REIMAGINING COMMUNITIES
A LOOK INTO GREEN INFRASTRUCTURE AND GREEN BUILDING DESIGN

By

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EPIGRAPH

John Muir once said, “When we try to pick anything by itself, we find it hitched to
everything else within the universe”. I think his statement highlights what we have as a
society has lost. Many of our day-to-day activities and our future plans have and
continuously fail to recognize this concept. This is especially true within the
developmental ideals that our society uses to construct homes, neighborhoods,
communities, towns, and cities. A refocusing of the interrelationship between ecological
systems and human systems needs to be achieved if we are to be successful in
sustainable development.

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ABSTRACT

This paper attempts to compare current community infrastructure and building design strategies with those strategies that embrace green and environmentally-inclusive infrastructure design as well as green building design. Through extensive research of many green infrastructure and green building design strategies this paper has highlighted those options that are widely accepted and regarded as intelligent and worthwhile strategies towards integrating green technology and ideas into a community design.

PREFACE

Thesis Statement

The current development of communities is not conducive to sustainable growth and best management practices as they fail to integrate, or in many cases inhibit, concepts and ideals of sustainable development.

Why did you choose topic?

I wanted to learn more about smart growth; best practices as well as the various techniques and technologies that are available. By further expanding my knowledge of technologies, material use, energy use, water management, and waste management practices, I hope to use it as a foundation for my pursuit of becoming a professional in sustainable building and sustainable infrastructure design.
Goals

1. Determine Best Practices, Techniques, and Technologies of Sustainable Community Infrastructure and Building Design

2. Outline best practices and concepts as it relates to Green Infrastructure and Green Community Design

3. Provide strategies for Green Infrastructure and Green Building Design based off the aforementioned concepts.

Research Problem and Questions

It seems that the problem lies within the fact that there is a clear disconnect between mankind and nature which needs to be resolved if we are to be able to adapt to the changing natural environment. Communities of today do not lend themselves to sustainable and environmental ideals, as they rely on resources well outside of their boundaries, in particular, energy and food products. This hinders localized workforces and their residents by making commuting relatively convenient which becomes a detriment to the environment. How cities, towns, and developments are situated and planned acts as a hindrance in our ability to “roll with the punches” as we are so embedded in our current lifestyles. In the future we need to plan communities, villages, and cities that are self-sustaining, constructed from local materials, and are powered by renewable technologies. These communities should be able to provide all necessary services such as health, education, leisure and entertainment as well as consumable goods. The problem that I am trying to solve is how to successfully implement a plan to design a sustainable community/development that meets widely recognized and
accepted concepts of sustainable development through the lens of Green Infrastructure and Green Building Design.

**Significance of Sustainability Studies**

This project is significant in the field of sustainability studies because of the concept of taking an integrated approach in designing sustainable practices into the existing urban and community developmental landscape. Developing alternatives and options in planning a community to be more sustainable is at the heart of what we are discussing. The exploration of these examples of sustainable development permits one to be able to mesh these various avenues of approaches into a cohesive document. Understanding the interactions between the hundreds if not thousands of variables and having the knowledge and skills to recognize them is the only path of true integration and sustainable development.
CHAPTER 1: LITERATURE REVIEW

Community Involvement

Developers and governments have found that promoting community participation in the planning stages of a new development will more often than not bring about suggestions and ideas that advocate smart growth ideals. Many avenues of promoting community participation include performing a charrette, which is a collaborative design process involving multiple stakeholders, as well as placing information in local newspapers, and running a real-time information website. (Duany, Speck, & Lydon, 2010) Decisions made early in the design process will have the largest impact on the success of the development of a building or a community. The U.S. Green Building Council and the Department of Energy have determined that by the time 3% of the design budget for a new home has been spent, nearly 70% of the energy use of its lifetime has been set in stone. This clearly demonstrates that success is dependent on the active participation of everyone with the project. (Johnston & Gibson, 2008) Many experts agree that getting the community involved early in the process could only be beneficial to the overall outcome of a project. The community knows what is important in their neighborhood, town, or city as they live in the area. Promoting the interaction of local community members is important as they have a stake in the process and they are more inclined to be of assistance in the decision making process. Many new redevelopment projects make an effort in trying to get the community’s input as they recognize the wealth of
knowledge that can be utilized. The knowledge of this is evident in the books and articles that I have read and decided are worth mentioning in this paper.

**Growth Priorities**

A community built with a smart growth mentality needs to have a clear prioritization of growth alternatives if it is to be successful in obtaining public funding for infrastructure and private investment for development. Development goals should start with urban revitalization or urban infill projects rather than promoting the creation of new neighborhoods which require new infrastructure or even worse are built in areas that are environmentally sensitive. (Duany, Speck, & Lydon, 2010) Providing well defined and structure growth priorities is a must if a town or community seeks to explore avenues to grow their infrastructure and expand areas, whether vertical or horizontal movement. Many experts agree that failure to look closely at what is prioritized during processes of growth is the main cause for the absurd levels of growth in sub-urban locations. Examples of the unchecked growth is prevalent everywhere and the various problems that are linked to this type of growth are very visible. Experts are well aware of this problem and there is much literature that deals in some shape or form with this issue that plagues towns and cities.

**Food**

Communities and cities need to allocate area for localized farmland to help protect cities and metropolitan areas from the growing costs of shipping and refrigeration of foods from long distances away. Communities that have any hope of surviving in the long run need to come to the realization that planning for food security now will only
benefit them in the future as other towns struggle to maintain their livelihood. (Duany, Speck, & Lydon, 2010) The cultivation of food was at one time a much more integral part of western culture. Institutions and communities tended their own agriculture spaces. Life was aligned with the health of the earth and its inhabitants in a single ecosystem. By providing a framework for community involvement, institutions can foster food production for individuals and communities. (Clark, 2010) Food is an integral part of our lives and culture so there is no escaping the fact of its importance. Of recent times, there has been a large push for the localization of food as local food is not put through the same processing processes as food shipped across the country or from other countries. It is suggested that because of this difference, local food is healthier to consume since the minerals and vitamins are not lost in the processing as compared to conventionally harvested food. Understanding the importance of localized food is paramount because protecting this natural resource is in our best interest. Much of the literature agrees that the localization of food is not only good for our own health, but also for the health of the environment. There is no argument that local food is good food when comparing it to the agribusiness food system.

**Limits of Water**

It is well know that many metropolitan communities are greatly exceeding the replenish rates of their local water bodies and aquifers. Neighborhoods need to be planned to promote the replenishment of local water bodies in conjunction with reducing the overall need of fresh and potable water for uses other than human consumption. There are too many locations that are “borrowing” water sources to supply their overuse of
the resource which puts a strain not only on the other location, but feeds the idea that if water is not readily available in one location that to import it is a viable solution.

(Duany, Speck, & Lydon, 2010) This is a big problem in much of the world but specifically in the Midwest of the United States. Towns and cities are consuming much more water than their local water bodies are able to store and replenish. A prime example of a city operating well out of its capacity is the city of San Francisco which has to have water pumped from northern Californian water bodies and aquifers, a distance of 250 miles to over 400 miles. Towns and cities need to operate within their means as “borrowing” resources depletes the ability for other sources to maintain a sustainable yield.

**Stormwater Management**

Communities should promote the existing natural drainage and percolation patterns of the site. Planners should prohibit changing the overall topography of the area while promoting infiltration of water by using permeable surfaces. Buildings and hardscapes should be built with a setback to protect porous soils as they have been found to be better absorbers and retainers of water than designed retention and detention basins, which have been found to also be somewhat aesthetically undesirable. (Duany, Speck, & Lydon, 2010) To prevent flooding in many of the early city-states in Europe, planners set aside large sites dedicated to native plants, the precursors of today’s bioswales, to handle times of heavy rainfall so that the water flowed out of the city or percolated directly into the ground. (Corbett, 2010) Planners and landscape architects are well aware of the problems of not properly managing stormwater runoff. Unfortunately this poor strategy has a tendency to disrupt natural waterways and damage natural and
human-created structures. That said, it is widely known that designing systems that slow and reduce stormwater runoff, such as swales and retention ponds, are best practices to solve this problem. There is no doubt that managing stormwater benefits not only the integrity of the built environment, but also protects waterways and enables for the reestablishment of water bodies and aquifers. I am not aware of any potential gaps in studies or articles of how to manage stormwater and the various techniques and technologies that go along with it. This is a well-recognized problem and there are many natural and engineered solutions to resolve this problem.

**Transit Orientation**

For communities to promote the use of mass transit alternatives over single user automobiles they need to follow four established criteria. The mass transit system needs to follow a simple trajectory. Two of the most popular are either a relatively straight line or a loop, as users of mass transit prefer the simplicity and ease of knowing the exact path of the mass transit vehicle. To further boost mass transit ridership, frequent service is necessary as studies have shown fifteen minutes is the maximum time that users will wait. Finally, the transit stop must be comfortable and shielded from the elements while the path to the transit stop must be easy to get to as well as a pleasant trip. Studies have shown that residents will readily walk five minutes to a bus stop and ten minutes to a rail stop. Buses are more useful at linking neighborhood centers while light rail can remain along the outskirts of these centers to better enable further use of mass transit for distant travels. (Duany, Speck, & Lydon, 2010) Good transportation planning has become very important in planning dimensions for towns
and cities as major thoroughfares in many active cities and towns have become
overwhelmed with personal vehicles and the associated traffic problems. Many cities
are developing new strategies to deal with the growing problem of extreme congestion
and traffic, so it can be said that solving this problem is on the minds of many traffic
planners and developers.

**Complete Streets**

Neighborhoods that have integrated automobile use with pedestrian and bicycle usage
have been shown to enliven downtown community life. Many of these thoroughfares
include narrower lanes for cars, which inhibits faster traffic, as well as on-street parking,
continuous tree cover, wide sidewalks, and supportive building structures. If designed
correctly these areas can be places of community gatherings and pleasant experiences
which will make people more likely to walk and bike to the area rather than drive their
automobiles. (Duany, Speck, & Lydon, 2010) Complete streets is a concept that is
gaining steam in towns and cities that seek to better integrate walkable spaces, bike
lines, mass transit lanes, and through traffic. Many cities that wish to liven up their
downtown areas, or create a sense of a downtown, are implementing ideas of complete
streets to provide access for residents to walk to stores, coffee shops, and local public
spaces to purchase goods and interact. This concept is not in its infancy but it seems
that many urban planners and designers are not looking at it as a resource to better
integrate different kinds of mobility options that are available to a town. I think the
concept is complete and understood well, but it is not implemented in many areas that
could benefit from it.
**Urban Parks**

Access to nature is considered a basic right. By promoting the development of urban parks allows better entry for those who are without the means of driving, mostly the elderly and the early teens. Studies have shown the creative-class workers consistently list having ready access to natural areas as a dominant factor in choosing an area to live. Having a place for individuals of the community to escape for a few hours or a whole day is a great benefit to strengthen the wellbeing of both the individual and the community. (Duany, Speck, & Lydon, 2010) Urban parks used to be more popular in urban settings, but lost the battle with new construction of large skyscrapers and buildings. However, individuals understand the importance of having a small piece of natural land dispersed within the confines of an urban landscape. Many major cities are making the connection of human interaction with nature; New York City made a fairly large jump into this field by retrofitting an existing elevated subway line into an elevated park strip. Much of the literature makes reference to the importance of green spaces in urban spaces to provide a point of relaxation and release of stress of urban dwellers.

**Smart Code**

The concept of the SmartCode provides a method to work around the many current building codes that have made smart growth techniques illegal. The SmartCode is a viable alternative in locations where it might be politically difficult or simply unnecessary to change the existing codes for communities but allow them to have more power to better integrate smart growth. (Duany, Speck, & Lydon, 2010) The SmartCode is a form-based code that incorporates both smart growth and new urbanism principles
by addressing development at all scales of development. The code is based on rural-to-
urban transects instead of the conventional separated-use zoning that has been the go
to source for regional planning. Towns that have implemented the SmartCode have
been successful in promoting development patterns such as mixed use and walkability.
(Center for Applied Transect Studies, 2009) The SmartCode has been implemented in
some cities in the United States but it has not really made it to the national scale as far
as I can tell. I think that if more planners and developers’ embraced the SmartCode,
towns and cities would be better prepared to handle changes in growth patterns while
promoting integrative techniques and technologies that would lead to smart growth and
environmental stewardship. Much of the literature mentions some type of form based
code, even if they do not mention the SmartCode directly, as being an important
resource to be had.

**Form-Based Codes**

Form-based codes promote development that is framed around a smart growth plan of
building configurations. These codes mandate that big buildings are zoned with other
big buildings, midsized buildings with midsized buildings, etc. As buildings move further
from the community center the size of the buildings shrink to the neighborhood edge.
These types of codes are beneficial as the coexistence of multiple building types avoids
physical and social monocultures and allows for evolution of uses. It also promotes
keeping street’s lengths and looks consistent as this keeps the aesthetics of zoning
transitions palatable. Form-based codes are able to better regulate buildings by
controlling their configuration and disposition on a lot. (Duany, Speck, & Lydon, 2010)
Urban developers and planners who seek an integrated approach such as smart growth techniques look toward form-based codes to set forth expectations for zoning and building configurations that are in line with higher density and diversity development. Literature that discusses urban transformation and redevelopment promotes the enacting of form-based codes as a standard for retrofitting a community.

**Pocket Parks**

Providing small open space lots for the use of recreation has been found to benefit communities where space might be an issue. These open spaces can be developed as a conventional park or a playground for young children or any combination of the two. Most pocket parks are around ¼ acre in size and are best placed at a staggered intersections or vista terminations. Pocket parks in many communities are funded through municipal park departments and in some cases, are maintained through neighborhood associations. (Duany, Speck, & Lydon, 2010) The concept of pocket parks is not new as many urban cities at one time contained these types of areas, although they might have not been designated as “pocket” parks. The important aspect of pocket parks is that they provide a small area of natural landscape in a sea of urban development. Pocket parks are well understood and in many communities are welcomed as an area for residents to go and relax. The only gap that I found in the literature about this topic is that many towns and cities are prioritizing development over maintaining or creating parks in urban settings.
Edible Gardens

By encouraging food production within a community it not only reduces dependency on shipped produce from outside of the community but also can cause a sense of ownership for those growing their own food. Small farms of a couple of acres on the outskirts of community can provide employment for residents of the community while providing localized food for the community. More suburban housing lots can implement yard gardens to help supplement their own food needs. For those living in more urban settings, container gardens within window boxes can provide a small supply for those residents. Another alternative for suburban and urban residents is implementing community gardens which are maintained by the local residents. (Duany, Speck, & Lydon, 2010) This concept sounds quite simple as it is just setting aside small parcel of space where residents to grow any number of types of produce. There is a plentiful amount of literature that describes the best locations for edible gardens, what type of produce to grow on a given parcel of land, and how to maintain the garden. It is safe to say that there is much knowledge on edible gardens.

