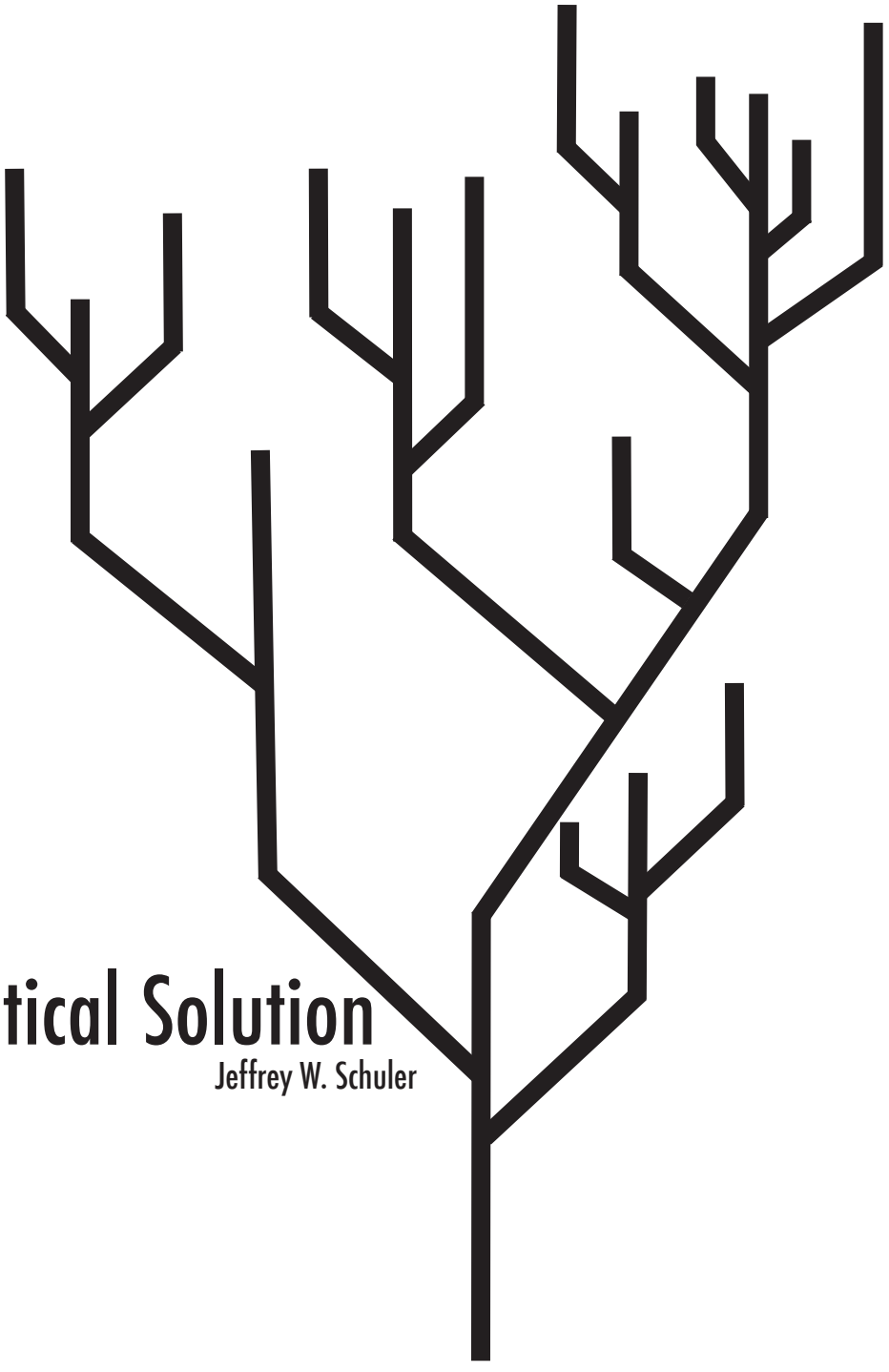

Cultivate: A Vertical Solution

Jeffrey W. Schuler

Cultivate: A Vertical Solution

A Design Thesis Submitted to the Department of
Architecture and Landscape Architecture of
North Dakota State University

By:
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In Partial Fulfillment of the
Requirements for the
Degree of Master of Architecture

Thesis Advisor

Thesis Committee Chair

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Abstract

This thesis titled “Cultivate: a Vertical Solution” will address the question, “How can architects stop suburban sprawl?” The typology of this project will be a 535,234 sqft high-rise mixed-use vertical farm in Brooklyn Center Minnesota. This building will use the site vacated by Brookdale Mall after it’s demolition. The theoretical premise explored in this research will be suburban sprawl and hydroponic farming techniques. The project justification is that architects need to create an inviting alternative to sprawl that requires fewer outside resources.

Keywords: **Sprawl, New Urbanism, Sustainability, Human Scale, Vertical Farming**

Problem Statement

How can
Architects
stop
suburban
sprawl?

Project Typology:

- Mixed-Use Vertical Farm

Claim

As designers and developers, architects have the ability to create desirable, compact population centers that can be an alternative to sprawling suburbs.

Theoretical Premise

The trend of moving farther and farther away from the city needs to be changed. Instead of spending our money destroying virgin soil, we need to be improving urban centers, creating human-scaled, self-sufficient urban environments instead of solely relying on the car.

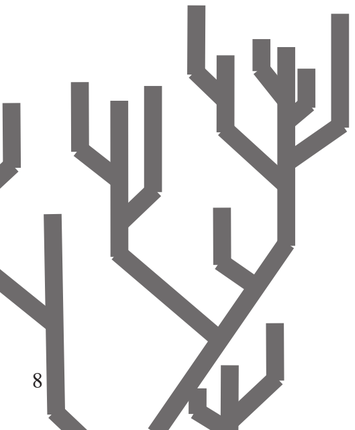
Since the end of World War II the American dream has been to move out of the city, have a big yard, and own a home. This model was fueled by cheap oil and ambitious developers. This model has shaped our nation and created a land of pavement and a society of automobiles. This growth outward has forced farmers to plow under more and more natural landscapes, forcing our food to travel farther and farther. Our entire life now revolves around the automobile.

"Cities will gain an amount of land roughly equal to that of Mongolia. This extensive and rapid growth will pose significant challenges to urban environments" (Moretti, 2011, para. 1). The age of the sprawling suburb has created many problems. One of the largest is the issue of sustainability. The expenditure of energy to feed a suburb is enormous. This is especially true if compared to the energy per person a city uses. Not only is it an unsustainable lifestyle, it has created an asphalt desert of cheap, ugly, repetitive buildings that don't accommodate people well.

Project Justification

In order to stop suburban sprawl architects need to create inviting alternatives. People want and need to return to human-scaled environments and those environments need to be created or enhanced by architects. The way people are currently living, in large, spread-out suburbs is unsustainable and needs to be stopped. These urban-centers along with creating a better environment to live in-need to be more self sustaining so less of our energy is spent on needless transportation. Dense population centers need to be created or improved to make them more desirable and to accommodate more people.

Narrative



In the pursuit of the American dream of a single-family house on our own property we have created the worst kind of development, sprawl. This pursuit has lead us farther and farther away from the city in search of cheap land and wide open spaces. This constant drive outward has lead to the degradation of people's way of life. This search for a cheaper place has created a cheap, barren, ugly, and plain existence. Very little in the suburbs is designed with attention to detail and original thought. People can no longer walk to the corner store or leave the car in the garage for a day. Everything we do now burns fuel. We burn fuel to get groceries, to go shopping, or even go to the park to exercise. In the sprawl outward we have lost the human scale. Our whole environment is designed for the car, not the people living in it. Suburban sprawl needs to stop in order to create a more conducive environment for living and sustaining society.

The search for cheaper land has been followed by the search for cheaper buildings. We have been obsessed with the idea that bigger is better. In this philosophy we have lost the importance of design. Cities are surrounded by a belt of garbage. The suburbs have incubated a building style that is unoriginal and depressing. All the buildings are massive concrete block structures that look the same as the one right next to it. Houses sprawl out in neighborhoods that are designed to be stagnant. Roads that lead nowhere to deter traffic have turned them into dead zones.

These dead zones contain an army of house clones all wearing the same boring beige uniforms of vinyl siding. This army crushes people's spirits and their individuality. The terrible suburbs have taken over large tracts of the U.S. and created a country not worth caring about. When an old building in a downtown area is in danger of being destroyed people come together to save it. In the suburbs if a building is vacant there is a rally to tear it down and get rid of it because a vacant lot is better then the dreary cardboard boxes that continue to be built. These cheap cookie cutter buildings are destroying the individuality and energy of our communities.

We need a return to a human scale. We need to resume using people as the scale of design. Why do people walk in the city? Is it because it is too congested to drive in or is it that it has been designed with people in mind so they can walk everywhere? Most large cities were first organized and built before cars. This means the main mode of transportation was people's feet. People want to walk in the city because it is easier then driving. The car still hasn't established its dominance there. Buildings are built right next to each other to create a shorter distance to walk. The entrances are right up to the sidewalk to invite the pedestrian. The buildings are designed with detail to stimulate the people walking by.

In suburbs not only is everything spread out so walking anywhere would take hours, but the spaces and buildings make people feel uncomfortable. The buildings are not actually for people; they are for cars. A sense of place is created when places are meaningful to a person and show character. This, however, is all contingent on a person's ability to define the space. We define space trough buildings and the boundaries they create. In the sprawling suburbs, the wide-open parking lots next to wide impassable roads separate every building so much that people feel like they are in the middle of nowhere. Even if we continue our cheap, unoriginal building style, bringing buildings closer together would have a tremendous impact in making the spaces around them more habitable. We need to start designing for people.

This world we have created entirely depends on outside energy, which is at least for now, finite and damaging to the environment. Everything we do and everywhere we go uses energy. It is the way the world has evolved and our lives are better because of these advances. However, it is the excessive use

of this energy that needs to be changed. The waste of energy is only exacerbated by suburban sprawl. The most apparent excessive use of fuel is in the necessity of the car to get anywhere. More and more in this country, people are working in technical and information careers. These jobs tend to be located in cities. With people moving farther and farther away from the job centers we are using more and more fuel to get to the city every morning and get home every night. We have created such a spread-out environment that everywhere we go we need to drive. In cities people walk to do most of their errands or at least are able to use public transit. It is a way to connect with the community and save energy and the planet.

The second biggest waste of energy is the individual house. Single-family houses have a much larger surface area then apartment and condo buildings, and lose heating and cooling energy. Even townhomes or row houses are more efficient. By sharing walls and HVAC systems, energy consumption and cost can be greatly reduced. Energy is costing the average American a larger percent of their income per year then any other time in history. Even if the degradation to the planet that our energy use is causing is ignored, prices will continue to go up and the average family wont be able to sustain their way of life in the suburbs. We can't keep building for the automobile.

It is this need to stop suburban sprawl that has lead me to this project. To stop urban sprawl we can't just create new dense cities. We need to work with what we have and make the land we have already developed fit this new model with a strategy of infill. Brooklyn Center, Minnesota is a neighbor to Minneapolis. It doesn't have many high density filled city blocks that Minneapolis has, but it is a well established city with its own character and a fairly dense make up compared to farther-out suburbs. Any addition to this city would need to be done by increasing the density. It is an inner suburb and additional development won't increase sprawl.

In our quest outward we have paved over valuable farm land. Farming is more than a pillar of our economy; it is the foundation of our existence. If we continue to build over farmland and the population continues to increase, we will need to find new ways to grow food. In this country we are currently farming all of the arable and some of the non arable land we have. Just as we have built up in cities to fit more houses, we will need to build up to find more room to grow crops. This is why vertical farming will become so important in our future.

In 1962, Brookdale Center was built in the heart of Brooklyn Center. It was once one of the busiest places in the metro for shopping. Now it is an example of the failed suburban mall. This is in the process of being torn down. The large site it sits on is the heart of Brooklyn Center. It makes it a perfect infill site to create an urban center in a populated area without the need for new land farther out from the cities.

Creating habitable urban centers needs to be the future of our society. We cannot continue down the path we are going with sprawling development. This change doesn't need to be radical and there isn't a large learning curve. We just need to return people to cities and return city planning to the knowledge of the early 20th century. These are not new ideas, we are just returning to proven design that has worked well for thousands of years. We need to return to more dense living, where we have the money and people to support a vibrant built environment. This kind of environment will encourage a vibrant society and be environment we can be proud of and marvel at its beauty. We need to return to a time when people, not cars, were the rulers we design for. We need to create places for people to live in. We need to relieve ourselves of the depressing, unsubstantial garbage belts that surround our cities. Either we do it now because we can see the improvements it will bring to life or we wait and are forced to by an energy crisis that this nation and all of humanity may not recover from. We need to end the failed experiment of suburban sprawl.

Client Description

Clients

A project to create a new urban center will have many clients. Interested parties in this development will be developers, businesses, and individual homeowners. With a development of this size, multiple contractors and designers will have interests in this project. The developers with the money to fund this large-scale building project will ultimately not be the people who will inhabit the site.

This development will be built for individual families and business owners who will be the final owners of these places. The living spaces will be mostly condominiums, providing the American dream of being a homeowner.

Along with homeowners the building will include business owners and provide leased spaces. It is important to encourage ownership to give families and businesses an incentive to take care of the community.

Beyond these people, will include city officials. They will have an interest in seeing this once-profitable site return as a tax base, and also as an experiment that may influence future development of the city and the surrounding areas.

Users

The users of this project will be the citizens of Brooklyn Center. This project will become a new city center not only for the people living on the site but all the people who will come to work, and shop at this site.

This project will provide the building blocks of a new urban center that will create a gathering place for the city. Even people who don't visit this building will be impacted by the ability to buy farm fresh food year round from a local producer.

Major Project Elements

Mixed-Use Building

This building will accommodate a dense new urban center by providing space for multiple uses. The first floor will be the most engaging to the public by providing commercial space for passersby. Above the first floor will be residences that can house 200 people.

Vertical Farm

Integrated into the mixed-use building, a farm will provide enough food for the inhabitants. The nature of the site and program will require this farm to grow upward instead of outward to save the space around the building for more urban activities. The farm will be self contained and require few outside resources.

Site Information

Region

Minnesota is located in the center of the United States on the Canadian border. It is the 21st most populous state, with 5,266,214 people (U.S. Census Bureau, 2011). It is known as the Land of 10,000 Lakes for its abundance of them. Minnesota experiences temperatures in the summer of more then 100 degrees Fahrenheit, and winter can bring stretches of double digit negative temperatures. These extremes are part of the identity of Minnesota and create spectacular sites during all four seasons. Minnesotans are known for their kindness, as the popular term “Minnesota Nice” demonstrates. A stereotypical Minnesotan is of Scandinavian descent and is Lutheran by faith. The state routinely votes liberal overall, but in the rural areas there are strong conservative communities. The people of Minnesota tend to be outdoors people and cherish the large amount of natural areas throughout the state.

