bob Walton, Worcester Public School IT manager
		  o Develop maintenance schedule for this program
		• Posters to tell printer operators to put in energy saving mode when not in active use
		• Reduce idle time before sleep for smaller laser printers.

	National Grid relationship/incentive programs	• One recommendation we make to help with the cost of these projects is to utilize National Grid's Incentives Program. o This is because National Grid will pay for a percentage of the cost to make energy efficient upgrades.

Outreach	Teaching	• Utilize Worcester Tree Initiative curriculum
		  ○ Follow Initial Instructions in Planting Tree section
		  ○ Educational material and classes about the significance of planting trees
		• Utilize Regional Environmental Council curriculum
		  ○ Follow Initial instructions in Community Garden section
		• Cooking For Youth Program
		• Utilize National Grid Media Learning
		• Energy World Program
		• Found at http://www.ngridenergyworld.com/
		  ○ Multitudes of topics for students to learn about at Union Hill
		  ○ Electrical and Natural Gas Safety
		  ○ Energy Efficiency
		  ○ Energy and Your Environment
		• Make available Health Homes homeowner educational material in main office
		• After school activities
		  ○ Maintenance of community garden

	Community Garden	• School must go through the REC Application process in order to be chosen for the UGrow program • Build a committee of Union Hill Staff and Oak Hill Residence who would be interested in the UGrow Program. • Committee must determine how the garden will be taken care of • Committee must determine where the garden will go • Oak Hill CDC has an empty lot on Chaplin Street as an example of a possible area near the school. • The students of Union Hill Elementary and the Oak Hill Community will have to be involved in the build in order to ensure success of the Community Garden. At least twenty to twenty-five people should be involved. • The garden build usually happens in the spring time. • It's good to start as soon as possible to prevent any problems during the spring time when the build would actually happen. • Once application process and committee is built, a build date has to be determined. • Once the build is complete, educational programs and after school activities can be set up to utilize the garden.

Outreach	Planting Trees	• Contact Peggy Middaugh of the Worcester Tree Initiative program • President of the organization, her contact information can be found on the Worcester Tree Initiative website. • Build a committee of Union Hill staff, Oak Hill CDC staff, and community members to push for the program. • The environmental and educational benefits of the program should get this off the ground very easily. • Should incorporate members that will care about the well-being of the trees and the program itself. • Pick out a site for the tree planting • An Oak Hill property would be the most feasible to use in this case. An example being the Oak Hill Property lot right down the road from the Union Hill Elementary School on Chaplin St. • Fill out the application form on the Worcester Tree Initiative website.
	Cleaner Streets Program	• Integration into school curriculum or after school activities. • Anti-littering messages on buses, billboards, etc. • Mass media campaigns on the radio, and/or television. • Cleanup campaigns that also provide information about how litter, or chemicals from litter, can be harmful to human and wildlife health.