Architectural Designs

Buildings are built independent of their systems. Building occupants should be able to thrive in a building. To achieve this, a building’s its architecture, internal systems, and landscape should be designed in conjunction with each other. The architecture is not dependent on the mechanized systems of the building. For a building or community to meet this principle ideal, architects must design buildings and communities with natural systems to meet basic comfort needs. Buildings are designed to be independent of their
internal systems, such as lighting and space conditioning. Designers and planners can substitute mechanized systems for natural systems. Space lighting can be replaced by daylighting systems; space conditioning can be replaced with operable windows, etc. The building’s form enhances and amplifies its performance. It is measured by the degree of human comfort and optimal use of energy, water and material. A building’s form should incorporate the aspects required for proper daylighting and ventilation. An example of this principal can be seen in organic architecture where the building form connects directly to the natural word including its systems and materials. (Clark, 2010)

Constructing a building as part of a system by having the architecture work for the building, instead of it just being the aesthetic shell of the building can spell great savings in reducing or eliminating mechanical system costs. This is not a new idea, but seems to have been forgotten in much of the way buildings are conventionally constructed. There is plenty of knowledge of how to meld the architectural and building processes together, but very few individuals and companies are implementing such a technique.

**Aesthetics**

A fairly compelling reason to encourage stylistic consistency is to support diversity of the building stock. When mixing residential and commercial spaces, a common architectural vocabulary provides a level of camouflage in hiding the distinctions of the different building uses. For example a corner store will not seem out of place when placed near a series of row houses if there architecture is similar in appearance. This prevents the look of “cookie cutter” development while achieving a better sense of place. (Duany, Speck, & Lydon, 2010) The current design of our neighborhoods, towns, and cities, promotes
architectural clutter. As we move through our urban areas, almost every view is infected with unsightly telephone poles, towers, and wires, along with fences, barricades, enclosures, and utility structures. The urban landscape is inundated with buildings of many different designs and materials with no logical local theme. They were designed with inconsequential details and random materials that were applied with no regard for the local climate, culture, or history. (Corbett, 2010) The aesthetics of a building is very important as too few planners and developers create ugly buildings that do not reflect the look or feel of the area it is constructed in. There are too many buildings that use bland colors or unexciting shapes, like the big gray box stores that dot suburbia. There are also many examples of buildings that are both functional and aesthetically pleasing to the users and the surrounding environment. There architects need to be both artisans and designers in order for their buildings to be functional and pleasing to the eye. Local knowledge exists for different localities as the look and feel of a building will change as the location changes.

**Mixed Use**

A community should achieve a balanced mix of housing units, commercial units, areas to shop, areas for recreation and public civic properties. To encourage mixed use, communities should incentivize developers and neighborhoods that promote these techniques as they have been shown to reduce the impact of traffic as well as the costs of infrastructure. Other types of mixed use buildings include live/work buildings. These structures tend to be located closer to the neighborhood center as they provide a better transition from residential structure to more commercialized buildings. (Duany, Speck, &
Lydon, 2010) This concept is well known and welcomed in many towns and cities as it strengthens the ability for the establishment of downtown areas and brings residents closer to commercial and community locations. Unfortunately, relatively few towns and cities have implemented mixed use codes into their development and building codes, so there is not much of a push. There is much knowledge about planning for mixed use but it seems there are few who are really promoting it.

**Housing Diversity**

A healthy neighborhood survives on social networks which can be further strengthened by having a diversity of ages. By providing different types of housing within the same community, it allows individuals to maintain their already established social networks. This can be beneficial if they choose to upsize or downsize into a different residence. Lifecycle communities generate the strongest support systems for those who reside in them. Also by providing a diverse set of housing types, communities can readily support faster adsorption of different groups of individuals (young professionals, families, elderly). (Duany, Speck, & Lydon, 2010) This concept is well known and welcomed in many towns and cities as it strengthens the diversity of individuals that chose to live in area. It also allows for residents to live in a town for an extended period of time as different residential structures are available as the residents might want to upgrade or downgrade their living spaces. Unfortunately, relatively few towns and cities have created the necessary housing diversity in their development, so there is not much of supply of housing types for residents. There is much knowledge about the planning of housing diversity but it seems there are few who are really promoting it.
Retail/Workplace Diversity

A community should establish a main street of local stores that include places of businesses, such as cafes and barbershops, which should be easily accessible by the residents of the town. Many developers who have implemented store diversity on the main streets of their communities proclaim that it is regarded as a prized amenity of the community and helps establish social interactions between residents of the community. Integrating local stores and civic facilities, such as a café and a post office, will further strengthen the community bond between residents. Providing opportunities to residents to live and work within the community is beneficial not only to the individual, but will also reduce traffic congestion during peak commuting hours. Providing employment centers nearby to housing complexes also promotes easier access to local services. (Duany, Speck, & Lydon, 2010) This concept is well known and welcomed in many towns and cities as it strengthens the diversity of businesses that choose to set up shop in area. It also allows for residents to work or shop within the town as different types of structures exist. Unfortunately relatively few towns and cities have created commercial and workplace diversity in their development, so there is not much of supply of shop types for residents. There is much knowledge about the planning of retail and workplace diversity but it seems there are few who are really promoting it.

Civic/Support Centers

Public and civic buildings and institutions should be situated within walking distance, which is determined to be within one quarter of a mile to a half mile of most, if not all community dwellings, in order to promote walking and bicycling to locations. Schools
should be located within the neighborhood and be within walking or biking distance of residences rather than be consolidated into larger school buildings which are outside of the community forcing the implementation of busing routes. A greater number of smaller schools are more beneficial to the community than a handful of larger schools. In addition to the benefits already mentioned, smaller class sizes are also beneficial to the educational quality of the students as smaller schools have been shown to produce higher-performing students who are healthier since they walk to school. Also since more students are walking or riding their bikes to the schools, is reduces traffic as the need for buses and chauffeuring parents is virtually eliminated. This idea should also be applied to other services such as day care centers and local recreational centers. (Duany, Speck, & Lydon, 2010) In old European cities, the town center almost always contained a central plaza in which contained many of the civic buildings, including town hall, governmental buildings, libraries, etc. These cities were designed in this fashion because it provided a central point for all residents to congregate for entertainment and other activities. (Corbett, 2010) It is well understood that towns and cities that have strong civic and support centers are better suited to serve their residents. These spaces support the livelihood of the town’s residents and bring the community closer. There are relatively few towns and cities that have created or maintained their civic and support centers in a capacity that is beneficial to the community. Many planners and developers are beginning to understand (or remember) the importance of designing strong civic and support centers to benefit the community and its residents.
Density

Higher density development has been found to mitigate many problems that sprawl conjurors up. Density places more people on a section of land thereby preserving more open space. Density is also more supportive of mass transit as it reduces the dependence of automobiles. To combat the perception of the “American Dream” density must be seen as convenient and simple by promoting walkability and other smart growth techniques. (Duany, Speck, & Lydon, 2010) Many developers and planners shy away from using this “D” word as people have been taught to think that density is a bad thing. Many people moved out of the cities into what is now defined as suburbia to get away from this density. However, people fail to realize that density is a much more efficient use of land and resources. There is much discussion of how to integrate density back into the development of towns and cities without scaring off potential residents. This topic is well established and has plenty of literature to explain the various concepts and techniques of integrating density into areas.

LEED Neighborhood Development

LEED for Neighborhood Development (LEED ND) is a joint effort between the Congress for New Urbanism, Natural Resources Defense Council, and U.S. Green Building Council (USGBC). LEED ND is a community-scale expansion of the conventional LEED green building certification program. This provides municipalities, developers, and future residents with the opportunity to objectively determine the degree in which the community conforms to recognized smart growth principles. All LEED green building certification programs, including LEED ND, are able to demonstrate clear and readily
enforceable metrics in design and construction practices. (Duany, Speck, & Lydon, 2010) LEED ND provides a clear path of guidance of how to integrate the various concepts of mixed use, smart growth, and other environmentally, economically, and socially preferable development ideals. The USGBC has an overwhelming catalog of how to go about LEED ND and all the existing and planned projects around the United States that are constructing or reconstructing neighborhoods based of LEED ND guidelines.

**Smart Grids**

Power system management and optimization are about data management, response, and efficiency. When demand peaks and a reduction in energy use is needed, the smart demand response should help customers in energy conservation and reduction thereby promoting system reliability. To address the need for a grid transformation, it has been suggested to employ an internet web model for energy distribution and management. This path to developing a smart grid will create a system of a nerve network that determines, responds to, and controls the power needed for consumers. For energy consumers, power generation owners, buyers, and sellers, that nerve network of a smart grid will be flexible and economical while providing better security of the grid itself. (Clark, 2010) Smart Grid implementation would be beneficial for communities as it has the potential to greatly reduce the impact a community has on the environment, but can also provide a near constant stream of uninterruptible power sources. There are many types of technologies and techniques that can be implemented into the creation of a smart grid system so there is plenty of knowledge and expertise in this subject area to warrant me not to discuss it further at this time.
Floor Plan Layout

By planning rooms to track the sun as to maximize the use of daylighting for early morning to afternoon activities the need for artificial lighting is minimized. The kitchen, for example, should be placed on the southeastern side of the home to make use of the early morning sun while the living room, should be situated on the southwestern side of the home to make use of the afternoon sun. Research performed in Sweden has found that students who attended class in rooms with natural lighting do much better in school than students in windowless rooms. Natural daylight makes people feel better and work more efficiently as well as helping our bodies create natural vitamin D. (Johnston & Gibson, 2008) When I first discovered the literature talking about this topic I was surprised that a concept so simple is one that I did not think of. However, searching other literature for this topic, I found this idea mentioned various times, but it was referenced by different names. Literature that discusses green building design in some shape or form mentions the importance of laying out the floor plan of the structure so that it supports passive and active resources.

Pervious Materials

Many conventional communities spend a great deal of funds on street designs that are aesthetically pleasing rather than functional. Experts suggest that communities would rather spend their money on streetscape technologies that are better suited to help regulate storm water management and reduce the effect of hardscape heat island effect than on street designs that have only an aesthetic purpose. Also permeable urban surfaces that allow for better percolation are better suited for trees in urban settings.
and can be used for further opportunities in developing rain gardens and swales. (Duany, Speck, & Lydon, 2010) Pervious materials are a means of mitigating urban stormwater runoff while reducing the potential flow for pollutants to move off-site. There are many different applications of pervious materials, such as pervious sidewalks, pervious driveways, and pervious roadways, and the type of materials, such as plastic grid systems, porous asphalt pavement, and porous block pavement systems. (Kwok & Grondzik, 2011) There are many technologies and products of pervious materials that can be applied to walkways, bike paths, and even large thoroughfares such as roads and highways. There is much interest in the implementation of pervious materials in the desire to reduce stormwater runoff by increasing the permeability of a surface. The literature on this topic is expansive and is filled with plenty of case studies to be used to further my research.

**Natural Light / Ventilation**

Many buildings are designed with large floor plates and permanently sealed windows. These buildings lack the ability to provide sufficient natural illumination and ventilation. Users of these buildings tend to feel more disconnected from nature and are less productive than their colleagues in more airy locations. Some studies suggest that the loss of productivity ranges from fifteen to twenty percent. (Duany, Speck, & Lydon, 2010) Natural light can be used to light up the interior of buildings through windows and skylights or even through new fiber-optic daylighting and solar tube systems. (Clark, 2010) Many early European buildings utilized small openings on the roof and overhangs to promote light and air infiltration into the buildings wherever possible since many of
the structures were built in very close proximity to each other making cross windows impossible to be used for lighting and ventilation. (Corbett, 2010) Maintaining good indoor air quality in a building is paramount. One such way to introduce fresh air while expending stale air is by using a heat recovery ventilator. This system pulls clean air from the outside and stale air from the inside, where the clean air is then cooled or heated by the stale air as it exits the system and the house. This allows the clean air to be around the same temperature of the indoor air saving costs of heating or cooling it. (Johnston & Gibson, 2008) Daylighting is dependent on easy access to portions of the sky that will permit the greatest luminance without the need of complicated or expensive shading technologies. (Kwok & Grondzik, 2011) Planning for natural light and ventilation is one of the most important initial steps when designing a building. In searching other literature about this topic, I found strategies for natural ventilation and natural lighting mentioned various times as there is a very large array of techniques and technologies for implementation. Literature that discusses green building design in some shape or form mentions the importance of using natural lighting and ventilation within the structure so that it supports passive and active resources.

**Solar Orientation**

Attention paid to the orientation of the building early in the design process will result in a building that at no additional cost can save a considerable amount of energy and is much more pleasant to inhabit. Windows and overhangs should be sized and located to optimize passive heating, cooling, and daylighting. In North America, this means placing overhangs to the south which blocks the sun in the summer months, but allows the
winter sun access. (Duany, Speck, & Lydon, 2010) The developers of early city-state European villages understood how to properly orient their buildings in order to make the most of the sun’s lighting and warming benefits. Homes and civil buildings were constructed to allow as much available light into the deep recesses of the spaces while taking passive approaches to prevent unneeded heat gain. (Corbett, 2010) Orienting a building to take advantage of passive solar gains can reduce heating costs by thirty to fifty percent compared to the conventionally built building. South facing windows should be designed early in the process to reduce construction costs. If utilized correctly the orientation of windows can reduce the need for a heating and/or cooling system. (Johnston & Gibson, 2008) Orienting a structure so it follows the track of the sun is one of the most important initial steps when designing a building. Literature that discusses green building design in some shape or form mentions the importance of orienting the structure so that it makes use of the sun’s passive resources and provides for future use of more active applications such as photovoltaics.