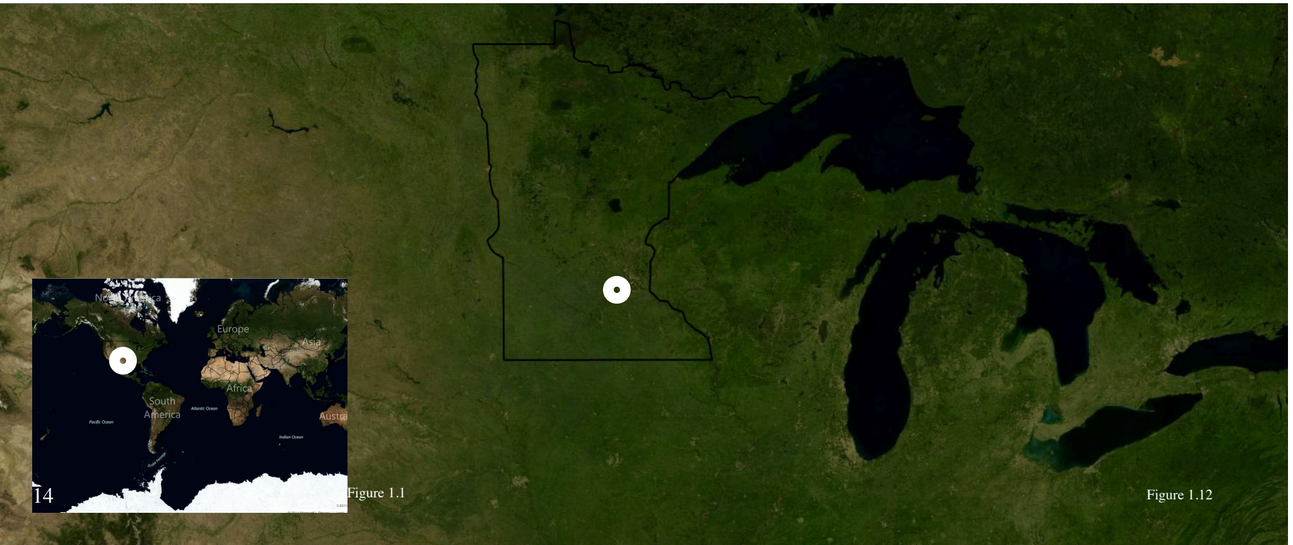


Figure 1.1

Figure 1.12

Brooklyn Center, Minnesota

Brooklyn Center is a neighboring suburb of Minneapolis. Brooklyn Center has a population of just over 30,000 (U.S. Census, 2010). It was once a booming city but has fallen into somewhat of a slump as the sprawl movement has passed it by. It is not, however, dead. There is still new construction happening; the most notable is a new $61 million FBI field office (Baca, 2010).

The city consists of many medium-density neighborhoods and a large core of commercial properties, such as high-rise office and condominium buildings. The city is well connected to the metro through the multiple highways that run through it. Two major highways create direct routes to the Minneapolis /St. Paul area and the third, interstate 694, is part of the interstate belt that surrounds the Twin Cities and connects the larger suburbs.

Figure 1.2

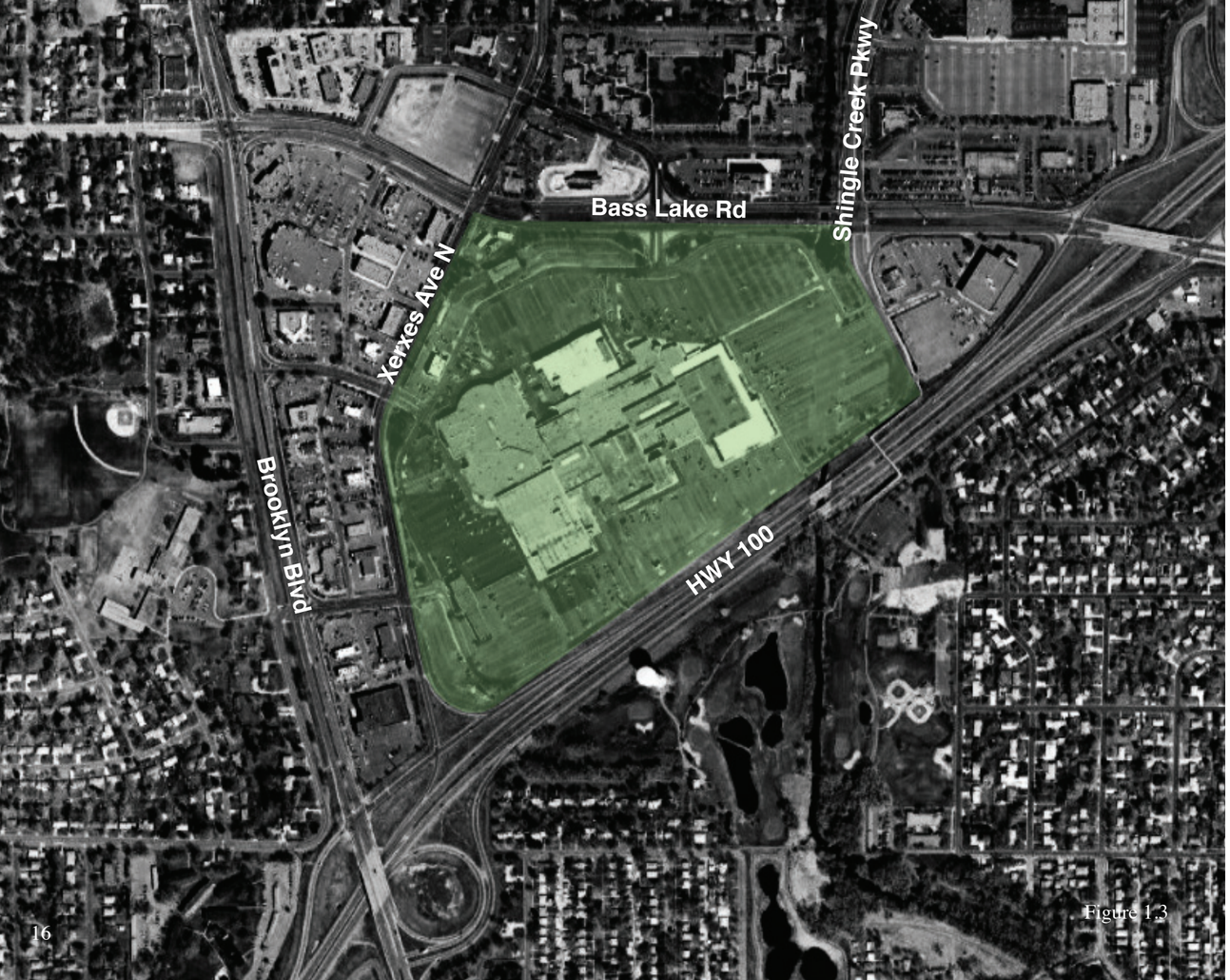


Figure 1.3

Brookdale Center

Brookdale Center is located in the commercial district of Brooklyn Center. The site encompasses 88 acres that the mall and a massive parking lot used to occupy (SEC Report 1996). The site is surrounded by light commercial properties and is within walking distance to some of Brooklyn Center's older neighborhoods.

The site also borders Highway 100, which runs south to Minneapolis and north to the 494-694 interstate belt. In addition to the city connections Shingle Creek runs through the site. The creek is accompanied by walking paths that connect to a park, a golf course, library, and the community center, all of which add to the site.

These connections and the proximity to the metropolitan area create an ideal place for a dense urban center. The fact that this project will be infill and won't add to the project makes it even better. In order to stop sprawl, we need to work with the land we have already developed.

Project Emphasis

The emphasis of this project will be to create an alternative to suburban sprawl. This building will be able to sustain the inhabitants by giving them a place to live and grow the food they need. The properties of the design will make it an ideal building block for a new urban environment that brings new development back to a human scale and reduces the need for travel in everyday situations.

Plan for Proceeding

Definition of Research Direction

The research for this project will look at the phenomena of sprawl and new ideas that can curb the trend. This search will help me develop a clearer understanding of the theoretical premise concerning the problems of sprawl, why it is occurring, and how to create a dense community that people will enjoy living in. This will mean studying mixed-use communities and buildings. These lessons in successful urban centers will be implemented into my design.

The lessons in the typology will be even more useful with the knowledge of the historical context of the urban environment and the community that will be home to the proposed project. Along with the history, I will gather information about the site. This information will help to create a solution that is specific to the context around it. Finally, research into the programmatic requirements of this type of project will be compleat.

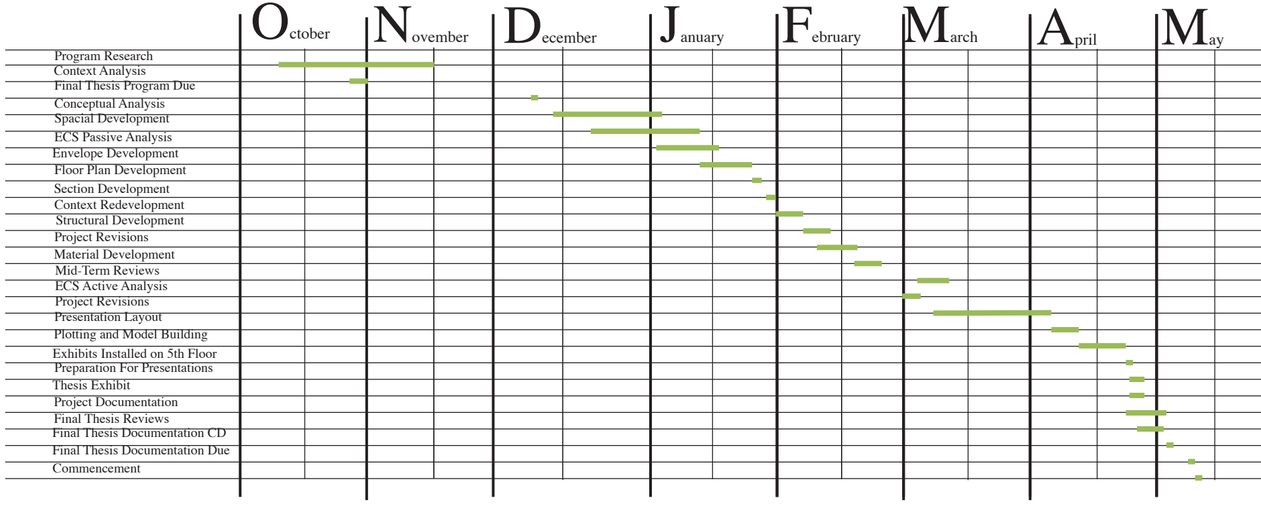
Plan of Design Methodology

The methodologies that will be employed are mixed method, quantitative qualitative analysis, graphic analysis, and digital analysis. The research will be guided by a concurrent transformative strategy guided by the theoretical premise. This plan will gather quantitative and qualitative information throughout the research phase of this thesis. Quantitative data will include scientific and statistical information. Qualitative data will be gathered through direct observation and archival searches. Analyzing the data collected will occur frequently as information is assembled. This assembled information will be presented in text and graphics.

Plan for Documenting the Design Process

This thesis will be documented in this book detailing the entire design process. It will be preserved digitally in the North Dakota State Institutional Repository and made available to future students there. The conclusion of this thesis will be presented to students and faculty members of the Architecture Department in a formal presentation.

Thesis Design Schedule

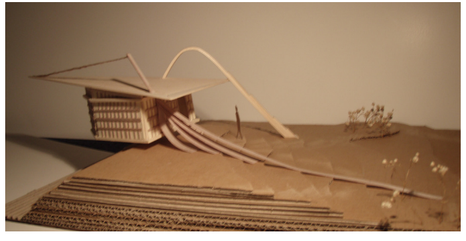


Previous Studio Experience

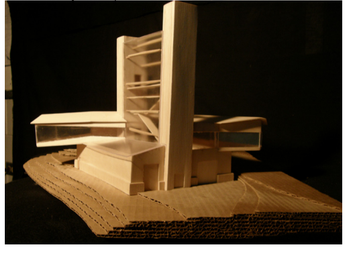
Second Year

Fall 2008 Joan Vorderbruggen

Tea House
Fargo, North Dakota



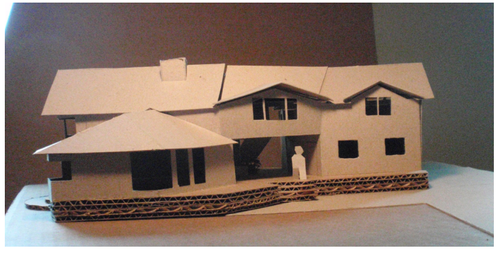
Boat House
Minneapolis, Minnesota



Spring 2009 Meghan Duda

Dance Theater
Fargo, North Dakota

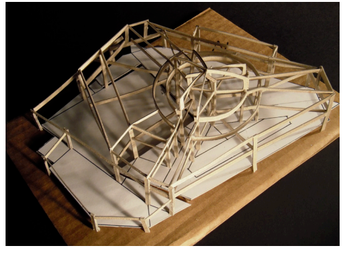
Family Residence
Fargo, North Dakota



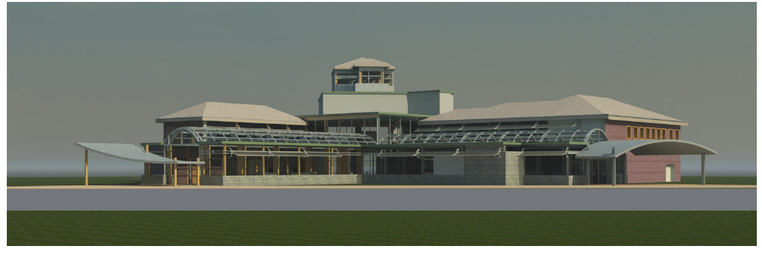
Third Year

Fall 2009 Steve Martens

Arctic Satellite School
Aklavik, Northwest Territories



Airport
Bemidji, Minnesota



Spring 2010 David Crutchfield & Mike Christenson

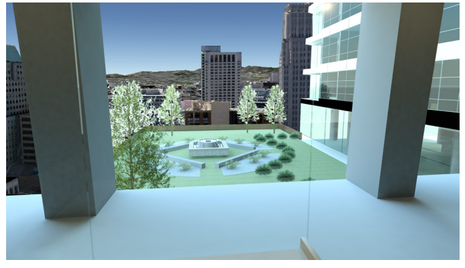
Performing Arts Center
Austin, Texas

Art Gallery
Minneapolis, Minnesota

Fourth Year

Fall 2010 Frank Kratky

Mixed-Use High- Rise
San Francisco, California



Spring 2011 Frank Kratky & Don Faulkner

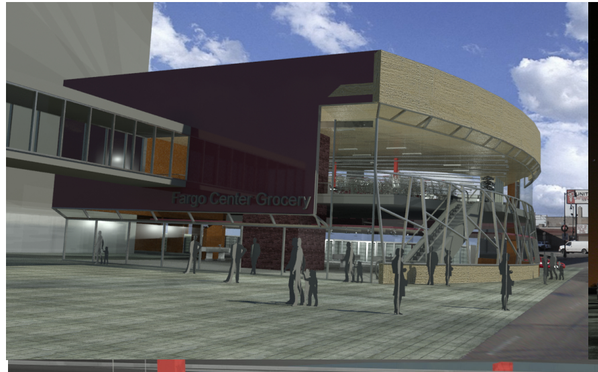
Mixed-Use Building
Fargo, North Dakota

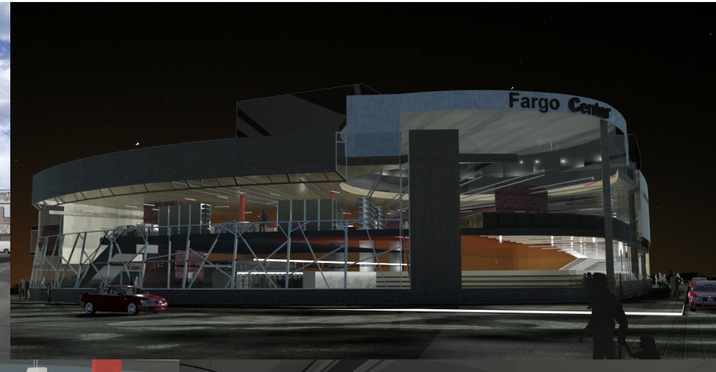
Master Plan
Williston, North Dakota

Fifth Year

Fall 2011 Paul Gleye

Grocery Store
Fargo, North Dakota






The Proposa

Theoretical Premise Research

Suburban Sprawl

The definition of sprawl as it relates to land development, according to Anthony Flint, is

> Low-density development that disperses the population over the widest possible area, with rigidly separate functions-homes, shops, and workplaces-connected by limited-access roadways. The car is the primary mode of transportation; there are few functional sidewalks or lanes for bicycles, and little or no access to transit. (Flint, 2006, pp. 47)

Sprawl is taking over our country at an alarming rate. From 1987 to 1997, 25 million acres of rural land was developed into subdivisions malls, office parks, and parking lots. The amount of land suburban sprawl has swallowed up is about the size of Maine and New Hampshire combined. None of this land developed as suburbs is used to its full potential (Flint, 2006).