**Thermal Envelope**

Superinsulation and advanced window technologies allow buildings to maintain comfortable interior temperatures with minimal heating and cooling energy. Older technologies like straw-bale designs and adobe walls can have a similar effect to keep a space warm or cool. By implementing these technologies in the design, the thermal envelope is able to fight the entropic tendency for heat and air to evenly disperse across natural barriers. Prefabricated buildings allow for more precise and tighter buildings which can further diminish the chance of the transfer of heat between the interior and
exterior of a building. (Clark, 2010) To maintain a proper thermal envelope, the foundation of a building, whether it is a basement or a simple concrete slab, must be well insulated. Many builders fail to include the basement as part of a building’s thermal envelope. This is problematic because if the basement is not properly insulated it can be a major drain on the heating and cooling systems which will cost the homeowner more in the long run. The insulation will keep the basement at a warmer temperature which will reduce the chance of condensation and mold to develop while at the same also keeping the temperature more consistent. There are many options for insulating the basement. One popular way is to use insulated concrete forms, which is a composite of insulation and concrete forms in one product. To provide a good thermal envelope for the rest of a structure, structural insulated panels (SIPs) can be used to provide a good thermal break between the interior and exterior temperature swing. These SIPs are prefabricated in a manufacturing plant to provide easy set up and reduction of waste. (Johnston & Gibson, 2008) Developing a very strong and well established thermal envelope of a structure is one of the most important steps when designing a building. Reviewing other literature about this topic, it was mentioned various times as there are many options of materials and technologies for implementation.

**Sustainable Building Materials**

Building materials can be considered green if they meet some, but preferably all, of the established criteria. Products that are produced within a 500-mile radius of where they will be used minimize transportation costs. Salvaged, recycled, and/or recyclable materials minimize waste. Renewable materials, such as those that meet Forest
Stewardship Council (FSC) guidelines, meet green criteria. (Duany, Speck, & Lydon, 2010) The Forest Stewardship Council’s certification protects forests around the globe. The certification requires strict guidelines for how the wood is harvested, how much is clear cut, and how the existing ecology is protected and preserved. FSC relies on a chain of custody to track wood from the point of harvest to point of sale, which forces each link in the chain to meet the FSC certification or the products fail to receive the certification. Another organization that promotes the preservation of wooded lands is the Sustainable Forest Initiative (SFI). Although SFI is not as large as the FSC or as strict, it has strong guidelines for sustainable logging. (Johnston & Gibson, 2008) Durable materials, which are constructed to last into the distant future, are considered green products. Products that are manufactured without hazardous chemicals and are free of ozone-depleting chlorofluorocarbons (CFCs) and Halon gas, also meet the criteria. (Duany, Speck, & Lydon, 2010) An example of a durable product that can be used as a substitute for virgin wood is engineered lumber. Engineered lumber has the same strength factor as natural timber, but requires only half the fiber. Many engineered lumber products are also made from aspen trees or similar species, as the trunk is the fruiting body and the roots are the actual tree making it possible for the tree to be harvested without killing it. (Johnston & Gibson, 2008) Many European cities that were built in the early 1400s were built with local quarried stone and felled timber which still remains the construction material for those European communities. The developers of those European settlements understood the importance of local materials because it was beyond their ability to do anything else; it was built out of necessity. (Corbett, 2010)
Using materials that meet well established green material certifications is very important if a building is to be constructed in an environmentally friendly fashion. By choosing such materials, a planner is also committing to provide a healthy and safe environment for the users of the structure. Finding other literature about this topic, specifically implementing environmentally conscious materials into the design, was mentioned time and time again as there are many examples of its implementation. Literature that discusses green building design mentions the importance of using materials that are relatively inert to maximize environmentally friendly and healthy buildings.

**On-site generation**

Making use of solar energy is at the heart of a sustainable building. If the building is sized correctly and many energy-saving improvements have been added to a structure, installing a solar array would be one of the last pieces of the puzzle. By installing an array on a structure that is already energy efficient, it could permit the building to move towards net zero or net positive energy. It also allows the structure to operate off the grid or during times of fluctuations in the national electrical grid. (Johnston & Gibson, 2008) Photovoltaic or small wind systems can help reduce or eliminate a project’s reliance on the national grid for electricity. Another primary benefit of on-site generation is that it protects the property from faltering energy supplies and spikes in the cost of the energy. These systems can be built into the envelope of the building allowing for potential savings by integrating technology with the support structure. (Kwok & Grondzik, 2011) Planning on-site energy generation is a recurring theme in
much of the literature I have found as it is highly suggested to be implemented if a building (or a community for that matter) wishes to remove itself from the grid at a moment’s notice. By choosing to install (or plan) on-site energy source a developer is promoting not only more environmental responsibility to the users, but also to market that this building has the potential to be self-sufficient. Finding other literature about local energy generation led to a large selection of techniques and technologies for implementation. Literature that discusses green building design mentions the importance of installing or planning for on-site energy generation.

**Waste Management**

Advanced framing techniques, also known as optimum value engineering, eliminates unnecessary framing without compromising the integrity of the structure. This reduces the need for materials for the project as well as reducing the amount of waste generated by the construction. (Johnston & Gibson, 2008) Other technologies, some simple and some more intensive, exist for dealing with post-consumer waste, especially on the organic side, since a majority of household waste is organic material. Most organic waste can be dealt with by using a compost pile, which houses naturally occurring bacteria and other organisms that systematically break down the material into simpler compounds. (Kwok & Grondzik, 2011) There is a plethora of techniques and technologies that are designed to minimize waste both in pre-consumer and post-consumer waste streams which many communities can readily implement into their operations. Many large waste management companies have realized that they are able to offer services by integrating waste handling technologies such as composting and
digesters. There is a significant amount of literature detailing the technologies, both active and passive, as well as many case studies of projects that have successfully implemented such systems.

**Water Management**

Sites that rely on xeriscaping, a technique that relies on landscaping and gardening in ways that reduce or eliminate the need for irrigation, are better prepared to handle drought conditions and reduce their overall impact on local water sources. Sites can also integrate water harvesting techniques, such as onsite cisterns or rain gardens, to retain water onsite for household use or to irrigate plants. Other technologies include designing a graywater system that recycles household wastewater to be used for non-potable uses, such as flushing toilets or irrigation. Unlike retention and detention ponds, constructed wetlands are able to not only increase the percolation rate of water, but also help filter the water as it progresses through the various stages of vegetation. 

(Duany, Speck, & Lydon, 2010) Creating a Living Machine to handle a building’s wastewater processes rather than sending the water miles away to a wastewater plant can help the project lower costs and retain the water on site for other purposes. (Kwok & Grondzik, 2011) Designing a V-shaped swale on the property to divert rain and ground water away from the house into a gravel or crushed rock dry well is a good practice to retain water in the soil and to protect the foundation of a house. To conserve water usage in a dwelling, there are many alternatives to the conventional hot water tank and heater. One such alternative is an instant-on tankless water heater which only heats water when it is called for, which reduces the fuel consumption as well as using less
potable water. (Johnston & Gibson, 2008) Water management systems can be designed from a large swath of techniques and technologies that are designed to minimize overall waste both in supply (water required for operation) and waste (water consumed), which many communities can readily implement into their operations. There are many organizations that have realized that they are able to use various technologies to reduce water consumption and water waste. There is a significant amount of literature detailing the technologies, both active and passive, as well as many case studies of projects that have successfully implemented such systems.

**Building Standards**

There are many different kinds of green building standards and they all have their strengths and weaknesses. However, individually, they each provide a clear and straightforward framework which promotes true green building practices by setting stringent guidelines and procedures that are heavily scrutinized by first and third parties and their standards. The first recognized green building standard was the Building Research Establishment Environmental Assessment Method (BREEAM) that was established in the UK in the early 1990s. The U.S. Green Building Council (USGBC) created the Leadership in Energy and Environmental Design (LEED) in 1998, which provided voluntary standards well above the established building codes to promote more integration of technologies and increase energy and environmental performance. LEED recognizes various categories including sustainable sites, energy and atmosphere, water efficiency, indoor environmental quality, materials and resources, and regional design. These categories are then subdivided into credits with earnable points which
determine the level of certification. LEED is now regarded as the most popular and respected of the green building rating systems and has been implemented in countries around the world. The Green Globes rating system was developed in Canada in 1996 and was brought to the United States in 2002. This rating system was developed to provide an alternative to the LEED rating systems as it tried to provide greater flexibility to design teams. However, it was thought to be less rigorous than LEED as it was based on self-reporting rather than third party validation. Over the years more third party verification processes were integrated into this program, but it is still thought to be weaker than LEED. The Living Building Challenge (LBC) was released in 2006 by the Cascadia Region Green Building Council, which is a chapter of the Canadian Green Building Council and the USGBC, as a compliment to the USGBC’s LEED certification program. The LBC was developed to challenge the industry to maximize the level of sustainability a building can achieve. The Living Building Challenge hopes to raise the bar for the green rating systems as it seeks to create buildings that are autonomous and regenerative, by promoting the triple-net zero approach, which demands that the project produces its own electricity on site, collects all the water it needs onsite, and processes water and waste that is consumed on site. Unlike all the other rating systems this program contains a prohibited list of materials that cannot be used on the site if the project wants to earn this certification. Another thing this system does differently is that the project must demonstrate that all 20 program requirements are met. ASHRAE Standard 189, which is the Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings, was released in 2009. It was developed by the U.S
Green Building Council, the Illuminating Engineering Society of North America (IESNA), and the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE). The purpose of this standard was to create clear green building guidance that is written in a language and format that can easily be adopted into existing codes. The PassivHaus standard was developed in Germany after the “super insulation” movement of the 1970s. This standard provides design guidance, a performance modeling tool, and performance requirements for air tightness that requires a systems approach to building design. This standard reflects the belief that climate change is an issue that goes beyond recycled content, landscape design and forestry management. This standard was brought to the U.S. in 2006 where it is managed by the Passive House Institute U.S. The International Green Construction Code (IGCC) was developed to provide an evolutionary path from a green building guideline, such as LEED, to a green building standard, such as ASHRE Standard 189, to a formal model code. The IGCC was co-developed by the U.S. Green Building Council, the Green Building Initiative, and the American Society of Heating, Refrigerating, and Air-conditioning Engineers and its first draft was released in 2010. These organizations hope that the International Green Construction Code will better define design and construction requirements that can and will be adopted by building authorities. The National Green Building Standard was created by the National Association of Homebuilders (NAHB) for single family projects, multi-family projects, and renovations. It is comparable to the LEED for Homes rating systems, but is usually regarded as not as strict as the guidelines used in LEED for Homes, as it does not allocate as much importance to site selection issues. (Kwok & Grondzik, 2011) As you
can see there are plenty of standards property owners, developers, and planners can reference if they wish to get third party verification that their project is recognized as an environmentally, economically, and socially responsible project. There are plenty of case studies that highlight each of these standards as well as references to the other third party verification organizations, such as ASHRAE and the United States Department of Energy (DoE). When these standards are worked in conjunction with each other, such as using the Living Building Challenge with a LEED rating system, they provide a concrete guideline to follow for true environmental stewardship.
CHAPTER 2: INTRODUCTION

This document was created in response to the inadequacies of current community design and development strategies here in the northeast region of the United States.

The purpose of this Sustainable Infrastructure and Green Building Design Plan is to: first, highlight the difference between current design and a more holistic design, then present concepts that can be applied to achieve a more holistic design, and finally, provide strategies that can be utilized to achieve a holistic design. The overall goal is to provide a framework for communities to develop a design approach that allows interested parties to pursue proper sustainable community design tactics. Although there is no “one-sized fits all” way to develop a plan for the development of a sustainable community, this document seeks to provide an extensive database of design concepts, development tools, and other resources. I have selected an area within the state of New Jersey that has been previously developed but now has been neglected for some time and I believe is a prime candidate to showcase the various design strategies and concepts that would provide this community with a more sustainable lifestyle.
CHAPTER 3: PROPOSED SITE – SKILLMAN VILLAGE

HISTORY

Skillman Village is located within Montgomery Township, Somerset County, New Jersey. In the early 1900s, the New Jersey Village for Epileptics, a 250 acre complex was built. It was designed to operate as a self-sustained village that included its own hospital, housing complex, farmland, power plant, and waste water treatment facility. It was fitted with its own dairy store, laundry store, and movie theater. The Village also had its own local train station. In 1998 the complex was closed and the buildings crumbled into disrepair. In 2007 Montgomery Township purchased the property from the state to create Skillman Village. Shortly after that purchase, 93 buildings on the site were primed to be destroyed and the environmental plan for the cleanup of the area, mostly for asbestos, was developed. (Duffy, 2011)

CONSTRAINTS OF SITE

Environmental clean-up status: Many of the original structures have been torn down and the site has gone through an extensive environmental clean-up process which removed asbestos, landfilled waste, coal ash, and other pollutants. Many proposals exist to revitalize the site, but not one has been given the green light as of 2007. I have found a few proposals that are also pursuing to rebuild this area to be a self-sustaining sustainable community by promoting mixed use areas and creating a centralized downtown-like district. However, none of the submitted proposals to build a mixed use area or a new development has been approved. In early 2010, Somerset County finally agreed to return the property back into a natural landscape. The plan included the
planning of walking paths and trails to go throughout the site. This plan will be instituted once the remaining buildings are razed and the environmental cleanup is finished. (Duffy, 2011)

Soil conditions: According to the United States Geological Survey maps, Somerset County’s soil consists of clay and light silt, which suggests that the area might have difficulty handling heavy flooding events, as clay inhibits infiltration of water and silt does not have a very good absorption factor. Also, this county has primarily been designated as farmland which suggests that much of the soil within this region has become somewhat degraded through the heavy use of fertilizers, pesticides, and herbicides. Potential evidence of this can be seen with the eutrophication and sedimentation of local waterways and water bodies.

Existing infrastructure status: Roads are in disrepair as the area is not traveled as frequently as it was in the past. Evidence of this can be seen with the plentiful array of potholes and the buckling of the parts of the roadways. The status of electrical lines, gas lines, and sewer lines is unknown and presumed not in operation or not well maintained. There are some residential homes on the outskirts of this region, but many of the Skillman complex buildings that remain are crumbling from disrepair and are overgrown with vegetation that has also taken over much of the landscape.
Hydrology: This site is located within the Millstone Watershed known as Watershed Management Area 10. To the southwest of the site is Sylvan Lake which, like many lakes in this suburban/agricultural landscape of New Jersey, appears to have gone through the process of eutrophication; large algal blooms have devastated the balance of the lake. Other small waterways, streams and brooks seem to be healthy based off visual inspection but any further details are unknown.
CHAPTER 4: STRUCTURE OF PAPER

This document will utilize Skillman Village as a baseline of sorts and as a framework for the application of the below sections. These sections that the document will be focusing on are as follows: Infrastructure, Community Design, and Residential Design. These sections will be subdivided into smaller sections that hone in on the current topic. Each subsection will then again be divided into the goals of that subsection, a brief comparison of current strategies versus integration strategies, an introduction to various concepts, and culminating into applicable strategies that will be applied to the proposed site, Skillman Village.
CHAPTER 5: INFRASTRUCTURE

STORMWATER MANAGEMENT

STORMWATER MANAGEMENT GOALS

Water Quality – Water management systems must be planned to allow for the filtration of excess sediments and other pollutants from runoff. By allowing water to interact with plants and soils, water quality improvements are achieved through a variety of natural physical and chemical processes. Water quality is enhanced through pollutant settling, absorption into the soil, and uptake by plants. (San Mateo Countywide Water Pollution Prevention Program Technical Advisory Committee, 2009)

Flow Reduction – Water management systems should be designed to slow the velocity of runoff by detaining stormwater within the landscape. By detaining and delaying runoff, peak flow rates are lessened and downstream waterways are protected from erosive flows. Conveying runoff through a system of naturalized vegetation mimics the natural hydrological cycle and minimizes the need for underground drainage infrastructure. (San Mateo Countywide Water Pollution Prevention Program Technical Advisory Committee, 2009)

Volume Reduction – Water management systems should collect and absorb stormwater to reduce the overall volume of runoff. Retention systems offer long term options for stormwater collection and storage while plants contribute to retention capacity by intercepting rainfall, taking up water from the soil, and assisting infiltration by
maintaining soil porosity. (San Mateo Countywide Water Pollution Prevention Program Technical Advisory Committee, 2009)

ENGINEERED STORMWATER VERSUS NATURAL MANAGEMENT

Engineered Processes

An impervious landscape, like one that is found in an urban development, prevents water from being captured and absorbed by plants and soils. Sedimentation and pollution buildup from streets, homes, and other hardscape surfaces are washed into waterways damaging natural systems by causing flooding and erosion events. Evidence of such ecological damage can be seen on the outskirts of any suburban or urban landscape. An example of an impervious landscape can be seen in Appendix A.

Natural Processes

An undisturbed landscape will act like a sponge by capturing, slowing and absorbing stormwater. A natural landscape will return water back into the hydrological cycle where it is first absorbed by the soil and vegetation. By slowing and absorbing water, the plants and soil that interact with rainwater will remove any toxins and pollutants from the water. This filtered water is then returned back into water bodies such as aquifers, lakes and oceans. An example of an pervious or natural landscape can be seen in Appendix B.
STORMWATER MANAGEMENT CONCEPTS

Water Balance

Achieving a water balance is most important when trying to reestablish the natural hydrology of a particular area. Understanding the potential supply and demand of a site can be a daunting task to try to overcome. A successful investigation into how much water is on site, in comparison to what will be needed, will determine what measures to take to achieve a water balance. The first step is just that, trying to get a fairly accurate estimate for the supply and demand of the site. Typically the next step is to estimate the amount of nonpotable water that the site might generate. The final step is to determine of that demand how much can be fulfilled by using nonpotable sources. These sources can include reclaimed water, such as greywater reuse and treated stormwater, and harvested rainwater. (Sarte, 2010)

Green Streets

There is a concept of there being “multiple shades of green streets”, where each increasing level or “shade” integrates more greenery and perviousness to a specific location or site. The first level is to maximize landscape areas along streets and roadways and by doing so minimize impervious surfaces. This is the simplest of the “shades” as it usually involves developing corridors for green cover and shrubbery along sidewalks or roadways. This level provides some area for water infiltration into the subsoil as well as some aesthetic properties. The next level builds upon the previous level by integrating significant tree cover within those landscape corridors. There are many benefits for adding tree cover to an area as trees cause a natural cooling effect by
evaporating water and providing direct shade of other surfaces such as, sidewalks, roads, and buildings. Also, by planting more trees the urban heat island effect can be substantially reduced which further provides greater cooling effects and more comfortable temperature levels. The third “shade” consists of integrating landscaped systems and stormwater management techniques. This can be achieved by providing enough landscaped area with vegetation which increases the ability to slow and absorb stormwater. Such a setup can help prevent drastic flooding events and reduce the need for extensive engineered stormwater systems. The fourth “shade” promotes the integration of the previous levels with designated avenues for alternative modes of transportation. Providing transportation alternatives for conventional single-occupant personal vehicles, such as sidewalks and bike paths, has a greater possibility of reducing the imperviousness of the area. Sidewalks and bike paths are better designed to make use of more pervious materials, such as pervious concrete, interlocking pavers, and gravel paths. The last “shade” of green streets is making buildings and street frontages part of the landscaped environment. This can be accomplished by promoting the installation of green roof systems or by planting vegetation that grows up the side of buildings. Dedication to forming a totally integrated storm management technique includes all the benefits previously mentioned but at a heightened state. Overall these different “shades of green streets” offer many benefits. Some environmental benefits include the reintroduction of bioretention into the area that will reduce peak runoffs rates as well as providing natural storage and infiltration that will recharge local aquifers and waterways. (San Mateo Countywide Water Pollution Prevention Program Technical
Advisory Committee, 2009) One community benefit is that it creates a more desirable and livable landscape that acts as the natural connection between nature and society. There are other benefits that are provided by plants such as an improvement of air quality. These improvements include the settling out of particulate matter, reducing local ozone, and reducing the local heat island effect. There are also some economic benefits, as a University of Washington study found that drivers are more likely to frequent businesses on a street when they are framed with trees and landscaping. Also the study claimed consumers are willing to pay, on average, 12 percent more for goods purchased at business with quality landscaping. (Sarte, 2010)

Vegetated Swales

Vegetated swales can be used in conjunction with the development of integrated transport avenues, such as roads that provide access for pedestrian travel, bike paths, personal vehicle travel, and mass transit availability. This landscape technique can provide both functional and aesthetically pleasing attributes by improving a relatively impervious and cold surface to a pervious and lively area. Vegetated swales can help provide more pervious space to a relatively impervious location by planting native grasses, bushes, and trees. These plantings will allow water to infiltrate into the soil while the plants filter and remove pollutants from the water as it passes through the swale. By allowing water to infiltrate into the soil it removes potential runoff from flooding hardscapes and stressing existing stormwater infrastructure. (Clark, 2010)
**Planters**

Vegetated planters can be used along pedestrian, bicycle, and vehicular paths to provide a more natural landscape to typically gray hardscapes. This landscaping technique can be applied more readily to act as a more aesthetically pleasing median between opposing traffic paths or to separate pedestrian walkways from bicycle or motor vehicle paths. Installing planters into a median or along pedestrian walkways will provide an increase in pervious surface for rainwater to infiltrate into the ground where it will be filtered by the plants and the soil. (San Mateo Countywide Water Pollution Prevention Program Technical Advisory Committee, 2009)

**Rain Gardens**

Rain gardens are typically used in conjunction with the water management facilities of a building. Rain gardens provide an avenue for rainwater that comes in contact with a building or similar hardscape to be directed to an area of landscape that is engineered with native plants and specific soil grading to slow and handle the volume of water that runs off of a hard surface. A rain garden can be constructed in stages; the first stage typically will slow the rate of the water causing it to drop large particles. Typically any other stage is planted with a different array of plant life that can handle and absorb different types of pollutants. For example mustard plants (specifically *Brassica juncea* and *Brassica carinata*) can remove high levels of lead, copper, and nickel from the soil. Corn (*Zea mays*) can remove very high levels of lead from soils. While sunflowers (*Helianthus sp.*) are one of the best plants to be used in bioremediation techniques as
they are able to remove many different pollutants from the soil. (San Mateo Countywide Water Pollution Prevention Program Technical Advisory Committee, 2009)

TRANSPORTATION MANAGEMENT

TRANSPORTATION MANAGEMENT GOALS

A primary goal in transportation management is to reduce the need for single-occupant personal vehicle usage for frequent traveling (to shopping center, commuting to work, etc.). By doing so this will reduce the instances of congestion on roadways as there will be fewer motorists on the roads at a given time. This can also decrease the need of frequent maintenance and repair on roadways by local transit authorities as the demand on the roadways is diminished.

The second goal is to provide convenient and reliable alternatives to traveling in a single occupant personal vehicle. Mass transit applications can greatly reduce the need for single-occupant transportation. These options include pedestrian and bicycle paths for local transportation as well as bus services and light rail infrastructure for longer commutes.

Finally, providing a network of pedestrian and bicycle paths for residents and visitors to use to egress from location to location within the site would be preferable. This will promote more walkability throughout a site and improve a sense of place for local residents and visitors transiting within the area. By increasing walkability it will also reduce the need for motor transportation which is beneficial to the existing
infrastructure, to the health of residents and visitors, and to the health of the local environment.

**EXISTING TRANSPORTATION STRATEGIES VERSUS INTEGRATED TRANSPORTATION**

Existing transportation strategies are dependent on the personal vehicle as the primary mode of transportation. This strategy has clearly backfired as many highways, interstates, and local roads have become inundated with individuals driving in their cars to and from locations. According to a study by the Texas Transportation Institute Study on National Congestion Statistics, they found that since 1982 that the yearly hours of delays per auto commuter caused by congestion have been slowly climbing. In the New York region this has grown from 10 yearly hours in 1982 to 54 yearly hours in 2010. The current strategy has led to unnecessary accidents, unnecessary stress and much frustration to all, not to mention the associated environmental and economic concerns that have grown as more non-carpool and non-mass transit trips have occurred. (Texas Transportation Institute, 2011) This data can be found in a table in Appendix C. The current strategy does not seem to place enough emphasis on developing mass transit systems that can handle a higher commuting load and provide a comfortable and timely experience. There is also not enough emphasis on the development of safe and easily accessible pedestrian and bike paths.

Integrated transportation strategies attempt to resolve many of the problems that currently plague the existing strategies. Such strategies include expansive sidewalks for convenient pedestrian access, designated lanes for bicycle paths, and an extensive mass
transit network. Using multiple strategies in conjunction with each other rather than relying on them as stand-alone entities provide a multitude of possibilities, such as permitting greater flexibility in developing a worthwhile transportation network. These types of transportation networks can be seen in some urban locations. For example, New York, New York is a fair model of extensive sidewalks while Portland, Oregon is a good example of large bicycle paths. The transit lines that service the Northeast corridor are fair examples of an expansive mass transit system.

**TRANSPORTATION MANAGEMENT CONCEPTS**

**Bus Rapid Transport**

Bus Rapid Transport (BRT) systems are based off the qualities of regular bus services, such as cost effective and flexibility, with the qualities of light rail transit which include more direct and efficient service. BRTs typically are developed with a right-of-way or a dedicated lane on a surface street. BRTs can vastly improve the efficiency of local mass transit systems by providing faster service for users to commute to home, to work, or to other locations in comparison to conventional bus services. In Kansas City, Kansas, a Bus Rapid Transport line was established to serve downtown and local residential spaces. The development of this BRT line increased ridership by over fifty percent over the pre-existing bus service while reducing the route from 24 minutes to 17 minutes which is an improvement of nearly 25 percent. (National Bus Rapid Transport Institute, 2009) Bus Rapid Transport lines can also be developed to bring commuters to more distant locations such as adjoining towns or other commercial centers. This will increase the likelihood that commuters will rely on mass transit for their commuting purposes
rather than personal vehicles. As mentioned previously such a strategy will most likely reduce congestion and thereby shorten the typical commuting times relieving a burden on the roadways and on commuters’ sanity. (U.S. DoT Federal Transit Administration, 2010)

**Designated Bicycle Paths**

Developing designated bicycle paths in and around residential and local commercial areas will promote more bicycle usage in the area. By doing so will also reduce the reliance on motorized transport. It will also promote more bicycle usage for additional recreational purposes. There should be defined areas for bikes to transit around and through residential, commercial, and downtown locations. There are many strategies to develop bicycle paths along main roadways, arterial streets, and local streets. Bicycle paths located on main roadways are typically found adjacent to pedestrian walkways to permit for bicycle storage locations and to keep bicyclists away from vehicular traffic as much as possible. Some paths can be shielded from vehicular traffic with a median that is installed to discourage such interactions. Arterial streets tend to lack extensive bicycle paths as they usually are designed for heavier motor vehicular traffic but there are strategies to allow for cyclists to cross these streets by using either a designated underground or elevated path. Local streets can choose to have designated bicycle paths on the surface streets or opt for wider sidewalk paths to accommodate pedestrian and bicycle traffic, although typically local streets have slower moving traffic so neither might be necessary. (Clark, 2010)
Designated Pedestrian Paths

Providing pedestrian walkways that are sized properly for their environment will help establish a greater connection with residents and the community. Proper street design should focus on pedestrian orientation as this has been shown to provide more of a community-oriented atmosphere. Sidewalks would require sufficient room for individuals using it as transportation but also for individuals who drive or take mass transit to a location. Typically pathways for motor vehicles are given higher priority than cyclists or pedestrians. In order to develop and strengthen the community environment, a strong focus needs to be on pedestrian pathway ease and access. Developing pedestrian pathways can reduce overall car travel demand which can solve both congestion issues as well as local air quality issues. For areas that are mostly designed for mixed use or to have a downtown feel to them, pedestrian mobility should be at the forefront. By developing more walkable streets, a location will promote community interaction by ways of more visibility of commercial properties as well as giving individuals places to congregate. (Sarte, 2010)

ENERGY MANAGEMENT

ENERGY MANAGEMENT GOALS

Renewable energy alternatives for powering the local electrical grid and alternatives to conventional fuels are of paramount importance. By implementing alternative power sources the reliance on fossil fuels is reduced while the emissions of such practices are equally diminished improving the quality of the local environment.
Developing a distributed energy system utilizing multiple power generation sources would be advantageous. This strategy will increase the reliability of the electrical grid and lessen the possibility of power outages. It also allows for different sized power generation sources, from small residential units to larger utility sized units.