The United State's population is currently at about 300 million people. In the next two decades, the population is expected to grow by 40 million more, according to the U.S. Census Bureau. They project that of this 40 million people 80% of them will live in the suburbs. By 2025 the growth of the suburbs will require millions of miles of new pipes to carry 9 billion gallons of clean water and 8 billion gallons of sewage. Along with pipes, the expansion will force local governments to build 2 million miles of new roads to accommodate 100 million more cars. All of this needs to be built and paid for in the next 15 years (Flint, 2006).

According to Flint (2006) in 1979, 26% of office space was in the suburbs. Compare that to 1999, when 46% was in the suburbs. Ninety percent of all office space built in the 1990s was built outside the limits of traditional cities. This trend shows the extent of the sprawl mentality. The cost of building, operating, and using this suburban infrastructure, according to researchers at Rutgers University will be $202.7 billion, or 26,294 per person through 2025 (Flint, 2006).

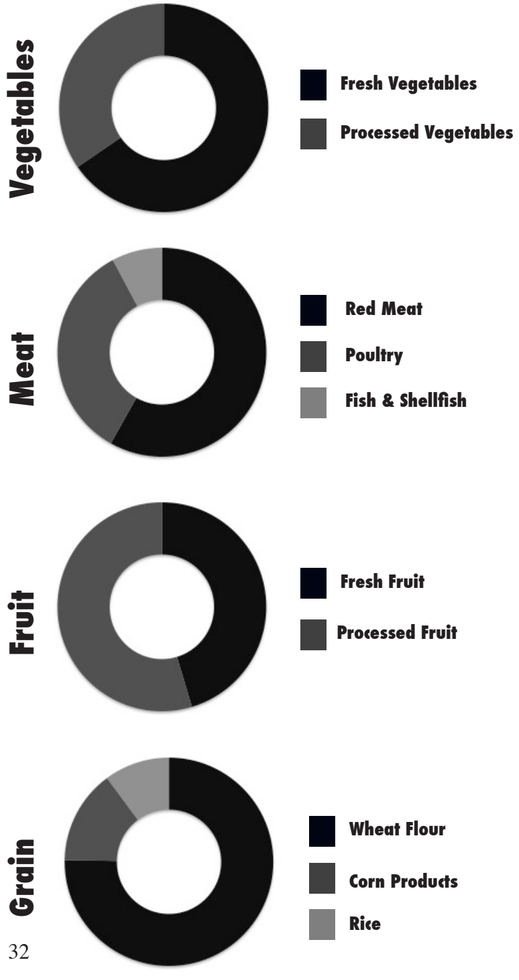
This sprawl isn't just costing money in infrastructure; it is costing both time and money in productivity. The average driver spends 443 hours per year behind the wheel. That's 55 eight-hour workdays. A 2005 Texas Transportation Institute report found that the total delay from congestion for the U.S. was 3.7 billion hours, wasting $63 billion in productivity. Along with time, congestion wasted 2.3 billion gallons of fuel while cars were stuck idling in traffic (Flint, 2006).

From 1992 to 1997, 12.8 million acres of cropland, pasture, and range land were taken over by sprawl. If the growth pace of the 1990s continues the U.S. will lose 30% of it's farmland by 2100. This land will probably be lost forever while the population that depends on farming increases. In this period crop land per capita will go from 1.5 acres per person to .5 acres per person. This limited land will make it impossible with today's technology to feed the people of this country (Flint, 2006).

The key to a more dense population is diversity. People need to be able to live their lives in a relatively small area. This means not only living and working in an urban center, but it also means producing what they need in the community. For this reason I am proposing to create a farm in the middle of a dense urban center.

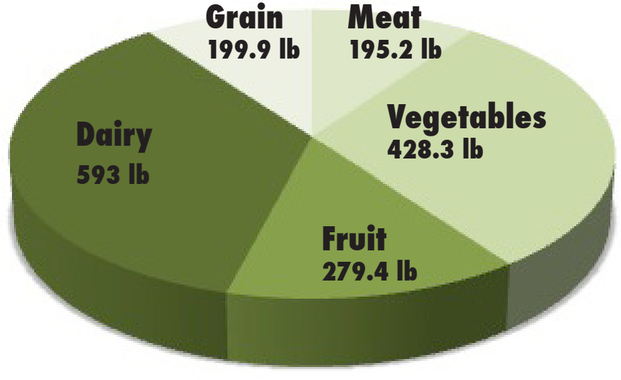
American Consumption

The United States is one of the largest consumers of food by country and capita in the world. The United States Department of Agriculture recommends a 2,000 calorie day diet for the average American. This doesn't mean, however, that, this is all the food needed to sustain our culture. In the year 2000 farmers produced 3,800, calories per day per person. Of those 3,800 calories 1,100 of them were lost due to spoilage, cooking, plate waste, and other losses. That means on average Americans eat 2,700 calories per day (U.S. Department of Agriculture, 2003). In other words the average American today uses approximately 1975.2 pounds of food a year. Farmers produce all of this food. The following page shows a breakdown of this in pounds per person per year.



Average American Consumption

Pounds per Person per Year



Data from (U.S. Department of Agriculture 2003)

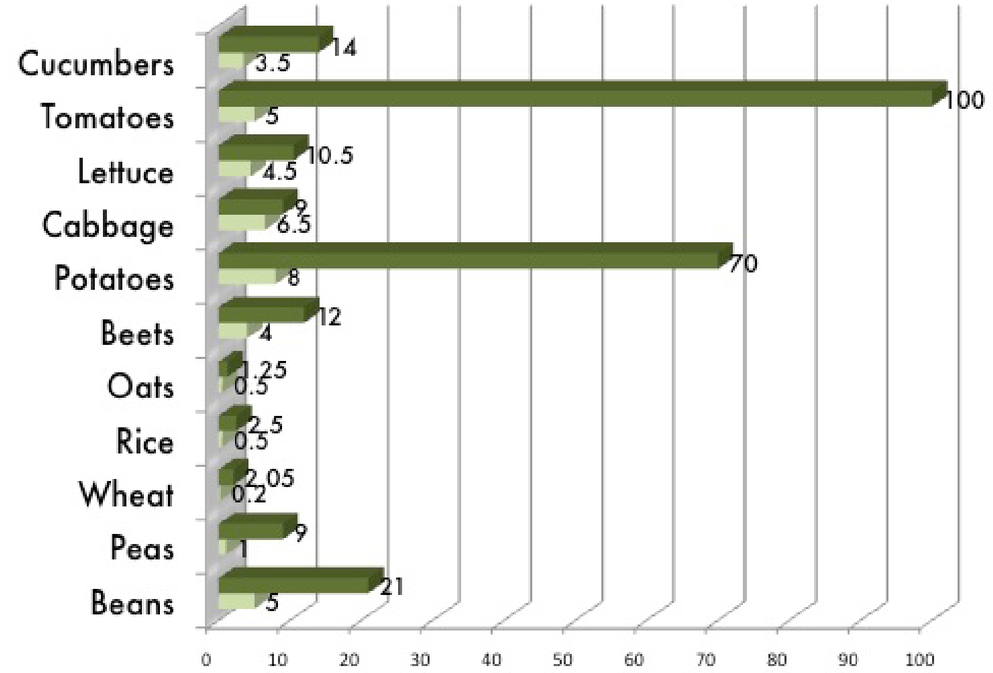
Hydroponic Farming

America is full of traditional farms. Basic farming techniques have changed little since ancient times. Fields are plowed and seeds are planted in the dirt and the farmer waits for the fall to harvest. The traditional system is almost completely reliant on the weather and good luck. For centuries people have been trying to control crop production to take chance out of the equation. This research has led to the advent of hydroponics.

Hydroponics is the practice of growing plants without soil by using nutrient-enriched water. Many different techniques have been devised to support different plants. Since its introduction hydroponics has been shown to increase yields with nearly every crop that has utilized the system. Across the range of different crops that are in large-scale production listed in table 3.2, hydroponics growers have experienced an average of 640% increase in yields over traditional farming (Resh, 2001). These figures are in open air farming, without the environmental control of a greenhouse.

Crop Yields of Soil Growing Compared to Soilless

Tons per Acre (figure 3.2)



Data from (Resh 2001)

Soil Versus Soilless Culture

The reason hydroponics is more fruitful than traditional methods of growing plants in soil is the control it gives the grower. It allows farmers to grow plants in the most ideal conditions. According to Resh (2001), advantages of hydroponic greenhouse production over traditional soil techniques are listed below:

Traditional Soil Farming	Hydroponic Greenhouse Farming
• Soil may lack nutrients or have poor structure	• Can create ideal base structure and nutrient balances
• Pests and disease accumulate in soil and make crop rotation necessary.	• Growing medium and nutrient solution are sterilized
• Plant spacing is limited by soil nutrient levels and available light	• Limited only by light which can be increased with electric lights
• Weeds infiltrate fields and require work and chemicals to remove	• Sterilization and sealed environment don't allow weeds
• Water is lost through percolation downward past roots and through evaporation	• Water is contained in channels and evaporation and transpiration can be collected and reused, and higher salinity water can also be used
• Fruit is picked before it's ripe so it doesn't spoil on the way to market	• Higher quality fruit can be picked when ripe and doesn't spoil as quickly
• Fertilizer is applied unevenly and 50-80% is lost in the soil	• Fertilizer is evenly distributed and is contained by the plant's roots
• Fluctuating growing conditions throughout the year so plants take the whole season to mature	• With adequate light plants can mature faster
• Continues growing in the same soil can turn it fallow and require replacement or abandonment	• No soil to go fallow

Overall the main advantages of soilless culture are more efficient nutrition regulation, availability in regions having non-arable land, efficient use of water and fertilizer, ease and low cost of sterilization, and higher density planting, which leads to increased yields per acre. The main problems of soilless growing are the high initial cost of the equipment and the possible shortage of nutrients (Resh, 2001).

Irrigation

The most important part of a hydroponic system is the nutrient solution and the delivery system. The simplest system for irrigation and nutrition delivery includes cisterns to store nutrient solutions, a mixing station to combine water and nutrients, and a method to deliver the water nutrient solution to the plants.

A typical commercial hydroponic operation will need to monitor the plants and their growing conditions constantly to achive maximum production. For commercial growers the entire nutrient delivery system can be computerized to adapt instantaneously to conditions such as heat, sunlight, size of plants, and maturity, which all increase the demand for water. These computers measure temperature, water pressure, water volume, nutrient contents, and health of the plants. With these readings the computer can mix unique nutrient solutions from the cisterns with water at an average of 1:200. For a typical 3-acre system, there should be two 1,500 gallon cisterns for concentrated nutrient solutions. Two tanks are usually

Minerals Essential to Plant Growth

1. Hydrogen
2. Carbon
3. Oxygen
4. Nitrogen
5. Potassium
6. Calcium
7. Magnesium
8. Phosphorus
9. Sulfur
10. Chlorine
11. Boron
12. Iron
13. Manganese
14. Zinc
15. Copper
16. Molybdenum

needed to address the changing needs of the plants as they mature. A third 30-gallon cistern is also needed to store acid that will be added to the mixture. The most common mixing system to combine these three solution parts include jets that spray the concentrated solution into a stream of water as it passes. Another vital component to this mixing system is a UV light sterilizer to make sure the solution can't infect the plants downstream. From there the nutrient solution is delivered to the plants (Resh, 2001). Different methods of delivery will be discussed later in this thesis when specific systems are discussed.

A mature cucumber plant can require up to 230 ml or almost half a pint of water per hour during midday. Multiply that times thousands of plants and one can see the large quantity of water that is required to support a hydroponic farm. Depending on the plant and the environment, the nutrient solution needs to be dispensed as much as once an hour to as little as twice a day. The need for these cycles stems from the need of the plants roots to be able to absorb carbon dioxide. If they are constantly submerged the plants will effectively drown (Resh, 2001).

Medium

The word medium as it relates to hydroponics is the substance that the plant grows in and is anchored by. The medium needs to provide support for the plant while facilitating the intake of water, nutrients, and to some extent oxygen. The medium must be hard for durability and support. However it can't be sharp or abrasive, as it will damage the stem. The medium must also retain water to allow the roots to absorb it but also drain so the roots don't drown. When using a medium one must also be aware of the properties of it. Some mediums, such as sand or sawdust, may already contain nutrients meaning less needs to be added to the solution for healthy growth. Selection of a medium is determined by the structure a plant needs and the availability (Resh, 2001).

Medium Materials

- Water
- Foam
- Gravel
- Rockwool
- Sand
- Sawdust
- Peat
- Perlite
- Pumice
- Peanut hulls
- Polyester matting
- Vermiculite

Hydroponic Growing Systems

Basic Water Culture

According to Resh (2001), "Of all the soilless methods, water culture, by definition, is true hydroponics." Along with being the truest from of hydroponics it is also the simplest. In water culture plants are suspended so the roots rest in a nutrient solution. One of the more common forms of water culture is the raft or floating system. In this system plants are grown on styrofoam and then floated in the nutrient solution.

The advantage to this system is the ease of construction and simplicity of the parts. A large shallow basin is the main-and only structure needed. This basin also serves as the delivery system instead of miles of pipes feeding individual beds. The other main advantage of this system is that the rafts are movable. This makes planting, inspection, and harvesting much easier. A typical system may have dozens of rows, or racetracks that contain the rafts in a single basin. In an ideal situation, farms can plant portions of a crop at different times to keep a continuous supply of fresh produce. With this system, the rafts with growing plants can be continuously moved down the track as they mature. At the end of the track is the harvesting station that now has the crop coming to the farmers and their machinery instead of bringing harvesting to the crop (Resh, 2001).