It would be beneficial to create an electrical grid that makes use of direct current as all renewable energy systems produce direct current electricity. By maximizing the use of direct current more of the usable energy can be utilized as transforming it to alternative current causes some of the energy to be lost in the transfer.

EXISTING ENERGY DESIGN VERSUS INTEGRATED ENERGY DESIGN

Existing energy infrastructure was built upon the premise that since fossil fuels was and still is believed to be abundant that it was wise to construct overly large power plant facilities far from the end user. Unfortunately we only realized recently that this system is quite dated. The degree in which our electrical grid has operated and its loss in efficiencies is evidence of the state of disrepair of this aging infrastructure. According to the Energy Information Administration, 40.67 quadrillion BTUs of energy were used to generate electricity in the United States in 2008. However after conversion, transmission, and distribution of this energy only 13.21 quadrillion BTUs were used in homes, businesses, and industries. (Sarte, 2010) This means that for every 1 unit of useful energy that is produced 2 units are lost, for an overall efficiency of only 33 percent. Most of the electrical energy in the world is derived from coal power plants, natural gas power plants, and nuclear power plants. Although these technologies have
their advantages, as their fuel sources are still in good supply, all of them have very considerable disadvantages. These plants during operation will produce carbon dioxide, carbon monoxide, mercury, sulfur oxides, nitrogen oxides, and radiation, such as uranium, thorium and radon, as well as particulate matter. Nuclear power plants during operation will also produce radioactive particulates and nuclear waste. This in itself is a considerable problem as we have yet to figure out how to deal with the tons of waste we have produced. In the current scheme very little of the energy produced around the world is from renewable energy sources, such as wind, solar, geothermal, tidal, or bio-fuels. About fifteen percent of the energy produced around the world is from renewable energy sources, where biomass accounts for nearly two-thirds of that. (Kwok & Grondzik, 2011)

Local and renewable energy strategies provide a clear alternative to the existing network of polluting and relatively inefficient power plants and the national electrical grid. The development of local electrical grids promote greater system efficiency, improve reliability of the network, and allows for better management of the system from where the power is created to where it is delivered to the end-user. This strategy also promotes the usage of many different types of energy sources, including photovoltaic, wind, fuel cell, bio-fuel, combined heat and power (CHP), and geothermal, which not only reduces the impact of electrical generation on the environment but also supports a greater reliability of the system. (Sarte, 2010) Local electrical grids also make distributed energy systems more possible and more reliable as more separate and different energy generation facilities are easier to integrate into the system.
Furthermore the uses of distributed energy systems are better utilized with smart grid technologies, that the “intelligence” of the electrical grid increases its potential and reliability. (Clark, 2010)

**ENERGY MANAGEMENT CONCEPTS:**

**Wind Power**

Wind power has been harnessed for over a hundred years to perform mechanical work and more recently it has grown to become one of the most popular forms of renewable energy. Wind power is harnessed by the use of wind turbines which are able to capture the energy of the wind and transfer that mechanical energy into electrical energy. Wind power output is a function of two factors: swept area and wind speed. Typical wind turbines are the horizontal-axis design which is more popular design because of their considerably higher efficiency of absorbing wind resources in comparison to the vertical-axis design. (Clark, 2010) Horizontal-axis turbines are known better for their ease of scalability into the megawatts and a gigawatts range as seen in many “wind farms”. Vertical-axis turbines are used more in remote or distributed energy networks as their footprint is more suitable for rural and urban landscapes. A wind turbine in general is considered to be a more attractive form of renewable energy because of its smaller environmental footprint and its ability to be installed more locally and have better security than the other alternatives. Wind turbines, like photovoltaic systems, can be scaled pretty readily, as small building-tied wind or micro-turbines can be installed on building rooftops while large wind turbine “farms” can be built within large acres of land. (Sarte, 2010) The Department of Energy in conjunction with the National
Renewable Energy Laboratory (NREL) created a wind map of the continental United States which highlights the typical wind speeds of any area within the U.S. This map can be found in Appendix D. (U.S. DoE Energy Efficiency and Renewable Energy, 2011)

**Solar Power**

Photovoltaic (PV) systems are at the heart of using the energy from the sun to create electrical energy. These systems can be integrated onto rooftops of buildings, within windows and skylights or as stand-alone arrays. Many standalone arrays have been designed in conjunction with parking lot car ports or with parking garages. Solar panels once constructed and installed provide clean and efficient energy for whatever purpose. (Sarte, 2010) An additional benefit of photovoltaics is that they are easily and readily scalable, as they can be sized to power a single street lamp or to power a large residential complex. PV installations can be tied in to any type of battery storage to increase their capacity and prolonging the availability of energy during the night and cloudy days. The purchase and installation of a battery-backed system is still considered to be somewhat expensive but there are many programs in place for incentives, subsidies, and purchase agreements that can lower or eliminate the upfront cost of these systems. The Department of Energy created a solar insolation map of the continental United States which highlights the typical solar incidence of any area within the U.S. This map can be found in Appendix E. (Clark, 2010)

Solar thermal systems are not as widely used as solar photovoltaics since on smaller scale they are typically used for hot water or space heating of a facility. Small solar thermal systems can be used to supply a residential building’s hot water needs as well
as heating swimming pools, or providing a heat source for radiant floor-heating systems. Larger thermal systems can be utilized to create electrical energy. These systems typically rely on a central tower in which hundreds, if not thousands, of reflective or parabolic mirrors concentrate the sun’s energy towards this tower to heat up a fluid which is then used to run a conventional steam turbine engine. These facilities also have the ability for energy storage but it is usually targeted at retaining the heat produced through the use of phase-change salts or other media that are able to absorb and then release the heat energy at a later time. Although these systems are able to produce a large amount of energy, they require an area that is very large and has high insolation for long periods of times. Insolation is a measure of solar radiation energy on a given surface area. (Clark, 2010) (Sarte, 2010)

**Fuel Cell Technologies**

There are many different types of fuels that can be harnessed in a fuel cell system. Hydrogen, however, seems to be the most popular fuel type because of its relative ease of use and its byproducts consist of only heat and water. A fuel cell can be sized small enough to operate within a motor vehicle or large enough to provide power to large commercial buildings and similar structures. Fuel cells are also operated in a fashion which utilizes them as backups for power generation and storage. Using these systems in conjunction with typically intermittent renewable energies like wind and photovoltaic is growing in popularity, as any excess power produced during operation of other energies can be effectively stored by transferring it into a hydrogen fuel cell. This stored
energy can then be called upon during times when the other renewable energy systems are not producing energy. (Clark, 2010)

**Distributed Energy Systems / Smart Grids**

Distributed energy systems and smart grid technologies are typically thought to be interconnected in their application. Distributed energy systems can also be referred to as decentralized generation as it usually relies on many smaller decentralized energy sources rather than the conventional large centralized power plant. One benefit of utilizing a distributed energy system is that localized energy improves the efficiency of electricity distribution to various customers as the point of production and the points of consumption are significantly closer. These systems can consist of a network of solar arrays, small wind turbines, fuel cells, small natural gas fired cogeneration plants, and many other energy sources. In some cases smaller “microgrids” can be designed to power certain areas of a community while still being connected to the larger grid to supplement power needs if necessary. Such a design will reduce the chances of the whole electrical grid from going down as many different points of generation are available; it simply puts all your “eggs” in different “baskets”. (Clark, 2010) (Sarte, 2010)

Smart grid technologies are attempting to raise the reliability and “intelligence” of electrical grids by integrating points of power production and power consumption with a neural network of computers and switchboards. By doing so the electrical grid will be able to better respond to supply and demand of various assets which will increase the overall efficiency and reliability of the electrical network. Smart grid technologies are also more readily accepting of different types of energy sources, allowing a greater
selection of alternative energies to be utilized in the grid. These technologies attempt to
link the “brain” of the electrical grid with the various appliances and systems of
commercial and residential buildings in an attempt to “learn” the times where demand
is high or low, which provides better input in how to regulate the electrical grid. (U.S.
DoE Office of Electricity Delivery & Energy Reliability, 2011)

SUGGESTIONS FOR INFRASTRUCTURE STRATEGIES

Suggestion #1:

Around the site designated as Mixed Use Area #1 (Main Blvd E, Larocque, Lakeview Dr)
utilize Site Design #1. A visual representation of Mixed Use Area 1 can be seen in
Appendix F and a representation of Site Design #1 can be seen in Appendix G. This
design includes enlarging the sidewalk to provide more space for pedestrian usage,
dividing the road into three one way lanes, one lane for local traffic, and one lane for
local and through traffic, and one lane reserved for a Bus Rapid Transport vehicle (BRT).
This road would continue to be in this structure all around the circle. Along the inner
road way (along the inner part of the circle) will be designated parallel parking areas for
temporary parking and/designated for carpool or alternative fuel vehicles only. Between
the sections of parallel parking stations will be small islands of landscaped plots with
native trees such as, Flowering Dogwood, Eastern Redbud, and Sycamore, and native
plants such as, Arrowwood Viburnum, Northern Bayberry, and Spicebush. These species
have been found to be native to the area and have attributes, such as good bio-
retention and being aesthetically pleasing, that are beneficial to the local environment.
The pavement of the pedestrian walkways and of the parallel parking stations will be
made of interlocking pavement pavers that allow for infiltration of water into the subsoil below the pavers while providing enough support for pedestrian and vehicular use.

**Suggestion #2**

The arterial roadways will utilize Site Design #2 should consist of four lanes, two in one direction and two in the other. These roadways should be made of a semi-permeable material, such as permeable concrete, to support proper stormwater management. The opposing lanes will be divided by a central median that will be designed with stormwater control systems and select landscape with native vegetation. These herbaceous and woody plants will be arranged to make the most of the space available but also to mimic natural landscape arrangement. The maximizing of both functionality and aesthetics is necessary for the success of this design, as creating a sense of place and a reconnection with nature is indispensable to a community. Visual representations of this idea can be seen in Appendix H. One lane will act as a High Occupancy Vehicle (HOV) lane for the BRT vehicles and any other carpoolsing vehicles. This arterial roadway will also consist of large sidewalks and bicycle paths for local residents to utilize to travel within Skillman Village.

**Suggestion #3**

Development of BRT: Develop a local BRT that will ferry residents around from one side of the community to various stations along the main roadways and eventually to the other side of the community where the loop begins again. This will provide a local transportation system that will reduce the reliance on personal vehicles. Develop
another network of a BRT system to ferry individuals to Princeton, NJ, which is about 6.5 miles to the southeast of Skillman Village. Create another network of a BRT system to ferry individuals to Trenton NJ, about 20 miles to the southwest of Skillman Village. Develop a fourth BRT system to service the Northeast Corridor Line at Princeton Junction. An example of these BRT lines can be seen in Appendix I. Developing these mass transit lines will provide more access for residents and visitors to travel within the site and commute to local cities and other mass transit options.

**Suggestion #4**

In Bergen Circle, develop centralized energy “farm” with a single large wind turbine, with medium-to-large array of photovoltaic solar panels, with a fuel cell storage facility to maintain some energy reserve of excess power produced by wind turbine and solar arrays. Having two main sources of energy provides greater stability and reliability to the system. The reliability is further enforced with the installation of a fuel cell system. The size of the wind turbine and the solar array should be determined according to the projected demand of the community by including commercial spaces and residential spaces. The system should be also designed to readily accept future upgrades and expansions of other renewable energy sources. Finally the system should be sized to produce anywhere between five to ten percent more energy than the community might require as to potentially provide a income for selling electricity to other towns and communities. This main power “plant” can be supplemented with smaller energy “farms” or “microgrids” within the mixed use areas. These smaller systems can include roof top solar arrays as well as fuel cell storage facilities. As well as providing further
backup capability to the entire community electrical grid which will further strengthen the reliability of the network, it will provide a greater resiliency to the grid failing if other power sources are knocked off-line.

**Suggestion #5**

Set in place the ability for smart grid technologies to be implemented at a later date to the electrical grid. Smart grid systems can help to regulate the supply and demand of the electrical grid by linking the various power systems with the end-use systems to gain a better understanding of the needs of the grid. Smart grid technologies once implemented in residential and commercial spaces can then feed data into the central network of smart grid power systems to provide a near real-time energy demand which can determine the level of output required by the renewable energy sources. This system will help make the community electrical grid more resilient and more efficient.

**Suggestion #6**

Make use of direct current (DC) electrical network. DC has a significant benefit over alternating current (AC) as renewable energy generation technologies, such as photovoltaic and wind turbines, produce DC power. Also some products used in the home, those with small transformers like a computer or a laptop, use DC as does the battery in motor vehicles, which might make the transition to plug-in hybrids and electric vehicles easier. By implementing DC, the overall system efficiency of the electrical grid will remain higher in comparison to an electrical network that utilizes AC as the need for invertors is eliminated, as inverting DC to AC or inverting AC to DC forces a loss in energy potential. Also providing a network that relies on direct current only
removes the need for phase transformers to step up or step down the voltage that is
typically needed for AC lines. Furthermore new DC power lines have been shown to
greatly reduce the line losses as the power is transported across distances and having a
relatively small community grid will further strengthen this opportunity for efficiencies.
CHAPTER 6: COMMUNITY DESIGN

COMMUNITY DESIGN GOALS

Vitality- can be described as the benefits that are available when people are living within close proximity to each other. This can influence the functionality and overall desirability of public places. Designers typically consider how structures that have front façades of plazas, parks, and streets through their use and appearance encourage public life. Promoting this visibility of community interaction will only further strengthen the bonds that are found in successful downtown and Main Street centered communities. (Bosselmann, 2008)

Sense of place- can be described as the psychological or emotional dimensions of living in a neighborhood, on a street, or in a building. Designers believe that it is possible to create a design that produces a highly develop sense of place, which in turn gives people a sense of belonging and potentially enriches the personal identity of the occupants. It is the contribution made by people and their memories, expectations, and ambitions as well as the economic and geographic atmosphere. (Bosselmann, 2008)

Livability- can be described as conditions within neighborhoods where residents are free from internal or external intrusions. This term was originally used to demonstrate proper management of traffic in neighborhoods but more recently has been broadened to include those qualities that are associated with sustainable cities. The qualities of sustainable cities include human life that is integrated with the social and natural
ecology, personal safety, comfort, availability of services, and transit within walking
distance to lower the dependence on the automobile. (Bosselmann, 2008)

EXISTING COMMUNITY DESIGN VERSUS INTEGRATED COMMUNITY DESIGN

A community can be defined as, “a social group of any size whose members reside in a
specific locality, share government, and often have a common cultural and historical
heritage.” (Merriam-Webster, 2012) Unfortunately the explosion of suburban
development in the United States has failed to keep the premise of the word intact.
Many communities and neighborhoods have been designed in ways that no longer
maximize the functionality of a space, or the prominence of a natural landscape, nor the
sense of place that was once found in older communities. Individuals that reside in
these communities seem to be more distant with their neighbors and seem lackluster in
their appreciation and ownership of their properties and the surrounding environment.
Conventional community design instead maximizes the illusion of privacy and stability.
Suburban neighborhoods and communities are primary examples of the misconception
of what they believe to be “smart” design.

This concept of having a closely knit community is not new by any stretch of the
imagination. Many older European cities and villages were constructed in such a fashion
that supported the locality of services and interactions between residents while limiting
the impact the village had on the environment. Only within about the last thirty years
has there been a reemergence in community design that attempts to reconnect the
aspects of “community” that we have lost. Developers are beginning to understand the
importance of maintaining a sense of place, of restoring the local environment, and that
uses space effectively. The new movement has been slow to re-engage but the
momentum is building as certification programs, such as LEED for Neighborhood Design,
and other communities known as “eco-villages” are moving to the forefront.

COMMUNITY DESIGN CONCEPTS

Mixed Use

Mixed-Use development can be thought of integrating a conventional downtown
location of commercial tenants and shop owners with residential complexes. Many old
towns were developed in this fashion; prime examples include Brooklyn and Manhattan,
New York, where shops and commercial spaces are found on the ground floor and
residential apartments are found above those shops. This permits more tenants on a
property which frees up other land for other purposes. Mixed-use development can
increase property values by stacking other commercial uses and residential structures
on top of the existing structures. It also helps protect the ratables of an area as a
property has multiple tenants so if a business leaves the other tenants of the property
can support the void until another business moves in. (Bosselmann, 2008)

Walkability

Walkable streets can be utilized to create a multimodal transportation network where
pedestrian travel is given the highest priority. Pedestrian-oriented streets tend to be
narrower than those that are more suited for automobile transport. Pedestrians and
bicyclists tend to feel safer on roadways that have adequate spaces that are clearly
delineated for their use, and have plenty of visual interest and enclosure provided by
the buildings lining the street. Designing walkable streets support public health benefits
by making it convenient for residents and visitors to meet daily needs by walking. A walkable street supports a mix of other uses, provides a comfortable environment for gathering or waiting for public transportation, and enriches an environment for students to walk to school. Developing a network of walkable streets has the potential of transforming a conventional streetscape that is not pedestrian friendly to one that is full of public amenities that have the ability to attracting tenants and residents to the area. This is done by placing functional entries along the street as it will peak interest and draw customers to the shops. Businesses are then supported by the constant foot traffic and residents will become loyal customers as they are continuously passing business on their travels to work or other locations. (U.S. Green Building Council, 2009a)

Connectivity is a large factor when designing high quality accessibility in a community that allows residents and visitors to take full advantage of services and public spaces. Connectivity is typically measured with intersection density as this shows the closest correlation with increased multimodal transportation options, such as bicycling and walking. Communities designed with a network of shorter blocks and frequent intersections make walking much more appealing. A street network that is properly connected will ensure that residents will have easy access to services and amenities within the community. (U.S. Green Building Council, 2009b) When designing walkable places the block size is the most important factor of walkability as it can determine the strength of the interconnectivity of the site. For example in Portland, Oregon the blocks are small enough to promote pedestrian usage while blocks in Chicago, Illinois are considerably longer inhibiting their usage. That being said the distances that people will
walk will of course vary, as they will commute longer distances for work or school but shorter distances for their lunch break. Typically a person will walk no more than five to ten minutes in any direction, which equates to a quarter mile to half mile walk, to a destination unless it is to a recreation center or their commute to work. (Dunham-Jones & Williamson, 2009)

**Access to Recreation**

Open spaces may provide valuable habitat for plants and wildlife, but they can also serve as important buffers around wetlands and other water bodies. Open spaces can also reduce the effect of the urban heat island effect and helps with stormwater management and infiltration. As a neighborhood amenity, public spaces have the ability to provide a place for community activities and socialization. This will help strengthen bonds between the individuals within the community and provide those residents with a better sense of place. Parks offer additional public health benefits by encouraging passive and active recreation and can be sized as “pocket” parks or as a larger civil park. Open spaces also allow people to reconnect with nature and with each other. This is of great importance as many people have lost their fundamental connection with the natural world. (U.S. Green Building Council, 2009c)

**Tree-lined Streets**

Streets that are lined with trees or similar vegetation can enhance the atmosphere of the street which might attract people to walk the area. This can be very beneficial to commercial tenants as more people are visiting the area. It also promotes other means of transportation rather than using an automobile as the area is more inviting and
pleasurable. Planting trees in more urban settings will offer a change of pace from the surrounding hardscape of the area. Shaded sidewalks will reduce the heat island effect of the local area and trees can help with air quality and stormwater control. The reduction of the heat island effect is beneficial to visitors of a site as it creates a cooler and more comfortable environment. It is also valuable for commercial businesses as it has been found that tree-lined walkways can provide a significant reduction in surface temperatures which can permit businesses to use smaller HVAC systems and lower their operational costs. (U.S. Green Building Council, 2009d)

**Compact Development**

Building compactly will make efficient use of the land and reduces the developmental footprint of the site. By doing so the amount of impervious surface is reduced as this will improve stormwater management. It also will free up land for additional development as a park or conservation area. Compacting development reduces the need for extensive infrastructure networks and thereby might increase the efficiency and reliability of those systems. A denser development is more supportive of public transportation and of other modes such as walking and bicycling as they become more feasible and pleasurable when the destinations are closer together. Compacting businesses, residential buildings, and other amenities will help to provide a livelier and active community network than if such structures were more dispersed. (U.S. Green Building Council, 2009e)
SUGGESTIONS FOR COMMUNITY DESIGN

Suggestion #1:

For Mixed Use Area #1, develop a series of pathways, one for each cardinal direction, which culminates at a centralized courtyard. The width of each pathway should be at minimum fifty feet but no more than one hundred feet so to permit pedestrian traffic and bicycle paths. Within and along these pathways will be areas set aside for vegetated planters and for local commercial uses, such as outdoor restaurant seating. Moving outwards from the center courtyard develop another walkway in the shape of a concentric circle that will service other properties. This walkway will also be designed to allow for vegetated planters and other community amenities as mentioned before. Finally the last walkway will terminate adjacent to the main roadway that encircles the site. This walkway will also be concentric circle and will be developed to permit vegetation and community amenities. An initial sketch of this design can be found in Appendix J.

Suggestion #2:

For Mixed Use Area #1, immediately adjacent from the central courtyard designate land for mixed use development so as to develop both residential and commercial use of the property. The first floor of these structures should be zoned for small shops, restaurants, and other community amenities like post offices and community banks. Tenants of these commercial spaces should be given preference over the space if they are or form a local small business. The second floor of these mixed use structures can be zoned for other commercial spaces like medical offices, law offices, and other similar
professions, or for residential apartment usage. These buildings should not be taller than four stories, as to permit more light into the central courtyard and the remaining two floors should be designated for residential apartments to be rented or sold to tenants. The second ring of buildings can be developed in a similar fashion by zoning the lower floors for commercial space and businesses. Another alternative is designating these buildings only for residential use for individuals who wish to own or rent these spaces.

**Suggestion #3:**

Within the center courtyard provide areas for individuals to congregate and for other community activities. This can be achieved by promoting the development of vegetated islands, or pocket parks within this area. When creating these vegetated areas it would be a requirement to use of native trees, shrubbery, and flowering plants. Other possibility for enhancing this area is to install park benches, picnic tables, and outdoor chessboards or similar activities. The development of these areas can be designed with regard to the daily activities of local businesses and organizations to maximize the potential for active as well as passive usage of the space.
CHAPTER 7: RESIDENTIAL DESIGN

RESIDENTIAL DESIGN GOALS

Living Buildings – What is a “Living building”? The Cascadia Region Green Building Council (CRGBC), the Pacific Northwest chapter of the USGBC, who in 2006 would go on to create the International Living Future Institute (ILFI) and the Living Building Challenge (LBC) whom defines a living building as a structure that “generates all of its own energy with renewable nontoxic resources, captures and treats all of its water, and operates efficiently and for maximum beauty.” (International Living Future Institute, 2011) A “living building” is one that attempts to mimic natural systems by utilizing technologies and systems that are designed to use water efficiently through water reduction and reuse strategies as well as making effective use of energy production and usage. These buildings also support excellent indoor environmental quality standards by making the most of active and passive ventilation systems and in most cases use vegetation to cleanse the air. Finally the building needs to be built to be aesthetically pleasing to the eye to the point in which it seems part of its surroundings. It must be not be considered a blemish on the landscape but as a beautiful and comforting addition to the natural area. By doing so it reinforces a sense of place for the building within the landscape in which it is constructed.

Materials and Resources – In line with the previous goal of “Living Buildings”, residential buildings must utilize materials and resources over its entire lifetime, spanning from its construction to its operation to its end-of-life, that greatly minimizes its impact on the natural world. It should do this by consuming as little of resources as reasonably
possible during its construction and operation but also have the ability to give back resources, such as water and organics, into the natural processes from which they came from. Materials that are to be used in the construction of a residence must be from sources that are rapidly renewable, recyclable or reusable, and contain minimal amounts, if any, of chemical compounds that have been “red-listed” by governmental or third-party organizations.

Sustainable Sites – This goal builds upon the “Living Buildings” goal, as residential structures should be designed to work in conjunction with the natural local cycles of water systems and organic turnover. In many cases however homes are constructed with no regard to the local water cycle, to the nutrient cycle, or any other possible interactions within the site. Committing to construct a building on a new or existing site requires an analysis of the natural systems that are interacting within the site. Planning to revitalize or strengthen the existing water and nutrient cycle within that site and those interactions that occur outside of the site needs to be designed from the beginning. A residence can be designed to return water and nutrients back into the natural cycle, through the use of graywater systems or composting technologies. Overall the site must be able to replenish any resources that it may have otherwise consumed or diverted because of its construction and operation.

EXISTING RESIDENTIAL DESIGN VERSUS INTEGRATED RESIDENTIAL DESIGN

For far too long many residences have been designed and constructed without much regard for their locality. The need to construct homes as quickly as possible as well as
constructing uniform “cookie-cutter” design homes has caused many aspects that we have at one time held dear to our lives to be lost in the process. Since the late 1950s, designers, architects, and contractors have created homes that have fit this mold. They have replaced a sense of place and community with privacy, favored size and aesthetics over functionality and efficiency, and utilized cheap materials while sacrificing the interior environment.

There has been a relatively select few developers and architects that have maintained ideals and strategies that enliven a community and its residents. Striving to maintain the local environment, to enhance the sense of place of a home, and to procuring and utilizing materials that have less of an impact on regenerative ability of the planet as well as having less of an impact on the health of the interior environment are all key aspects of green building design. Furthermore, the explosion of green building rating systems such as Leadership in Energy and Environmental Design, the National Green Building Standard, and the Living Building Challenge are prime examples of this shift of how residential buildings should be designed and constructed. Homes constructed to follow the guidelines of those programs as well as those designed with such ideals in mind are re-nurturing the connection between community and nature.

RESIDENTIAL DESIGN CONCEPTS

THERMAL ENVELOPE

A thermal envelope includes all building components that are designed to protect the interior space from the outdoors. A building’s thermal envelope should be designed to reduce the influence of temperature changes, humidity changes, and air infiltration to
the inner workings of a building. Typically this is done with the use of insulation, air barriers, and water barriers that resist or prevent the introduction of those changes to the building.