Aeroponics

Aeroponics is also included in the category of water culture. Aeroponics is a system in which the plants are suspended over a dark chamber that the roots are contained in. In this chamber a mist of water nutrient solution is sprayed over the roots periodically. This system is inherently lighter than the others as the main volume is air. This means the construction can be lighter than other systems. This system also gets rid of the need to dispose or reuse extra nutrient and water solution because only a small amount is dispensed at a time, most of which will be absorbed by the plants before it runs off (Resh, 2001).

Aeroponics has shown great promise as being more efficient and producing a higher yield then basic hydroponics. One of the most innovative implementations of this is the barrel or drum configuration. In this system an array of aeroponic bins are arranged in the form of a barrel so the upper part of the plant grows toward the center and the roots grow toward the outside of the barrel. In the center of this circle is a suspended florescent light. The plants rotate around the light so no plant stays upside down for too long. The purpose of this configuration is to reduce energy consumption by utilizing all the available light to grow the plants. The main flaw in this system is that with being flipped constantly, only small leafy vegetables like lettuce and herbs can be grown this way (Resh, 2001).

Nutrient Film Technique

The nutrient film technique is almost a hybrid of the raft system and the aeroponic system. This water cultural technique uses a thin film to create a trough that nutrient solution is continually circulated through. This system combines the principles of the basic water culture technique by submerging the roots in the nutrient solution, but similar to aeroponics, only a small amount of water per plant is needed. The need for water is low because the liquid needs to be very shallow so it doesn't completely submerge the roots and allows them to absorb oxygen (Resh 2001).

Research Summary

To address the problem of urban sprawl, civilization needs to be more dense. This is true not only about where we live, but also where we work and produce food. This research has shown that the sprawling society we live in is inefficient and detrimental in many ways. It has explored what it will take to sustain people in the United States. The basic principles, techniques, and yields of hydroponics have also been explored. This research has shown that a change in our lifestyle needs to take place.

Suburban sprawl is draining our country. Supporting our spread-out communities will cost the country $202.7 billion between 2006 and 2025 to build, operate, and support them. The impact of sprawl isn't just on the budget supporting the infrastructure, it is also in wasted time and energy we use to go longer distances to get to everyday locations. Extra time spent waiting on congested roads will waste 3.7 billion hours of Americans' time. This waste of time is on top of the 2.3 billion gallons of fuel people will waste as their cars idle sitting in traffic. Fuel especially isn't a commodity the world can waste. This picture of waste typifies the way Americans are living.

Americans are some of the largest food consumers per capita in the world. As of the year 2000, farms produced enough food to provide the average American with 3,800 calories per day. After spoilage and other losses, Americans typically consume 2,700 calories a day. This means that the average American consumes approximately 1975.2 pounds of food a year. For the population to continue growing and consuming at this level, whether it's appropriate or not, agriculture needs to change to be more efficient.

Current projections show that by 2100, 30% of the nation's farmland will be taken over by suburban sprawl. This will reduce the acre per capita of farmland from 1.5 to .5. At this level we cannot feed everyone in the country. Hydroponic farming could hold the key to the problem of feeding the masses.

Hydroponic farming is the practice of growing plants in a controlled nutrient water solution rather than soil. This technique of growing crops is currently the most efficient and productive method to produce food. Researchers and producers alike have seen an average of 640% increase in yields with hydroponic farming over traditional farming practices. The three most important hydroponic systems are the raft or floating system, aeroponic system, and the nutrient film technique. All of these systems have advantages and disadvantages and all of theses systems will need to be utilized to grow the variety of crops people expect.

This research shows that something needs to be done to solve the problems sprawl has created. The best way is to stop it, but that wont be enough to support what we have already done and the increase of people in the future. The theoretical premise of a vertical farm is one of the solutions that will help keep this country from collapsing.

Case Studies

Scientific Barn

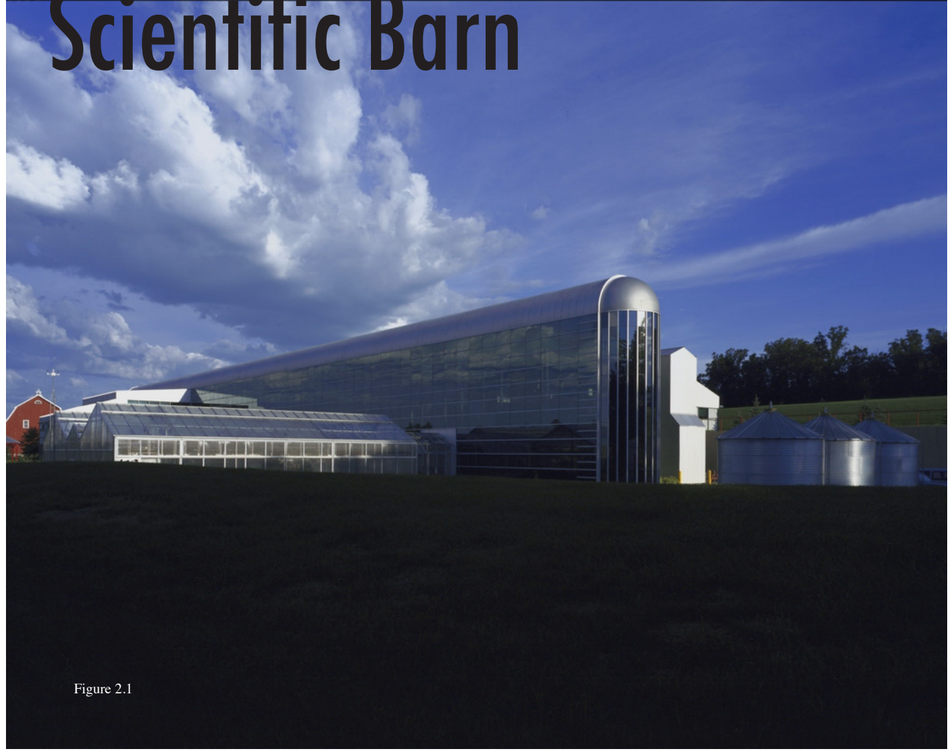


Figure 2.1

Brandon, Manatoba

IKOY Architects

97,000 sf

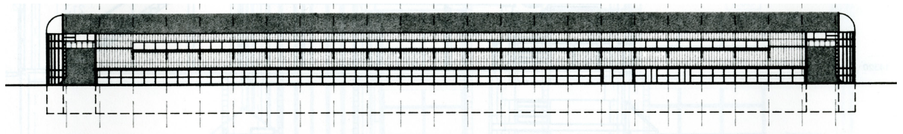


Figure 2.2

The Agriculture Canada Research Centre is an agriculture research facility in Brandon, Manitoba. The 97,000 square foot building houses laboratories and a computer-controlled greenhouse to research farming techniques and bread crops that will increase production for the surrounding farmers. Along with these research areas the building provides all the necessary support spaces for staff and visitors including offices, meeting rooms, and a cafeteria. These spaces together created a very functional place that will better the surrounding area. The most noticeable feature IKOY Architects describe as, " A 115 m long, 3-story glazed galleria that interconnects all of the above functions. The galleria is a gathering space that facilitates the interaction between the permanent and visiting researchers, other staff and visitors" (Agriculture Canada Research Centre, 2011 para 3).

This project, along with the other studies in this thesis, shows how well a project plan can be executed to facilitate the building's uses. It also shows how a building that is very focused on the program can be beautiful. For all the ways this building is similar to the other, more extensive studies in this thesis, it is different in its use and location. With these more obvious differences, this is also a public government building that deals with people moving in and out and not living here. It is a place for production; production of food, but more importantly, knowledge.

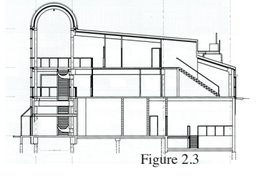
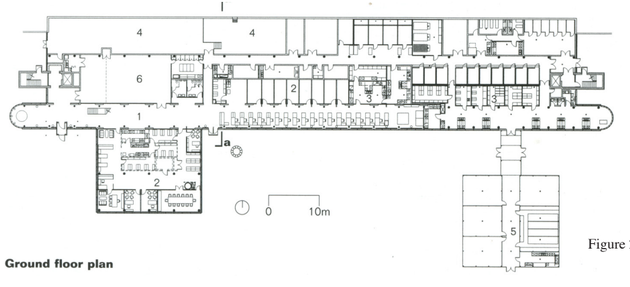


Figure 2.3



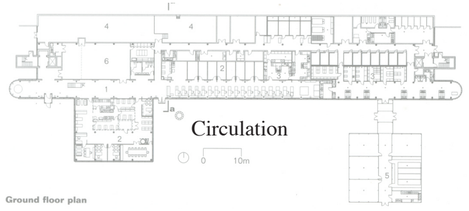
Ground floor plan

Figure 2.4

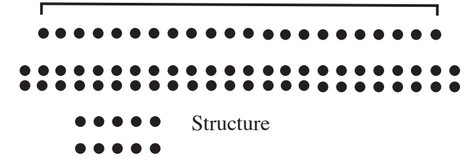
The site for this project was an existing experimental farm outside of Brandon. Brandon is large farming community of about 35,000 people. The farm is situated on a hill over a river. The initial site was on flat land between the farm and the river, but due to flooding concerns was moved back from the river onto the hill. IKOY Architects took this opportunity to connect the farming building to the land, literally, by building into the hill (Wilson, 1990).

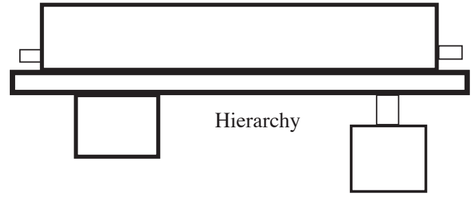
The most successful aspect of this project is its relation to the site and the typology that generated the building. The Scientific Barn was designed to be the new center for an old barnyard. A farm has its own vernacular that was created out of function but is now admired for its beauty. When one looks at the Scientific Barn they can't help but see the tall roof line of a barn with the towering circular silo making its mark on the countryside. The form of the design speaks to the culture of the farm, but the material pallet of it illustrates the high tech nature of the activities inside (Wilson, 1990).

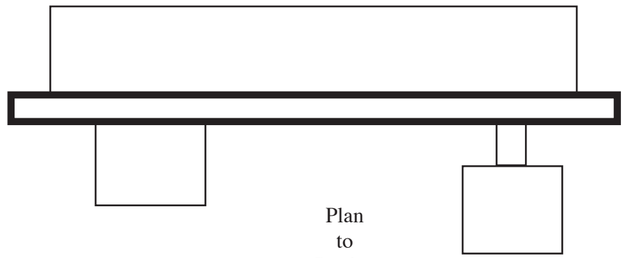
The Scientific Barn shows how one building can house multiple spaces with very different needs. It is an office building that can attend to all the needs of its inhabitants while supporting an activity as resource intensive as farming. This project shows that the very traditional farm can be changed to use modern materials and technology to improve an activity that has been around for millennia. It shows how many people can coexist with a farming operation in close quarters; not only coexist, but intertwine. This project shows it is possible to make our communities more dense and more self-sustaining by producing what people need where they need it.



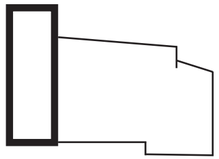
Ground floor plan

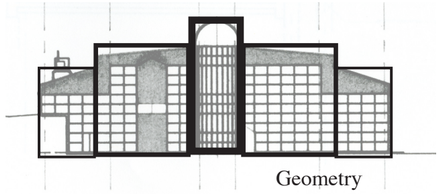




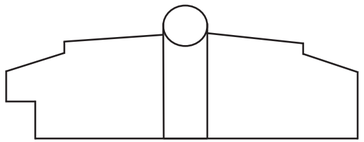


Plan
to
Section

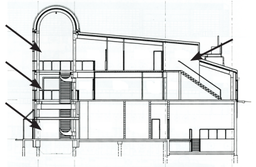




Geometry



Massing



Natural Light

Figure 2.5

State Street Village

Figure 2.6

Chicago, Illinois

Helmut Jahn

110,000 sf

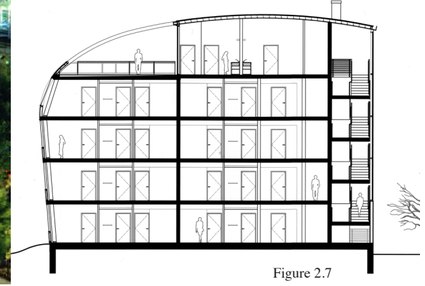


Figure 2.7

State Street Village is a new dormitory for the iconic IIT campus in Chicago, Illinois, originally designed by Mies van der Rohe. The project was completed in 2003 and encompasses 110,000 square feet of living area that houses 2,800 beds. This building is best recognized by its flowing organic form and its position as a border of the campus. It was designed primarily as a dormitory, but its secondary function was to shield the campus from the noise of the loud elevated train tracks that run just feet away from the building (Becker, 2004).

The appearance of this project also shows similarities to the Scientific Barn in the use of modern and industrial materials. Not only do they share a material pallet but they both serve as gathering spaces for the community.

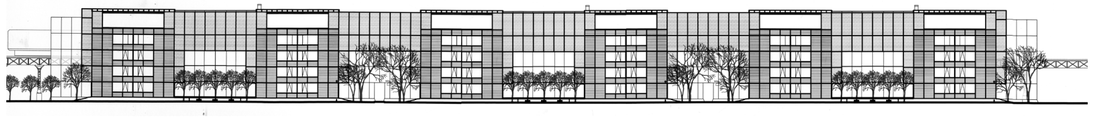


Figure 2.8

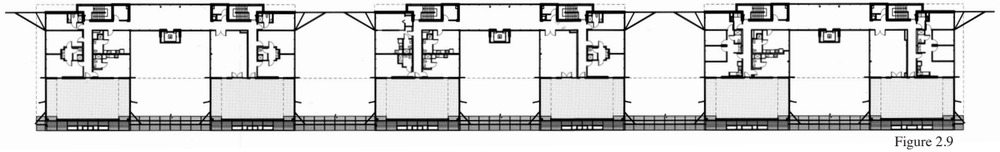
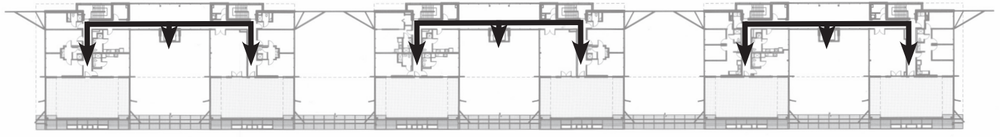
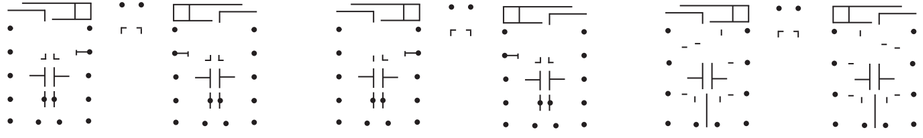


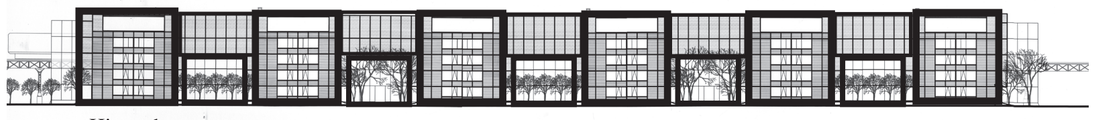
Figure 2.9



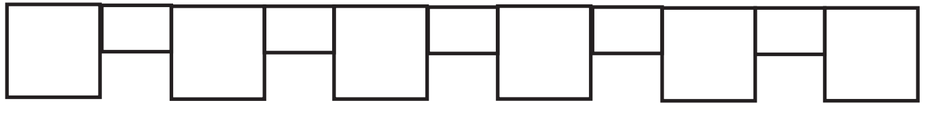
Circulation



Structure



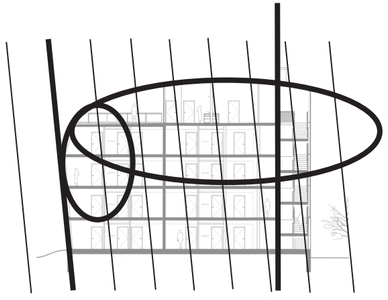
Hierarchy



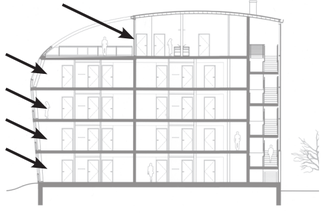
Massing

Unlike the Scientific Barn, this building serves as a living space instead of a research space, but there is a parallel in the people who use the spaces as they are all pursuing of knowledge. This project is also different from 1111 E. Pike in the location. Both sites are in an urban environment, but State Street Village is in a controlled open setting with no adjoining neighbors, while Pike is a single lot in the city of Seattle. Unlike the neighbors in Seattle, IIT will be able to control the surroundings and preserve the vision of the building in the site.