**Foundation**

Foundations are typically perceived as only necessary for the support of a structure; this perception fails to take in account that the foundation should be regarded as part of the system, part of the thermal envelope. Basements, whether a simple slab or a full basement are thermally connected to the rest of the house which presents a considerable problem as the basement will be the source of thermal loss. Obviously the solution is to design the foundation and basement as part of the thermal envelope of the residential structure. This can be done by installing insulation along the exterior of the foundation which will help keep the basement a more constant temperature year round. Another good idea is to also insulate the slab as it too is a prime point for thermal loss and gain. By doing so the insulation acts as a thermal break between the indoor and outdoor temperatures. (Chiras, 2004) Another approach to insulating the foundation is to utilize insulated concrete forms which combine insulation and concrete to form the finished walls of a foundation. These forms consist of insulating foam on the exterior connected to another section of foam on the interior with spacers in which the concrete is then poured into. This provides two thermal breaks preventing heat gain or loss through the concrete forms as well as keeping the concrete a more consistent temperature which helps with moisture control within the concrete. (Johnston & Gibson, 2008)
Insulation

Insulation is the most important aspect when it comes to regulating and maintaining a building’s thermal envelope. Insulation is used to block the flow of heat across walls and other surfaces. Insulation is rated based on its level of heat resistance or more simply by its R-value. The higher its heat resistance or R-value, the better the insulation is at preventing the transfer of heat across surfaces. (Chiras, 2004) There are many options when it comes to insulation and all options have their advantages and disadvantages, ranging from costs, to efficiency, and even chemical make-up. Insulation is typically divided into a few general categories which are as follows: rigid board insulation, spray-applied foam insulation, cellulose insulation, fibrous batt insulation, and structural insulated panels (SIPs). Historically the insulation found in many homes consisted of fibrous batt insulation because of its relative ease of installation and its fair R-value figures. However it does have it disadvantages as it is a poor option for stopping air flow and consists of urea-formaldehyde, a very toxic pollutant that is emitted during its production and during use, and of fibrous glass fibers which have been linked to various respiratory problems. The use of this type of batt insulation has diminished as other options such as blow-in or cellulosic insulation has grown in popularity. (Kwok & Grondzik, 2011) For a house to be well insulated, all surfaces that are in contact with the outdoors need to contain some varying degree of insulation to prevent thermal transfers between the interior and exterior. Typically the ceilings and attic space of a residence has insulation of greater thickness and higher R-values than that of the walls or basement. The United States Department of Energy Office of Energy Efficiency and
Renewable Energy provides a map graphically representing recommendations of insulation R-values depending on the climate zone of your area. These recommendations are a good starting point when trying to determine which and how much insulation to install. (Johnston & Gibson, 2008)

**Windows & Doors**

Windows and doors are prime locations for thermal heat transfer as they are typically not as well insulated as the attic or walls of a residence. Windows and doors are typically rated using U value, which is simply the inverse of an R value, so a better insulated window or door will have a lower U value. To make a comparison a U value of 0.07, which the highest-performing glass as of yet can reach, is the equivalent to a wall with an R value of 14. A window’s performance in maintaining a thermal break between the interior and exterior relies on three factors; the frame construction, the make-up of the glass, and the spacer material that separates the panes of glass. The performance of windows and their efficiency is regulated by the National Fenestration Rating Council (NFRC) which tests their performance. Their test includes determining the window’s U factor, its solar heat gain coefficient, its visible light transmittance, its air leakage rate, and its condensation resistance value. The solar heat gain coefficient represents the amount of heat that is transferred through the glass, so a lower value is better. The visible light transmittance value is a determination of how much light is shone through the glass, a higher value equals more light through the window. The air leakage rate is the rate in which air will pass through the window, the lower the number the better. Finally the condensation resistance value is exactly what it says, a higher number is
better. (Johnston & Gibson, 2008) Windows currently come in single-, double-, or triple-pane varieties, with single-panes dominating the construction industry for decades. The increase of panes within the window helps increase their U values but it is the air space between the glass in which holds the real power in acting as a thermal break. Air is a relatively poor conductor of heat, but many of these air spaces are filled with inert gases like argon and neon, which are even poorer conductions of heat. These windows are then further “strengthened” by the use of glass films that retard heat transfer through the glass. Windows that have these qualities are termed as low-E windows, where the E stands for low emissivity of heat. (Chiras, 2004)

**SITE DESIGN**

Unfortunately, proper site design is typically overlooked when a new residence is in the planning and design stage. Developing a site correctly can help reduce future cost and headaches caused by overheating of the residence, flooding of the site, or intrusion of non-native species on the land. The benefits of proper siting include those above while enhancing the aesthetics of the local landscape and enriching the native local wildlife.

**Water Quality**

Although a residential site interacts with much less stormwater than a more urban setting, water management is still quite important. The quality of the water within the site depends heavily on the conditions of the soil and vegetation of the site. Utilizing vegetation to control and filter the water will further enrich the local landscape and prevent costly damage to either the residence or the landscape. Trees and smaller vegetated plants are well suited for controlling the flow of water across a landscape
while helping filter out any potential pollutants from the water. Any greywater or stormwater created on the site can be diverted to the site’s vegetation rather than sent to the wastewater utility. A simple way to describe such a process is through the use of a rain garden. A rain garden typically consists of native plants that are planted in a fashion to slow down the speed of the water while absorbing some of it. Here the water is filtered through the soil and the plants and eventually percolates into the ground.

(Keeler & Burke, 2009)

**Native Plants**

On many residential sites lawns seem to be the dominant type of vegetation which leads to excess fertilizer, herbicide, insecticide and water use to maintain them. Replacing lawns with native species is necessary to conserve water and strengthening the local environment. Planning a proper site design relies heavily on using passive techniques to replenish local waterways, keep the soil healthy and promote an establishment of a healthy and resilient local environment. Native vegetation is more resilient to droughts and other weather-related incidents than exotic species. Once established in an area native plants will require less water, less fertilizers, if any, and less attention overall than any exotic species planted in the same area. Native plants will also help reestablish the local environment by providing an area for local wildlife to settle. (Chiras, 2004)

**Shading Techniques**

A site’s landscaping can be used to provide shading for the home to prevent overheating and wind infiltration. Proper planning can help shade the home from the sun in the summer where heat gain is not wanted while letting the sun in the home in the winter
where heat gain is more desired. Native deciduous trees and small plants should be planted on the south facing side of the house. During the summer months the trees are fully leafed which blocks the harsher summer sun from entering the home while in the winter the tree is bare which allows the winter sun to enter the house. Along the east and west façades vegetation should be planted as the walls and windows on these surfaces tend to be the source of the most unwanted heat gain as they face the rising or setting sun that rides lower in the sky. Along the north façade of the structure evergreen species should be planted as the north side of the building tends to be the source of much air infiltration and heat loss. (Johnston & Gibson, 2008) By planting vegetation on the north side of a building the plants act as a natural windbreak protecting the house from harsh winter winds while acting as a thermal break which reduces potential heat loss from the building. Another benefit of using vegetation around a home is that plants evapotranspire during the summer, which means they “sweat” out water, which will cool the surrounding air. Mature tree canopies can reduce the surrounding air temperature by anywhere from three to five degrees. (Chiras, 2004) See Appendix B for a diagram illustrating the hydrological cycle of a vegetated area.

INDOOR ENVIRONMENTAL QUALITY

The indoor environment of a residence can be easily polluted by the types of materials and products that individuals bring into their homes. Minimizing the amount and types of materials that could cause indoor air pollution is the first step in preserving a healthy indoor environmental quality. Typically the next step involves developing a system in which the home can be properly ventilated with fresh outdoor air. An environment in
which the users are not subjected to concentrated pollutants whether through proper material selection or ventilation controls can be thought of having good indoor environmental quality.

**Material and Product Selection**

All materials that go into the construction of the residence including the paints, sealants, flooring, sheetrock, and others, are all potential sources of poor indoor air quality. Other materials and products that are not necessarily part of the construction, such as cleaners, can also be potential sources of air pollution. Maintaining a high indoor quality can become very complex as the number of household chemicals within the furnishing, products, and building components continues to grow. Avoiding these types of products can greatly help maintain a superb indoor environment. Choosing products that are protect and enhance the health of the indoor environment can be quite a challenge as there are many products that fail to meet established standards that certify products to meet those qualifications. Some products seem to be the real deal but in fact are just “greenwashing” the truth. “Greenwashing” is a term designating that a product might be promoted to be a green or sustainable alternative to a conventional product when in fact it really is not. (Chiras, 2004) Many products contain volatile organic compounds or VOCs which are chemicals that evaporate easily at room temperature. Some more “popular” forms of VOCs include benzene, toluene, formaldehyde and ethylene glycol, all of which have been found to be very detrimental to human health. Benzene and toluene are usually seen together and are derivatives of oil-based products like plastics and sealants. Formaldehyde is commonly found in
adhesives that are used for countertops and cabinets and is a suspected human
carcinogen. Ethylene glycol, which is the main ingredient in anti-freeze and many de-
ciers, is a very toxic chemical when absorbed through the skin or ingested will likely
cause death. (Johnston & Gibson, 2008) These pollutants are just the beginning with
trying to deal with the innumerable chemicals and compounds that are within building
components and the products that are used in the home. Although the interactions
between many chemicals and humans have yet to be determined there are many third-
party organizations that are trying to determine the toxicity of many of these chemicals.
(Keeler & Burke, 2009) A full list of these organizations and what they test for can be
found in Appendix K.

Ventilation

Unfortunately proper ventilation in a residence is habitually placed on the back burner
when it comes to the plan and design of a home. However ventilation is very important
in maintaining a healthy indoor environment as it can be used to flush stale and possibly
polluted air out of the house replacing it with fresh air. There are many approaches to
properly ventilating a home; some are more passive while other approaches require
active systems. The simplest passive approach consists of opening windows on opposite
side of a home, preferably the east-west windows as they typically have the greatest air
flow. Another passive approach that can be utilized if the building has a centralized
stack that will cause a chimney effect pulling the hot air up the stack while pulling cooler
air from the outside (assuming the desired temperature is warmer than the outside
ambient air). (Johnston & Gibson, 2008) More active approaches require a fan of some
sort to pull the stale air out of the interior and releasing it to the outdoors. However this approach might not be the best as it might pull fresh air through leaks in the insulation and air barriers bringing unwanted moisture into the home. A better but slightly more complex approach is to install a heat recovery ventilator (HRV). A HRV is an air exchanger that pulls the warmer stale air into its chamber while pulling colder fresh air from the outdoors into its chamber. Within the chamber most of the heat is transferred from the warm stale air to the cold fresh air, causing the fresh air to warm. On average these systems can recover anywhere between sixty to eighty percent of the heat from the exhaust air. (Kwok & Grondzik, 2011)

**WATER EFFICIENCY**

Maintaining a healthy water system is important in revitalizing the local environment and increasing its ability to survive drastic weather events such as droughts. By reducing one’s impact on fresh water systems and supplies, that person is committed in making the local and national water cycle to be more resilient and adaptable. There are many technologies and techniques that are available to minimize the impact of humans on the natural hydrological cycle. The most important of these strategies are active conservation goals and water reuse.

**Greywater**

Greywater is wastewater that does not include food or human waste, which is regarded as blackwater. Greywater usually consists of water from lavatories, showers, and washing machines. Reusing greywater can be a very efficient strategy in reducing a residence’s overall water consumption by diverting this wastewater to other purposes.
rather than sending it into the sewage system. (Kwok & Grondzik, 2011) Greywater can be used within the residence if only used in which there is no contact with humans.

Typically greywater is used to flush toilets and urinals thereby reusing the water rather than wasting potable water to perform the same task. Most building codes that allow greywater require it to be deposited beneath the surface along the root systems of small plants and trees. Greywater can also be used to irrigate vegetable gardens or floral gardens, although again there are limitations to when and where it can be used. Some greywater systems that are used to irrigate a landscape include a pumice bed, where small microorganisms and bacteria interact with the water removing some pollutants from it. It is then used directly to irrigate plants or channeled to an irrigation system to be used across an entire landscape. (Chiras, 2004)

**Rainwater Harvesting**

Rainwater harvesting can be an effective way to conserve water for nonpotable uses through the usage of cisterns. Cisterns can be sized anywhere from holding a few gallons to tens of thousands of gallons and require screens to prevent sedimentation and other contaminants from polluting the water. The rainwater collected by cistern systems is typically collected off of a metal roof, as asphalt roofs might leach pollutants, where it continues to downspouts and finally into the cistern. These systems are typically used for irrigation or other non-potable needs but can easily be outfitted with filtration and purification systems to make the water potable for human consumption. The rule of thumb is that for every inch of rainwater your system might recover about half of a gallon of water per square foot of your roof. (Chiras, 2004)
Another way to harvest rain water is to utilize a green roof or vegetated roof. Green roofs have many benefits over conventional rainwater harvesting techniques. Green roofs, being a vegetated surface will passively filter any contaminants out of the runoff water, acting as a preliminary filtration system thereby saving the first steps of further filtration needs. Water filtered through vegetated roofs can then be directed into a cistern system for later use. Both systems are initially costly to the consumer but will lead to future savings as the residence might not need to rely on municipal water sources, if at all. (Keeler & Burke, 2009)

**Conservation systems**

The installation of water efficient fixtures within and outside of the home can greatly reduce the quantity of water needed to fulfill the needs of the residence and the property. Interior water fixtures could include low-flow showerheads and water faucets, water-efficient appliances, and reduced flush or compostable toilets. These fixtures can be built towards WaterSense® certification, which requires showerheads, water faucets, and toilets to consume at least twenty percent less water than the conventional unit. (Chiras, 2004) For example some manufacturers, especially Kohler, sell high-efficiency toilets (HETs) that consume at least twenty to fifty percent less water than the conventional toilet. These HETs include reduced flush systems, pressure-assisted systems and dual-flush systems. For those who really want to reduce their water usage when it comes to toilets, a composting toilet would be the way to go. (Johnston & Gibson, 2008) There are other conservation technologies, such as efficient irrigation systems, that can further improve water conservation measures. Some outdoor water
fixtures could include micro-irrigation systems and drip-irrigation. Drip-irrigation systems bring the water to the point of use such as a planter of shrubs or a single tree. These run at much higher efficiencies that conventional sprinkler systems, saving a considerable amount of water. These systems can be connected into the greywater or rainwater cistern system thereby making use of reclaimed water resources. (Kwok & Grondzik, 2011)

ENERGY

Energy is one of the most influential impacts on the livelihood of a home owner as it tends to be the biggest expense second only to maybe mortgage payments. The importance of energy lies with how much is consumed, where it originates from, and how can one reduce it. The consumption of energy in most residential homes is unbelievable at some times, as homes continually find more and more gadgets and appliances to plug in. This leads right into the problem of where it comes from as most of the energy within the United States is produced from fossil fuels, which is a heavy burden on the environment and human health. Fortunately there many options and ideas for how to reduce one’s need for energy, whether it be electrical or fuel-based.