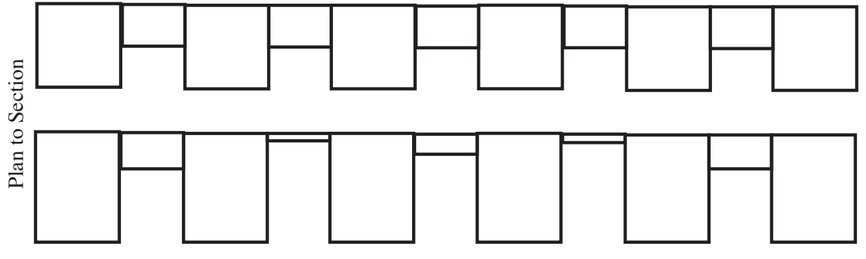
State Street Village is one of the newest additions to the legendary Mies van der Rohe IIT campus. The building responds to this by using principles that Mies designed by, including the idea that windows don't have to be holes in walls but rather that the windows could become the walls. By blurring the line between inside and out he created a better expression of nature than sculptural emulations of past designs. Jahn used this same idea to connect these dorms to the campus by using endless walls of windows. These windows allow natural ventilation, something Mies experimented with but ultimately didn't incorporate in most of his designs.



Geometry



Natural Light



Plan to Section

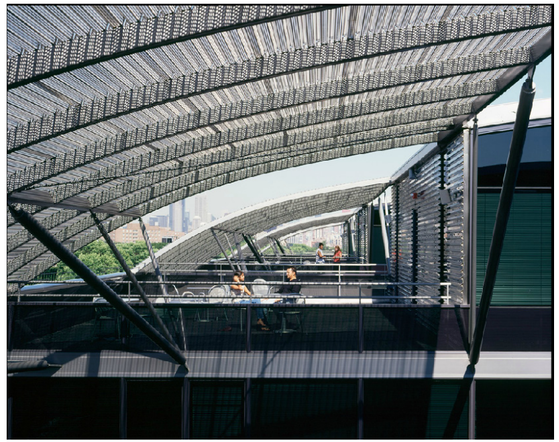


Figure 2.10

Jahn also responded to the site by acknowledging that he was creating a border between the city and campus and the elevated train and the campus. Jahn wanted this border to delineate the campus but not wall it off. With this in mind he created multiple court yards that act as entrances to the college. He also responded to the train with concrete walls and extra glass to keep the noise out of the building, making sure it wouldn't disturb the residents. This wall both delineates space and invites people in and is the essence of this project.

The State Street Village project illustrates how a dense urban dwelling can interact with and connect a city. The extensive use of glass shows that private living spaces can be illuminated with natural light while still being private. It also shows how urban housing can be pleasant to live in. This shows how natural energy can be harnessed. The limited budget also shows that a glass building can be built for a reasonable price and still be efficient.

Figure 2.11

1111 E. Pike

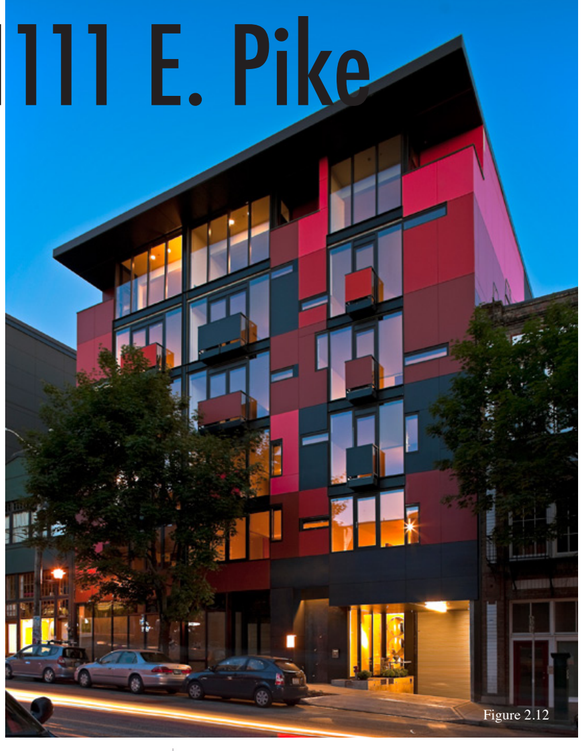


Figure 2.12

Seattle, Washington

Olson Kundig Architects

39,000 sf

Figure 2.17

1111 E. Pike is a multi-use building on Seattle, Washington's historic and vibrant auto row. The building is 39,000 square feet with dwelling units between 620 and 1,137 sf. The most notable part of this design is the attention to new urbanist principles while fitting in with the historic neighborhood. The building has a two story parking garage underground, ground floor retail space and five stories of condominiums above (Saieh, 2010).

1111 E. Pike, like State Street Village, is a new building for urban living. They were built on a tight budget to create affordable living spaces that add to the vibrancy of the community by allowing people from all backgrounds to live in one place. Pike differs from both previous projects mainly by its location and the constraints it has put on the design. Both the Scientific Barn and State Street had the luxury of open, unoccupied sites with space on all sides. This building was designed for a very urban site with zero lot lines and adjoining neighbors.

Figure 2.13

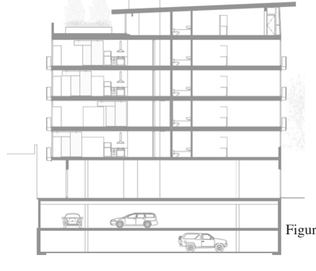
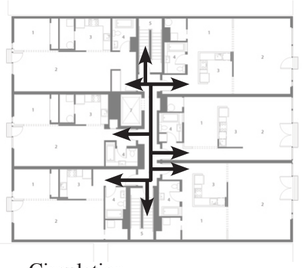


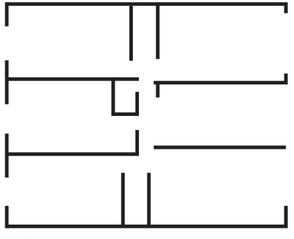
Figure 2.14

Figure 2.15

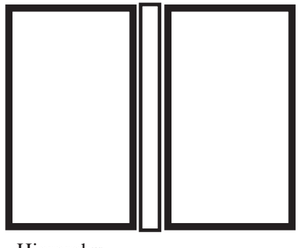
Figure 2.16



Circulation



Structure



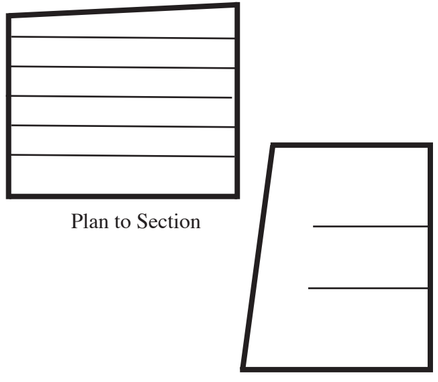
Hierarchy

The strongest element of this project is its response to the culture of the people living here. It was designed and built for $165/sf, making the condominiums it contains affordable to all. The affordable housing coupled with the perfect 100 walkability score makes this an ideal place for urban inhabitants to live (AIA Washington, 2010).

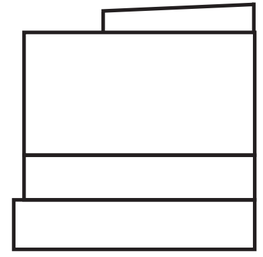
The response to the environment goes farther then its affordable nature, however. With very basic elements the building has responded to the site it inhabits. The red steel panels are painted with colors of 1950s cars that the dealers along auto row once sold. With this, the tall ceilings and industrial finishes hearken back to the time of this section of the city being industrial.

This project is about returning to cities and the way they were once built. It is about density and diversity. It is also about human scale and eliminating the car as a necessity to travel.

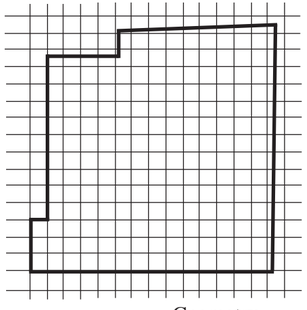
This case shows one project that uses the new urbanist concepts that need to be present in urban centers. It is an example of affordable housing in a mixed-use district. It also shows how urban infill works with the sites history and its constraints. This shows how this thesis's unifying idea can be implemented in the world.



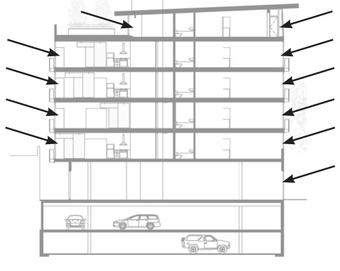
Plan to Section



Massing



Geometry



Natural Light

Theoretical Projects

Eco Laboratory

Figure 2.19

The “Eco Laboratory” is a design competition submission from Weber Thompson out of Seattle for a high-rise residence for ecology and social collaboration. This project focuses on creating a net zero building that will help sustain the neighboring community.

It doesn’t incorporate a large-scale farm for production, but it does house research facilities to expand the knowledge needed to create vertical farms. The building focuses on laying out the building in the most effective way to grow plants by dedicating most of the outer spaces to growing. This means this project would need no artificial lights for growing. This building is one of only a few that is able to make small-scale growing efficient. It is one idea of how living and growing can be done together. Unlike many vertical farm concepts this building has been considered for construction. Seattle is one of the only places in the U.S. that has a political climate that would support a project like this (Despommier, 2010).

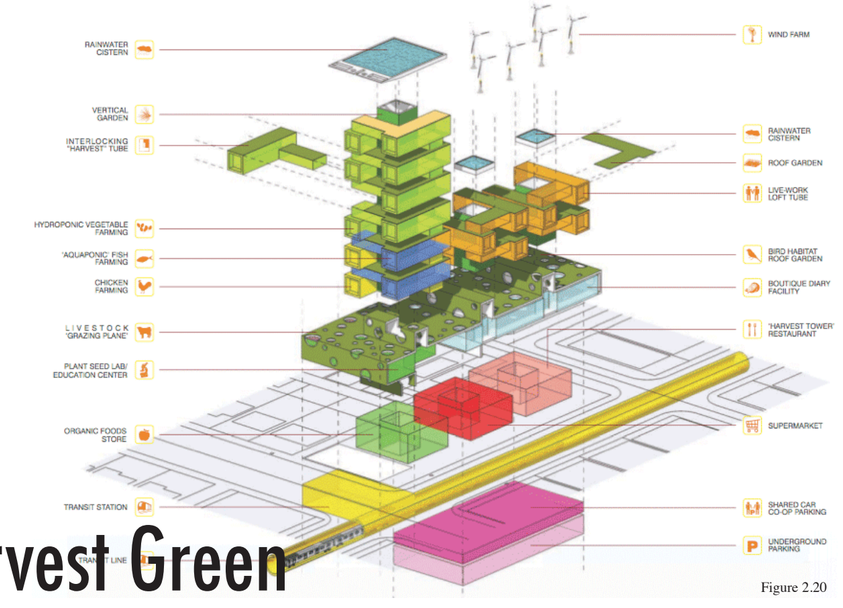


Figure 2.20

Harvest Green

The “Harvest Green Project” was the winning entry to Vancouver’s “The 2030 Competition.” The goal was to combat climate change through greener and denser development. This building’s only function its to produce food in the cleanest and most dense way possible.

This project was designed to grow multiple crops as well as raise fish, egg laying chickens, and goats to produce milk. It utilizes solar panels, wind turbines, and methane gas produced from decomposing plant by-products to power the building and perhaps the surrounding neighborhood. The design also includes a large cistern to collect rainwater and a farmers market to sell fresh produce locally. This building also has a plan for expansion to account for changing demands or technology. It is designed in modules that can be removed, replaced, or added. This is an example of how a large vertical farm building can take advantage of its size to be more efficient. Buildings half the size or with multiple uses wouldn’t be able to support a power plant (Designboom, 2009a).

Dragonfly

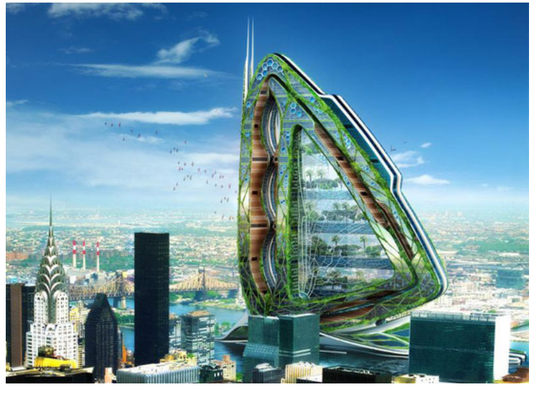


Figure 2.21

"Dragonfly" was created by Vincent Callebaut Architectures in Belgium. It is a 132-story vertical farm in downtown New York City. This building was designed to be as natural and self sustaining as possible.

The form and structure come from a dragonfly's wing. This building is designed to be self-sustaining using by reusing rainwater, generating its own power, and bio-fertilizer. The plan includes 28 agricultural zones to produce various crops, meat, and dairy. One of the most unique of these zones is multiple orchards to grow fruit. Most vertical farms don't accommodate trees because of their weight and size.

All of these production zones are held up by a central structural core that is used for offices and housing. This project shows that many people have envisioned ways that buildings can support all the needs of there inhabitants. The floor layout gives residences the ability to work and play in the indoor fields. This design unites all of its uses around the farming operation to bring natural aspects of the world to one of the largest cities on earth (Designboom, 2009b).

VF - Type O

"VF - Type O" is a project created by Oliver Foster out of UNI Queensland. It is a complex of farming buildings with one main high-rise for the bulk of the production.

Foster has overcome the problem of efficient use of sunlight by using mirrored surfaces to direct natural light farther into the building. This design also focuses on energy efficiently by laying out the growing spaces around a central ventilation shaft. This shaft would use no power to ventilate, relying instead on the stack effect, which would naturally draw air from the bottom of the building to an exit out the top. With adjustable dampers on every floor this system can heat or cool different spaces without any outside energy (Foster, 2009).

The idea of building one large complex of buildings close together has the advantage of efficient use of everything produced. Like "Harvest Green" they can produce energy from the by-products. The other advantage to multiple buildings is that they can be specialized for what they are producing. One building can raise all the cattle while another can support orchards. This separation of uses would make these buildings less complicated and possibly more efficient.

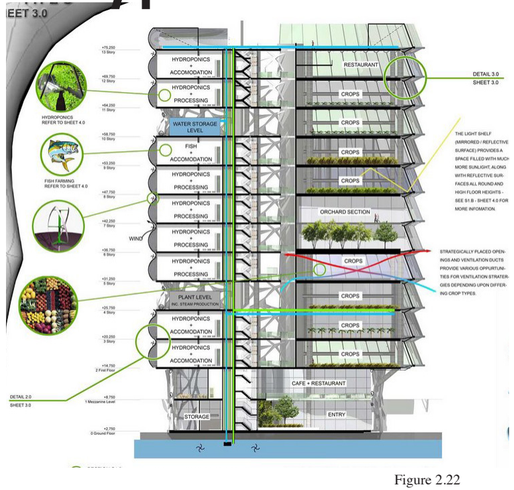


Figure 2.22

Typological Study Summary

The case studies described in this thesis all have a similar goal to their design; they are all designed to sustain people. Some do it through sheltering the inhabitants while others focus on growing food to sustain them. They are all examples of how humanity is moving to more self-sustaining communities. These projects show how urban environments could support large farming operations amidst a busy traditional community. These case studies have only strengthened my theoretical premise. It is possible to create a dense community with the ability to grow its own food.

The first typology that was studied was residential buildings. State Street Village and 1111 E. Pike provide excellent urban living spaces that connect the residents to the surrounding community. These two projects also show how good architecture can be incorporated into affordable housing. To create a vibrant, neighborhood diversity is needed. These projects allow for that by being accessible to the masses.

The second typology that was studied is buildings that support agriculture of the future. These buildings show how we can adapt to our changing world. Although most of these projects aren't planned to be built they show that real architects and scientists see vertical farming as a plausible and probable solution to meet a population's food requirements.

The common thread between these projects is the way they fit into the urban environment. Housing and farming can exist in very close proximity. This shows how the theoretical premise of reducing sprawl through dense urban environments can come to fruition. Not only is it possible to stop the sprawl of suburban neighborhoods, it is possible to stop all human sprawl by bringing food production to the same central urban location in which people will be living and working.

The uncommon characteristic of the projects is the scale of the buildings. This is especially true of the vertical farming projects. Most designers dealing with this topic are designing on a massive scale. This is advantageous because all of the food production for a large area can be done in one central location. These large diverse operations can take better advantage of all the natural processes taking place on a farm, such as feeding livestock unused plant material or using the unused plant material to fuel large internal generators. This large complex of buildings being more efficient impacts my theoretical premise by showing how this operation can't be justified at a small scale. For this plan to be efficient a vertical farm must be large enough to produce for hundreds of people.

The effect of the different sites on these projects highlight their need to be in urban environments to be best utilized. Building these vertical farms or residences in the new suburban environments not only defeats the goal of the theoretical premise but turns these efficient farming designs back to the old transportation model. For these buildings to reach their full potential, they need to be built in urban environments.

The politics of creating a vertical farm to actually be built is simply that the community needs to see that it is running out of options. The projects that were submitted to dense parts of the world have gotten traction and attention for being a viable option. Places in Asia where the population is growing out of control and land is harder to acquire have taken serious looks at these projects. The other political climate for this type of project is progressive thinkers. People in Seattle, Washington have started designing buildings with farming opportunities. They aren't full fledged vertical farms, but the idea of growing in high-rise buildings is gaining traction.

The projects this thesis has investigated have shown the importance of one main spatial relationship. The growing areas need to be on the outside of the building, while everything else is moved to a central core. This is the most efficient way to grow crops in these vertical farms because the largest expenditure of energy will be providing artificial light. The need for large amounts of electricity is the largest technical issue that plagues this type of project. This is why many designers have made their designs larger to support a bio-reactor as a source of power.

The research done on related projects has helped strengthen the theoretical premise. These projects have shown instances of successful built projects and well thought out and designed theoretical projects that are all converging on the idea that dense, self-sustaining urban centers are a logical next step in human settlement.

Historical Context

Since the dawn of time man has been driven to conquer the world. We have always pressed onward to explore. From Eden or Africa, as human beings we have always searched for greener pastures and until about 100 years ago we had always found them. There has always been a new stretch of land waiting for us until now. There is no corner of the world humans haven't reached. There isn't any true wilderness left anymore. With the knowledge that there isn't anywhere else we can go, it is time to reinvest in one of humanities first and biggest achievements, the city.

Humans began their time on this world as nomadic hunters and gatherers. They were at the will of the land for food. It was this need especially that helped drive people across the globe. It was a hard life and tomorrow wasn't guaranteed. Not until the invention of agriculture were humans able to stop roaming the plains, and become a civilization. Agriculture, being able to control one's food supply, made all the difference to early humans. It was as close to promised food as they could get. This constant, stationary food source is how the first town was created and the first civilization as we know it was formed.

Without constantly searching for food, people for the first time had free time. It was time to explore curiosities. People could share ideas with each other and learn specialties. All this intellectual activity is what propelled humans into the next 10,000 years of constant discovery and innovation. Without towns and the large populations they supported we could be millennia behind in technology or even still chasing down our next meal, unchanged from the beginning of time. Dense population centers have always been important to the human race.

Once it was possible for people to support a city, they started seeing the benefits of what they had created. The first benefit to city dwellers was safety. It gave them a fortified position with plenty of support. War with neighbors may not be a problem anymore, but the idea of safety in numbers is still a comforting feeling. People in cities always have friends who are close to help or easy access to police or other government services that are hard to get in a spread out community.

When the safety of a town had been realized, ideas and discourse started to change the way we live. Human civilization has always been about building on the previous generation. Meeting with many different people and getting different perspectives is how innovations are made. One person's initial idea may be good, but that doesn't mean that one person can bring it to fruition. The city isn't only about inventions though; it is also about social change. People have been able to share their ideas on the way we treat our fellow humans. These ideas and the spread of them have been the reason for the exceptional quality of life people have today.

Along with being the center of innovation they are the center of the economy. Cities facilitate the economy as being the place for people to exchange goods and services. Cities also provide the population base needed for industry. They are what drive competition and the free market that this country holds so dear.

Cities are the first and only environment created specifically for people. Humanity has evolved to better deal with its environment, but people are still not the master of the world. Without our technology we aren't at the top of the food chain. In the past people may have had to travel vast distances to survive but that is not our species' strength. A city is built at a human scale. It was created to make human travel convenient. In a city people can walk to get anything they need in a single day and not travel for weeks just to get food or the fuel to their fire. As unnatural as a city might seem, it is the natural place for humans.

Wetlands fed by Shingle Creek across from the public library.

When Europeans first settled in America they were an independent farming society. Some cities did develop, but the majority of people spread out across the vast wilderness and carved out a living from the land. For more then 200 years that is how people lived: independently. This all started to change at the beginning of the 20th century. People started moving to the cities for a better life and because most of the unclaimed land was gone. In this era the Industrial Revolution was at full steam and it was fueled by the cities.

These urban population centers provided a new quality of life that people in this country hadn't had before. There was an improvement in the quality of people's environment. Buildings were no longer built with rough-cut twigs. They were designed and build by craftsmen. Buildings were built to be visually pleasing and improve the environment around them. Not only were they beautifully designed but they were built to last. Many of these buildings still exist in our cities and are just as beautiful as the day they were built. It is the money and common interests in a city that makes it a better place for people to live.

So if people since the beginning of time had seen the advantages of the city for thousands of years, and in 1900 people in the U.S. started flocking to them, how is our country overrun with suburbs today? The suburbs were created from a convergence of three things: a war, the car, and cheap oil. After World War II thousands of men returned to America with money in their pockets. They wanted a car, a home, and a family. Property was too expensive in the city so they bought cheap land just outside the city and built thousands of cheap houses that spread out for miles.

At this time it wasn't a problem. They had money to buy cars and oil was abundant and cheap. Commuting a mile wasn't a problem at that time. This idea the soldiers created of having a slice of land with a house became the American dream for better or worse. This generation and everyone after has chased this idea. In order to accommodate everyone's dream cheaper land farther and farther out that was once used for agriculture was converted to these cheap housing development. This was the birth and spread of urban sprawl. In 2011 this unchecked suburban sprawl has created a

The Earl Brown Heritage Center is an original farmstead that is now at the center of the mid-rise development in Brooklyn Center. It is located blocks from the proposed site.

Metro Transit bus hub across Bass Lake Road from the proposed site.

way of living that cannot continue to expand or even be sustained at this level. The suburbs sprawl for miles now and make transportation to the cities one of the biggest wastes of time and energy in the world. There is no longer an abundance of oil for cheap energy. Humankind is at the edge of a cliff looking over the edge, scrambling to find the next source of energy.

In an effort to expand to find cheap land, we have cheapened the places we live in. Since buildings and sites now serve fewer people because of their proximity, the spaces have been made cheaper to make profits. This is why places are built without character. That same plain cheap big box store is built next to the same fast foot restaurant surrounded by the same cookie cutter beige houses all across the country. All these buildings are built cheaply and without proper design, making their lifespan short and insignificant. This is the depressing environment we have surrounded ourselves with and it is no longer ideal.

The sprawl of people hasn't just affected the built environment; it has affected the natural and agricultural land. As people moved out from the city more farmland has been paved over. This has forced farmers to move farther out still and plow under our few remaining natural habitats. Starting in the last century this loss of farmland was overcome by agricultural technologies that increased efficiency. Farmers now use chemicals to kill anything unwanted in the fields or fertilize the tired soil. Not only have we created dangerous chemicals and spread them across the landscape, people have altered the DNA of the food we eat. There is a limit to how efficient traditional farming can be and a limit to how far we can alter the food we eat without consequences.

So how is Brooklyn Center, Minnesota, a solution to the problem of sprawl? Before World War II Brooklyn Center was a small agricultural town next to Minneapolis. After the war it was developed into a large community of single-family housing. It was some of the first land in Minnesota to be taken over by sprawl. After some time, during the 1960s and 1970s the urban center of Minneapolis expanded and Brooklyn Center is now part of the dense urban community. Brooklyn Center now hosts signs of an urban center, such as mid-rise office buildings and multi-family residences. It is a perfect place to continue densifying the places people already live and return to the more efficient way of living from our past.

Brooklyn Center Public Library and Government Center 2 blocks north of the proposed site following Shingle Creek Regional Trail.

Goals

Obstacles are those frightful things you see when you take your eyes off your goal.

Henry Ford

The success of this project will be determined by the achievement of the goals set forth in this section. The goals of any thesis should be academic, professional, and personal. These three areas will be how success is measured.

A c a d e m i c
Vertical farming may not be an original idea but it is a new idea. I hope that this project will illustrate that this type of project is possible and may very well start appearing in the skyline. With more evidence on this building typology students will get the opportunity to explore the idea of farming in the sky.

P r o f e s s i o n a l
To the professional world this thesis should prove that vertical farming is possible. It is no longer science fiction; it is a real world solution to real world problems. As this type of project is designed more and more, architects will further our understanding of the systems at work in vertical farming and be that much closer to a built project.

This thesis started on the basis of stopping urban sprawl, and that is what it should help to accomplish. People are starting to see the problems with sprawl and it is time to start finding solutions. This project should illustrate a solution with not only vertical farming, but density and infilling our existing cities.

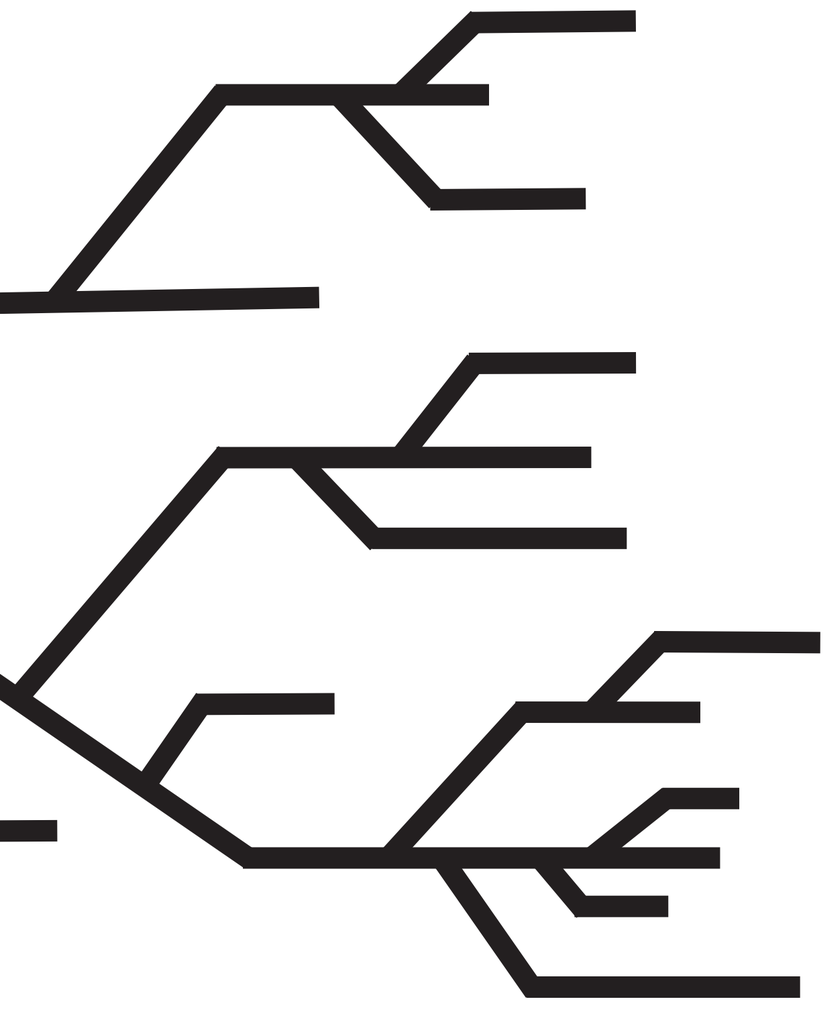
Finally, from a professional side I hope this project makes people think about their lives and how they might change them for the betterment of themselves and society. After reading this, people should take a second look at living in cities and invest in their rejuvenation.

P e r s o n a l
Personally, this thesis holds a lot of promise for self development. After all, at this point the real client is myself. During the design phase of this thesis I will hone my design skills by letting my creativity run free to create a beautifully designed building instead of a design bound strictly by the real world.

This thesis should improve and display my computer design skills. It is one of the most valuable links to my academic and professional life, and this is my final chance in formal education.