Building Automation Systems

In most applications a building automation system (BAS) is installed in a large commercial facility but such systems have been making headway in residential settings. A building automation system is a network of computers and other electronics that monitor and control systems within a building. Many of these systems usually are just programmed to regulate the electrical demand of the electrical panels and sub-meters
within the building but they can be upgraded to control more systems. A BAS can process and control lighting systems and the HVAC system within a home. The user of the system can set set-points in which the BAS will supply power to specific lights within the home or manipulate the HVAC system when the set point has been reached. For example, a user can set the system to turn on the air-conditioning thirty minutes before they return home and then keep the temperature around seventy degrees, just like a regular thermostat. However, a building automation system can supply the A/C to individual rooms where the occupants might reside, giving more energy savings and flexibility to the home owner. (Keeler & Burke, 2009)

**Onsite Renewable Energy**

Although the installation of an onsite renewable energy system is usually one of the last tasks to do when constructing a new home, if at all, as the costs at that time might be prohibitive, it doesn’t mean that the building cannot be designed to facilitate the future installation of such a system. There are a few technologies that can be utilized in such a situation as residences use considerable less energy than a commercial or industrial entity. A homeowner can choose to install a photovoltaic system or a micro wind turbine on their property to either offset some energy from the grid or completely remove them from it. (Chiras, 2004) These technologies are still quite expensive but the costs of such installations have continually dropped as more consumers consider making such a purchase. Another problem that solar and wind generation systems face is that they can be intermittent, if the sun doesn’t shine or the wind doesn’t blow these systems will not be generating much power. This potential problem can be solved by
using battery back-up systems to store power or sell the excess power to the grid which might offset the need to purchase power. Another solution, although still very costly, is to use a fuel cell system that uses any excess power to produce a fuel, namely hydrogen, that can be used during periods of solar or wind intermittence. (Kwok & Grondzik, 2011)

**Occupancy Controls**

Occupancy controls are very important as they can help regulate the distribution of energy to lighting systems and to the heating, ventilation, and air conditioning (HVAC) system. Having control over these energy intensive systems can save a lot of money with utility bills and prolong the life of those systems. Typically lighting controls include occupant sensors, manual switches, and daylighting sensors. Occupant sensors usually contain a motion sensor that detects if any individuals are in the room and if no movement is detected for a set amount of time it automatically shuts off the lights. Some more sophisticated occupancy systems include carbon dioxide sensors that while supporting the motion detector can also be used to regulate the HVAC system by determining if it needs to direct more fresh air into the space. A daylight sensor could be installed into a space to determine if the room has enough natural light coming into the room to provide for sufficient illumination. If the room fails to meet the illumination set point the sensor could manipulate the artificial lights to bring more light into the space. Of course the simplest of these approaches is just to supply the users of the room manual lighting controls but almost always automatic controls will bring the most reliable and sustained energy savings. (Kwok & Grondzik, 2011)
Daylighting

The use of daylighting is one of the most effective and simplest methods for reducing the need for artificial lighting loads. Daylight can be easily designed into the construction of the home through skylights, light shelves, and daylighting tubes systems. Depending on the application, lighting up a hallway or an atrium versus providing light to a larger room like a living room, will require proper sizing and location of whichever daylighting strategy one wishes to employ. If used correctly daylighting can totally eliminate the need to use electricity to turn on the lights. However the use of daylighting can become problematic as the more direct the sunlight the greater chance of unwanted heat gain and glare. This problem can be solved through the use of light diffusers, which will diffuse the light over a larger area reducing the potential for glare and high U-value window units that will reject some heat gain. Sidelighting, which utilizes the sunlight coming in contact with the side of structure rather than the roof, also has its own applications within a residential design. Sidelighting typically does not reach the same depth of conventional daylighting systems but that can usually be resolved with the use of light shelves which causes light from windows to be reflected into a space allowing more light into a room. (Keeler & Burke, 2009) The success of a daylighting strategy can depend on the types of finishes and furnishings that are within the room. Ceilings and walls should be light in color and have a relatively high reflective index, while the furnishings in the room should not be placed in locations where it might interfere with the transmittance of light. Also important is the placement of such daylighting systems as it is better suited for areas that require light during a large
portion of the day, such as a living room, rather than be placed to light up a utility room
or closet. (Kwok & Grondzik, 2011)

AESTHETICS

Too often buildings are designed without any regard for visual inclusion and natural
beauty. We are often surrounded by buildings and landscapes that are ugly and
unappetizing to the eye. The International Living Future Institute (ILFI) believes that if
we fail to care for our homes, streets, and neighborhoods “then why should we extend
care outward to our farms, forests, and fields?” The aesthetics of a residence should be
kept to the forefront during the entire design and planning process right up until final
construction. The beauty of the site will reinforce the surrounding landscape and
present a sense of place for the homeowners and visitors to the site. There are plenty of
avenues for individuals to aesthetically design their homes, because beauty is in the eye
of the beholder and cannot be scored in a similar fashion to energy efficiency or the like.
(International Living Future Institute, 2011)

SUGGESTIONS FOR RESIDENTIAL DESIGN

Suggestion #1

Require that multi-tenant and single-occupancy homes to be planned and designed in
line with green building strategies. These strategies include orienting the structure to
make the most of its southern exposure, following a green building material selection
process, and the concepts of net-zero energy and waste, among other concepts.

Orienting the building with a suitable southern exposure will provide more options for
other building strategies and green technologies to be utilized more effectively. By orienting the building in such a fashion you can promote better daylighting strategies, provide the ability for the installation of a solar photovoltaic system, among other things. Developing a process for selecting green building materials is the next logical step in designing and planning a new residence. This process can be investigated through the use of the U.S. Environmental Protection Agency (EPA) Environmentally Preferable Purchasing (EPP) program or through the use of The LEED for Homes Reference Guide for the Design and Construction of Residential Buildings (2009 edition) specifically the Materials & Resources category. Designing and planning a residential structure to be net-zero in energy and waste can be the most difficult processes to be undertaken as there are many variables that affect those systems. However limiting your impact on energy usage and reducing a home’s waste streams can benefit both the environment and your finances. Overall to successfully design a residence, a charrette should be performed so all project team members, including the architect, general contractor, owners, etc., are aware of the set goals and plan accordingly. This process will not only save time and money but will bring about a more complete and concrete plan.

**Suggestion #2**

As mentioned previously choosing the right materials that are suitable for the construction of the residential structure but also for maintaining a healthy environment for the laborers and the users of the building is very important. When choosing building components we must make a conscious effort to select materials that meet the
requirements for those certifications mentioned in Appendix K. Of those products, the
adhesives, sealants, paints, and flooring will have the biggest impact on the indoor
environmental quality and should be addressed properly. The adhesives and sealants
should meet the Volatile Organic Compounds (VOCs) limits determined by the South
Coast Air Quality Management District (SCAQMD) Rule #1168 or the Bay Area Air Quality
Management District Regulation 8, Rule 51. Paints should meet the VOC limits set by
Green Seal’s Standard GS-11. Flooring types should either be FloorScore-certified, for
non-carpetts, or meet the Carpet and Rug Institute (CRI) Green Label Test Program
certification. For other products it could require that they are either salvaged from other
projects or are of rapidly-renewable material and that they are harvested within five
hundred miles of the project site. For wood products, like the dimensional lumber used
for framing, try to select those that meet the Forest Stewardship Council’s certification.

Suggestions #3

Develop a plan on how to efficiently apply insulation and air tightness technologies to
the project. There are many different types of insulation and air barriers that can be
applied to a building but they are all reliant on how the building is framed. The
Department of Energy created a list of recommended R-values to aim for but it is
suggested to surpass these values by at least fifty percent. To keep it relatively simple
utilize at least eight inch structural insulated panels (SIPs), which is typically rated at a R-
value of 32, for the insulation of a building with an exterior face of either Dupont Tyvek®
Homewrap® or Grace Ice and Water Shield® or a similar product. These water and air
barriers will protect the structure and interior of the building from air infiltration and
water exposure. The R-value of the insulation can be improved through the use of thicker SIP panels or the installation of other insulation to support the eight inch SIP panels. Make sure to also insulate the attic space well as this is the site of most of the heat loss within a structure. The installation of thermal and air barriers in the basement is also required to protect the foundation against drastic temperature and humidity differences, as well as maintaining the thermal envelope of the entire structure.

**Suggestion #4**

Achieve a near- or net-zero waste stream, most importantly for the water and organic waste streams. Achieving a near-/net-zero water waste stream can be accomplished by installing various water collecting and conserving controls. First, select water fixtures that at minimum meet the EPA’s WaterSense® program requirements. Require the design of the roof to accommodate for rainwater harvesting and installing a cistern on the property to retain any collected rainwater. To increase the productivity of the rainwater consider installing a filtration system to increase the water quality to at least greywater for nonpotable and landscape use. Based on the requirements of the landscape, design a landscape management plan that accommodates the needs of vegetation as well as promotes the introduction of organic matter back into the environment. Design into the landscape a rainwater garden or a small engineered wetland to handle any stormwater and wastewater, excluding blackwater if deemed cost prohibitive. Finally for organic food waste, create a compost pile or utilize a mechanical organic waste digester, thereby returning the matter back into the environment.
Suggestion #5

Although putting this plan into action can become costly, develop a strategy to achieve net-zero energy usage for the home. The first task should be the installation of EnergyStar® rated appliances and lighting systems that utilize florescent or light emitting diode (LED) lighting, wherever applicable. The next step should be the integration of lighting control systems and possibly a residential building automation system into the lighting and appliance systems within the building. Lighting controls (or the more advanced BAS) will control energy usage throughout the home reducing the electrical energy needed to power the residence. Finally after all other options have been exhausted consider installing a small wind turbine or solar photovoltaic system to generate at least enough power to cover the home’s energy needs. However slightly oversizing the system can permit the selling of the excess energy to the grid or to supply power to a back-up battery or fuel cell system.
CHAPTER 8: CONCLUSION

The current path of conventional development with regards to infrastructure, community design, and residential design needs to change. This document has presented the current development practices of those developmental areas as well as highlighting the best practices, techniques, and technologies of sustainable community infrastructure and building design to date. It has then broken down the various concepts and applied them to a selected area for possible demonstration of those green building and green infrastructure ideas. By doing so this paper hopes to properly demonstrate an exploration of sustainable development practices and their application to a real-world situation. It is through this approach that one can attempt to understand the interactions between the hundreds if not thousands of variables and having the knowledge and skills to recognize them. By providing a holistic view of green infrastructure, green community design, and green residential design the path of true integration and sustainable development can be achieved. The next steps of this document would likely entail delving deeper within the concepts and ideas that were highlighted and providing more detail within the suggested actions. Another future step would to broaden this document to include the entirety of the Skillman Village site as the document currently only focuses on a small area of the 256 acres that makes up the entirety of the site.
BIBLIOGRAPHY


APPENDICIES

APPENDIX A – Impervious Landscape

APPENDIX B – Pervious Landscape
APPENDIX C – Traffic Congestion Tables

Table 7. Congestion Trends – Wasted Hours (Yearly Delay per Auto Commuter, 1982 to 2010)

<table>
<thead>
<tr>
<th>Urban Area</th>
<th>Yearly Hours of Delay per Auto Commuter</th>
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Very Large Urban Areas—over 3 million population
Medium Urban Areas—over 1 million and less than 3 million population
Small Urban Areas—less than 1 million population

Yearly Delay per Auto Commuter—Extra travel time during the year divided by the number of people who commute in private vehicles in the urban area.

Note: Please do not place too much emphasis on small differences in the rankings. There may be some difference in congestion between areas ranked (for example) 6th and 7th. The actual measured values should also be examined.

Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

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APPENDIX D – Department of Energy U.S. Wind Map

United States - Annual Average Wind Speed at 80 m

APPENDIX E – Department of Energy U.S. Solar Map

This map shows the annual trends in the amount of solar radiation received in the United States and its territories. It is a spatial interpolation of solar radiation values derived from the 1991-2000 National Solar Radiation Database (NSRDB). The dots on the map represent the 2,394 sites of the NSRDB.

Maps of average values are produced by averaging all 30 years of data for each site. Maps of maximum and minimum values are composites of specific months and years for which each site achieved its maximum or minimum amounts of solar radiation.

Though useful for identifying general trends, this map should be used with caution for site-specific resource evaluations because variations in solar radiation not reflected in the map can exist, introducing uncertainty into resource estimates.

Maps are not drawn to scale.

National Renewable Energy Laboratory Resource Assessment Program

APPENDIX F – Skillman Site Mixed Use Area #1
APPENDIX G – Skillman Site Infrastructure Initial Design 1

An initial design of the roadway surrounding Mixed Use Area 1.

APPENDIX H – Skillman Site Infrastructure Initial Design 2

Example of a greenscape along multiple transportation options
Initial design of an integrated transportation system that allows for different modes of transport

APPENDIX I – Skillman Site BRT Lines

BRT Line 1: To the left is a possible path from Skillman to Princeton
BRT Line 2: To the right is a possible path from Skillman to Trenton
APPENDIX J – Skillman Site Mixed Use Initial Design 1

Initial design of Mixed Use Area 1. A top-down view of the site.

Initial design of Mixed Use Area 1. A preliminary attempt to show the central courtyard surrounded by the mixed used buildings.
Initial design of Mixed Use Area 1. Another preliminary attempt to show the central courtyard surrounded by the mixed used buildings with an on-the-ground view.

**APPENDIX K – Materials and Resources Organizations and Standards**

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<td>EPEAT (Electronic Product Environmental Assessment Tool)</td>
<td>Electronic Equipment (HVAC, computer systems)</td>
<td>EPEAT Bronze, EPEAT Silver, EPEAT Gold</td>
<td>IEEE 1680.1</td>
<td>LEED 2009 v3 Reference Guides</td>
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<td>RFCI (Resilient Floor Covering Institute)</td>
<td>Flooring materials</td>
<td>FloorScore</td>
<td>California Section 01350</td>
<td>LEED 2009 v3 Reference Guides</td>
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<td>FSC (Forest Stewardship Council)</td>
<td>Wood</td>
<td>FSC Certified</td>
<td>ISEAL Code</td>
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<td>Green Seal</td>
<td>Cleaning Products, Paints, Sealants, Adhesives, Paper, Equipment</td>
<td>GS-11, GS-8, etc. (34 Standards)</td>
<td>ISO 14020, ISO 14024</td>
<td>LEED 2009 v3 Reference Guides</td>
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<td>SCAQMD (South Coast Air Quality Management District)</td>
<td>VOC Air Limits</td>
<td>Rules 1401 - 1472</td>
<td>N/A</td>
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<td>SCS (Scientific Certification Systems)</td>
<td>Building Material Systems, Chain of Custodies, Furniture</td>
<td>Indoor Advantage™, Green Squared™, FloorScore® calCOMPliant™, Sustainable Choice™, level™</td>
<td>California Section 01350, ANSI NSF 140-2007, etc.</td>
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