Finally for myself I want to produce a building I am proud of. As a designer I think it is impossible to create something that you think is perfect, but the end result should be close. I want to leave this project and say I did all I could. And in realizing I have done all I could it will be proof to myself that I can accomplish a large task such as designing an entire building that is not only complex but on the leading edge of technology.

This project will be successful if I meet these goals. Whether this building ever gets built or wins a prize is irrelevant, because my goals are for the betterment of humanity and myself.



Site Analysis

Brookdale Narrative

The site of this thesis project is the former site of a once-bustling suburban mall. Brookdale Center brought development and growth to Brooklyn Center but for many years has been visited less and less and started to deteriorate. In 2011 the demolition of all but an anchor store of the mall is complete and a large piece of urban land is ready to be developed. The specific location of the building in this thesis is the northeast corner of the mall property at the intersection of Shingle Creek Parkway and Bass Lake Road.

The traditional street grid of American cities, especially urban ones, runs throughout much of Brooklyn Center but not at this site. When this area was first developed it was developed to support the large mall. The streets ring the site, creating odd traffic angles.

The land surrounding the site has grown increasingly denser but is still laid out like a suburban city. The surrounding properties have open green space but it is ultimately unusable for activities. This community is defined by the expanses of concrete parking lots with a sprinkling of grass marking the boundaries of the streets and private property. All the buildings are accessed by large parking lots off of wide busy streets. For most buildings there isn't even a link from the sidewalk to the entrance unless one walks through the parking lot.

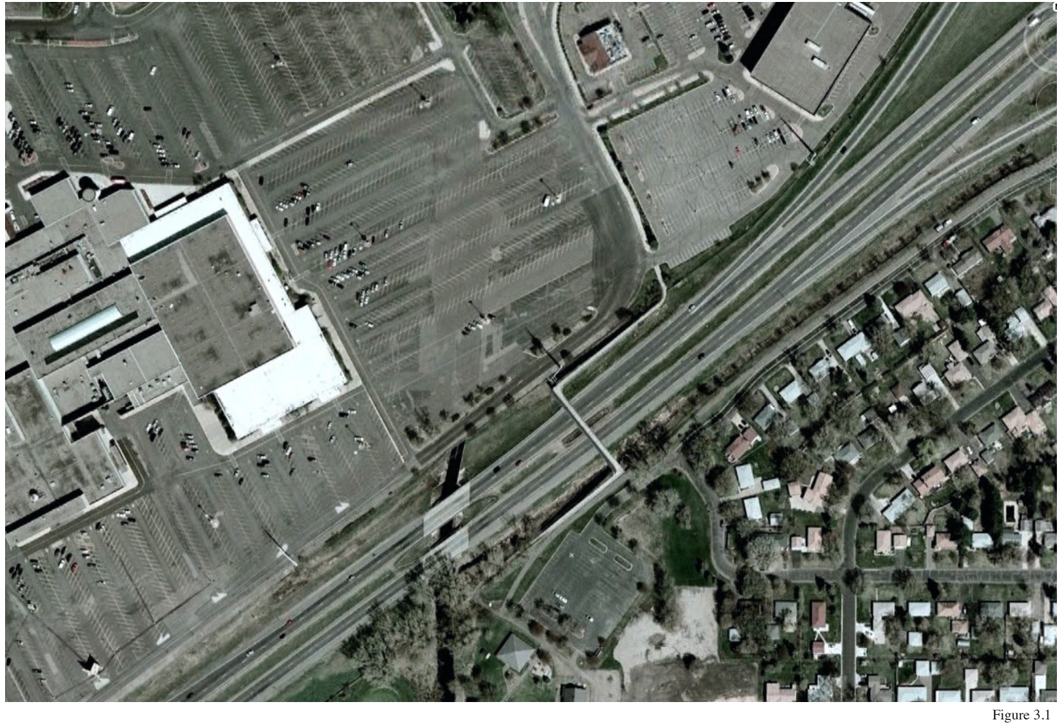


Figure 3.1

As unfriendly as this suburban layout is to walkers there have been large strides to make Brooklyn Center, especially this area more walkable. The Brookdale site is located next to a hub of the Three Rivers Park District trail system. From this site one can take the Twin Lakes Regional Trail, the Grand Round Trail, or the Shingle Creek Regional Trail. These trails lead to a library, golf course, parks, and a community center.

Probably one of the most distinguishing things about this site is Shingle Creek. It runs directly through the site. At different times in the year the water level changes, but for most of the time it is almost a foot deep. Two of the three trails previously mentioned follow the creek. It is a small slice of nature in this urban environment. Unfortunately for the integrity of the creek, however, it has been rerouted, straightened, and covered. When the mall was on this site the creek ran nearly a quarter of a mile through culverts under the expansive parking lot.

The creek has been mainly used to handle rainwater runoff. The runoff has polluted the water with some garbage and the water isn't too clear, but it isn't too polluted to save. It runs through wetlands and meanders through parks in its original form in some nearby places. With an effort to protect it and uncover it, this beautiful aspect could become a centerpiece of the community. Shingle Creek provides a refuge for wildlife at different points. If the creek is returned to a natural state it could be home to more and be a link to nature for people in an urban center.

The surrounding landscape of this community is very flat. The creek provides the only noticeable topography change in the area, but that is only a matter of a few feet. The years of development have made this site completely and perfectly flat, only sloping enough to control rainwater. As boring as the topography is though it is perfect to create a dense urban center.

Only two buildings are direct neighbors to the site. A Kohls department store blends into the community on the east side. The more interesting neighbor is an office building to the north across Bass Lake Road. This six-story office building commands the site. It is the tallest building around. The white color makes it highly visible. The color paired with the lack of close neighboring buildings makes this a significant building to this site. The layout of this building's site does show the overall characteristic of the surrounding area. The buildings aren't densely packed and they are set away from the sidewalk.

These two buildings are the only direct neighbors, but a little more then a quarter of a mile away is the remaining section of the mall that will remain. A Sears department store is the only store that escaped demolition.

This site is always lit up, either by the sun or street lights. The previous use for this site was a parking lot, so there are no trees or buildings to provide shade. If the sun is out there is always an abundance of light. No tree cover and spread out buildings are advantageous to increase light, but the negative aspect of that is there is little shelter from the wind. The built environment of the metro area helps to push the wind above the roof tops, but with such a large site it doesn't make much of a difference.

The Brookdale Center site since the demise of the mall has been an obstacle for people moving to other destinations. People only interact with the site by passing through. The size is what currently makes it an obstacle. People need to walk half a mile past it to get where they are going.

The vacancy of this lot is typical of the immediate area. The decline of Brookdale Mall was the explosion of the surrounding cities. Neighboring cities have been developing very quickly in the recent decades, which has prompted people to move farther out into the suburbs and shop at new shopping centers. This movement outward closed the mall, and with the mall went many of the businesses around it. Some of the strip malls and buildings that were once bustling from the business the mall brought have become half-full or vacant.

The decline of this central retail center in Brooklyn Center has prompted the city to upgrade the area, making it a perfect place for redevelopment. The streets and paths have been repaved, they have added more landscaping to the city property in the area, and have improved the walking paths running through the area. The empty buildings in this suburban layout have the potential to create a large in fill project in an established urban center that will improve people's lives. The area has fallen on hard times but is in the process of renewal.

Quantitative Data

Soils

The soils on this site are all products of cut and fill that has been done over the years. The closest classification for the soils on this site is a Hubbard complex. This type of soil is usually found near streams that mix and deposit different soil in one place. Though there is a mix of soils, the top layer is generally loamy sand and after 2 feet it turns to mainly sand (U.S. Department of Agriculture, 2011).

Water Table

The sandy composition of the soil helps drainage on the site as well as its proximity to the creek. On this site the water table is about 6 feet deep (U.S. Department of Agriculture, 2011).

Pedestrian Traffic

Pedestrian traffic near the site is limited. That is mainly due to the fact that everything is so spread out and it takes a long time to walk to various places. It is also sparse from the lack of a destinations. In the summer the trails are used moderately for recreation but rarely as a means to get somewhere. An added incentive to pedestrians near this site is it is adjacent to a walking bridge over Highway 100 that runs along the south edge of the site. It is a vital link for pedestrians between the commercial center north of 100 and the large, single-family neighborhood south of it. The site is very connected to the surrounding area with these paths, so with development of the site there will be more pedestrian traffic.

Vehicular Traffic

The site is bound by two major collector roads. Bass Lake Road is a four lane divided street with a central boulevard. This street runs east to west along the northern edge of the site. It's a very busy road that can be difficult to cross on foot. Shingle Creek Parkway runs north to south along the site. It is another major four lane collector road for the area but it essentially ends when it intersects Bass Lake Road from the north. The short section south of Bass Lake is currently only used to access the Kohls store, but when the mall was operating this was a major entrance to the parking lot. The intersection of these two roads is one of the busiest in the city. This is a good thing for development because of the number of people who pass by the site, but it is also dangerous for people on foot. For the final project of this thesis, Shingle Creek Parkway would be the best road to access the site. The south section of it slows down and is easier to cross on foot. In future development of the site, however, there are intersections on Bass Lake Road that would allow access to a new urban center.

Topographic Survey

The topography of this site is very flat. It has been graded multiple times to make a suitable building site. The flatness of the site does mean that drainage will be slow, so development of the site will need to include storm drains.

Evolution of the Site

From Rural Farm Land To Brookdale Center Mall

Figure 3.2

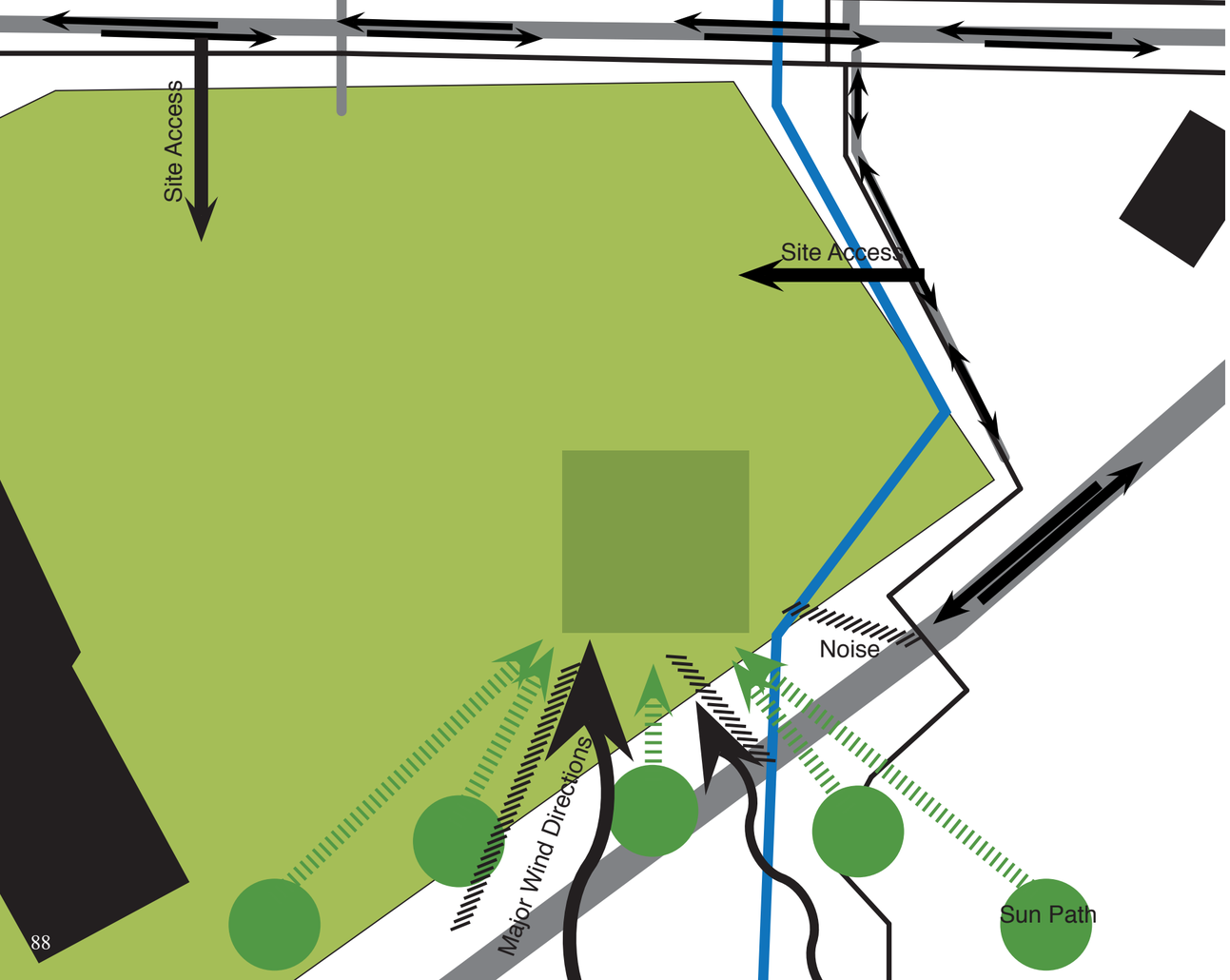
Figure 3.4

Figure 3.5

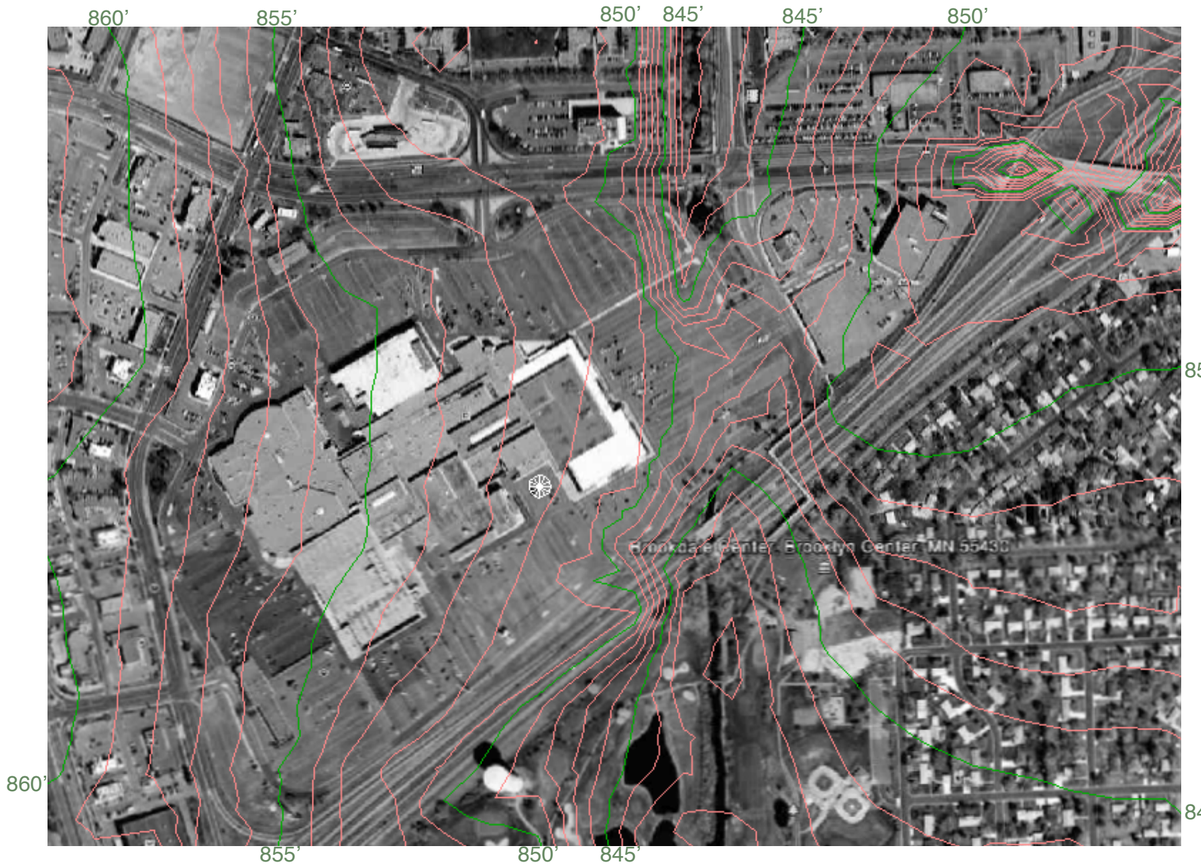
Figure 3.7

Base Map

Photo Grid



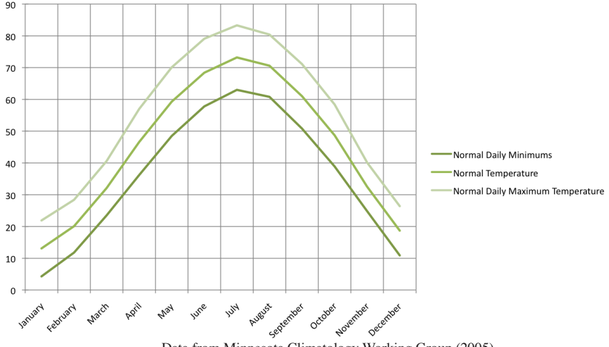
Contour Map



Data from Google Corporation (2011)

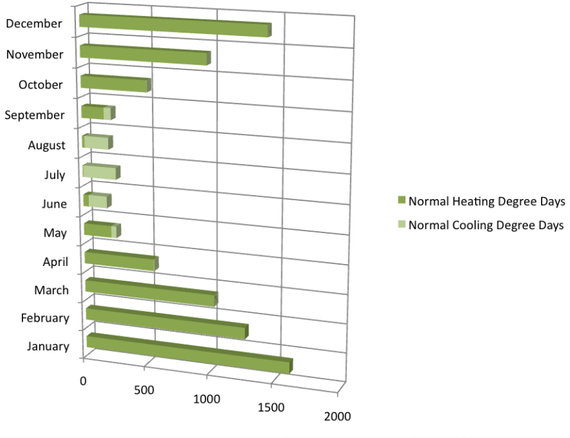
Climate Data

Average Temperature
In Degrees Fahrenheit



Data from Minnesota Climatology Working Group (2005)

Heating and Cooling Demands
In Heating and Cooling Degree Days



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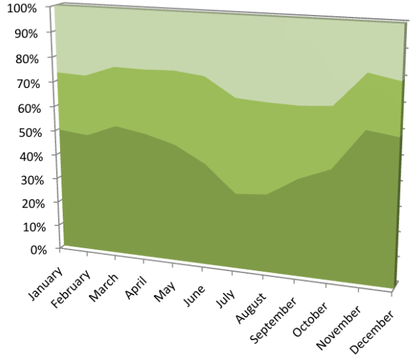
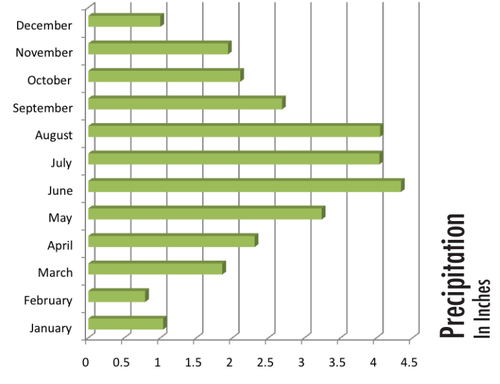


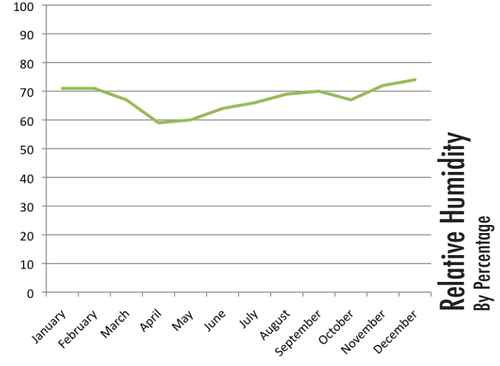
Cloud Cover
In Days

Data from Minnesota Climatology Working Group (2005)



Precipitation
In Inches

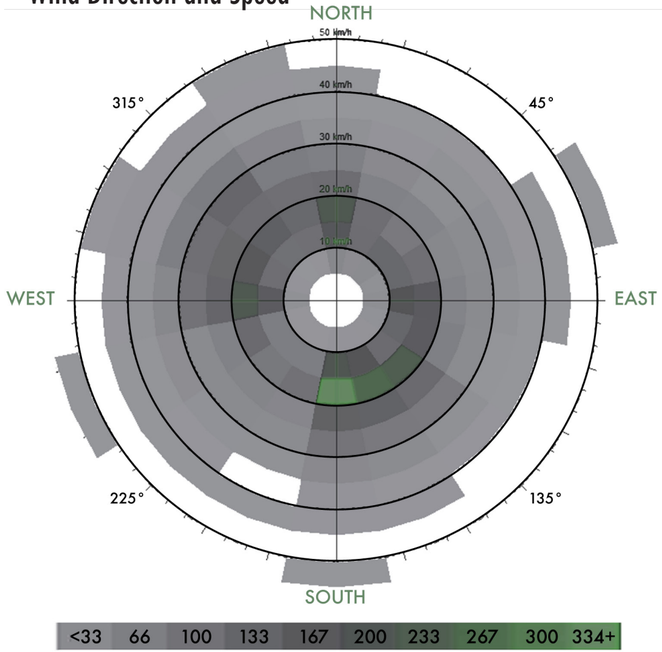
Data from Minnesota Climatology Working Group (2005)



Relative Humidity
By Percentage

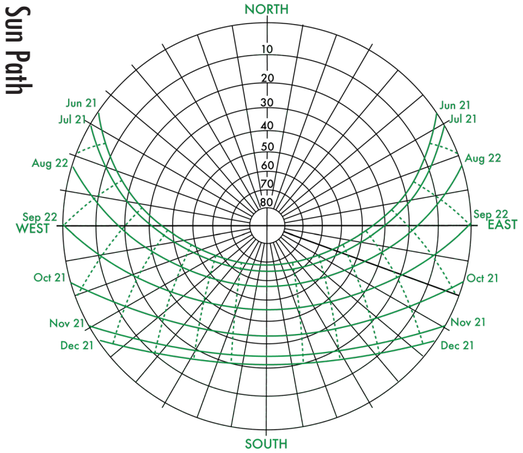
Data from Minnesota Climatology Working Group (2005)

Wind Direction and Speed



Data from U.S. Department of Energy (2011)

Sun Path



Data from University of Oregon Solar Radiation Monitoring Laboratory (2008)

Site Noise

In Decebels

Program

Program Requirements

Commercial

Grocery Store			40,000 sf
		Total	**40,000 sf**

Residential

Entrance Lobby			1,000 sf
Condominiums			64,100 sf
27 One Bedroom	700 sf		
27 Two Bedroom	1000 sf		
13 Two Bedroom	1,400 sf		
Support Spaces			4,000 sf
		Total	**69,100 sf**

Parking Garage

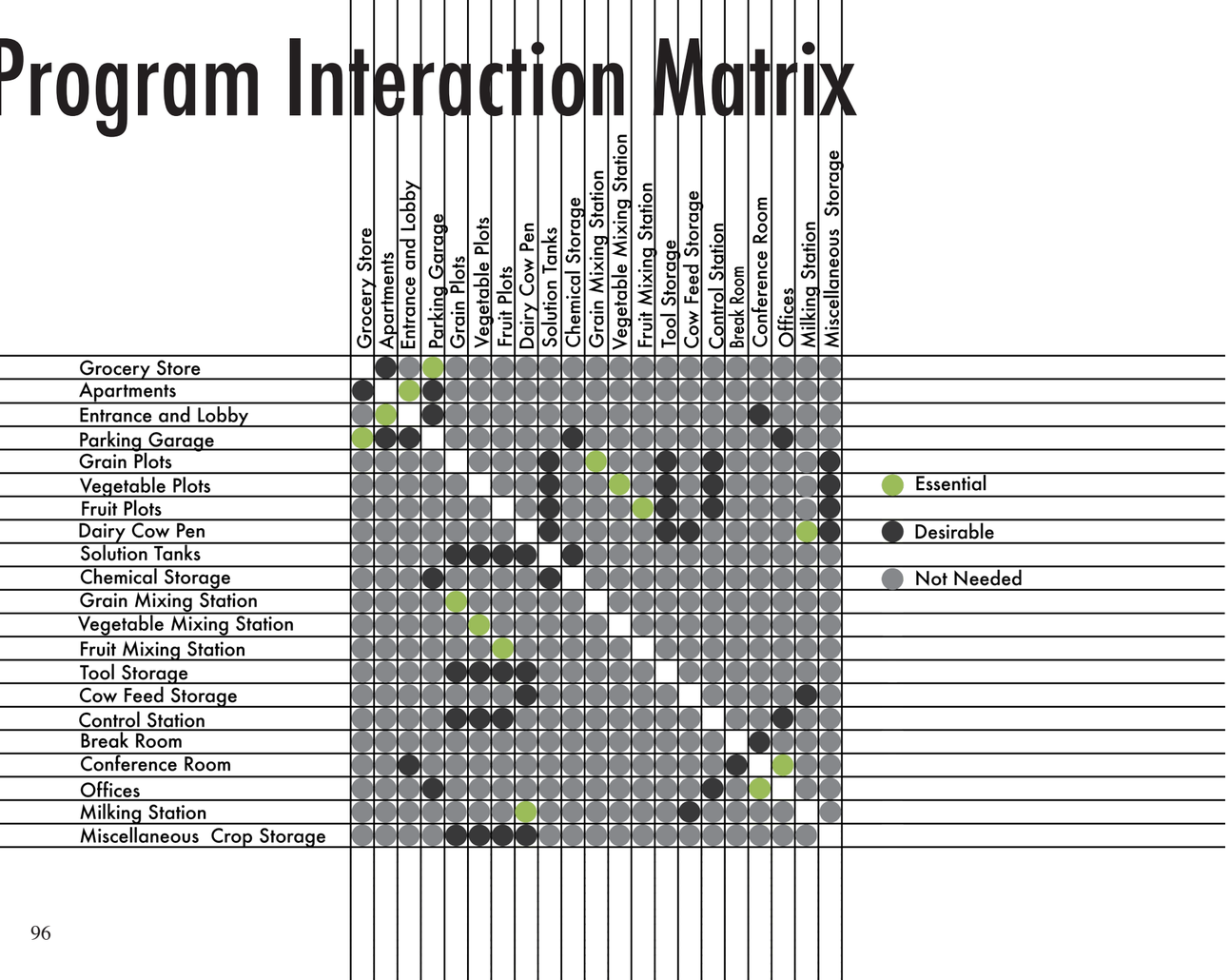
Parking	150 parking spaces	21,600 sf	
Truck Delivery			5,000 sf
	Total		**32,600 sf**

Agricultural

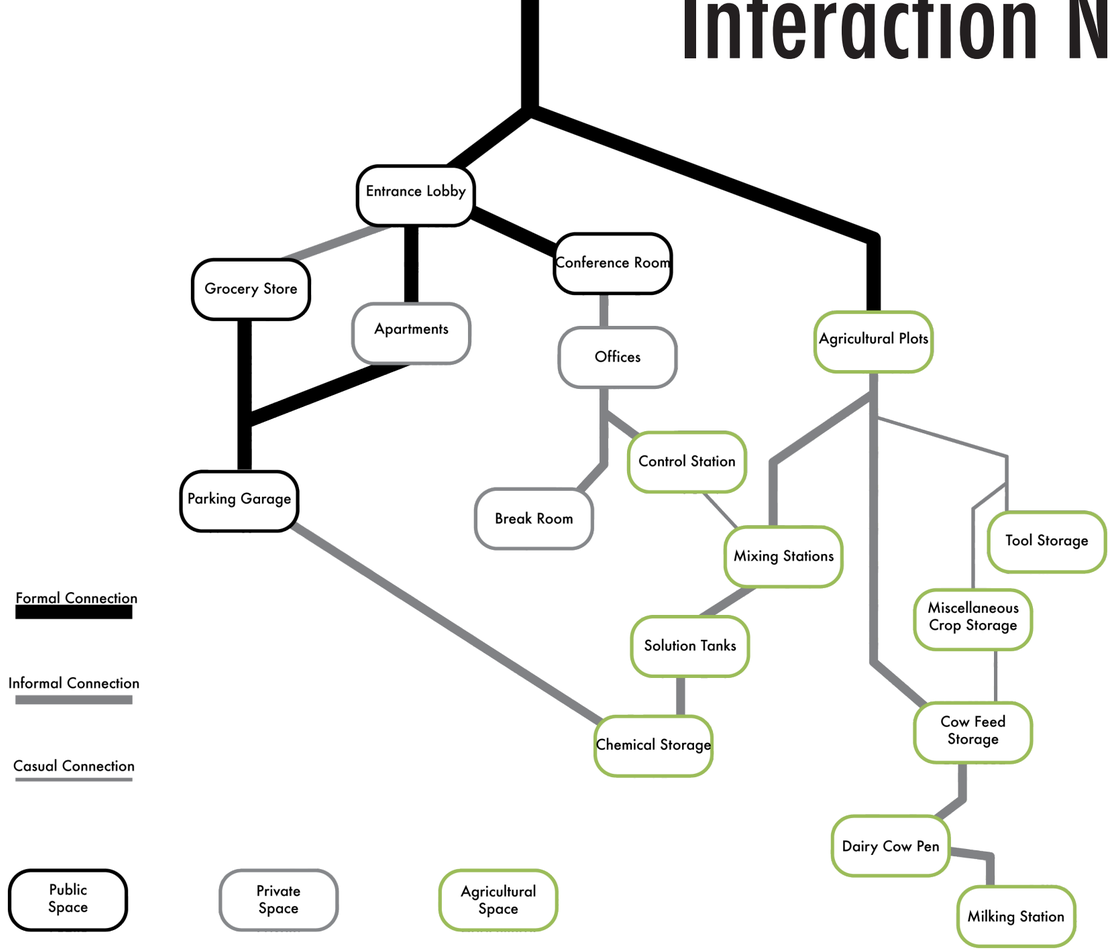
		Stacking	
Wheat/Grain Plots	13.9 acres growing space	÷ 4	151,374 sf floor space
Chemical Tanks	400 sf		
Mixing station	200 sf		
Tool Storage	1,000 sf		
Wheat/Grain Support Space Total		1,600 sf	
Vegetable Plots	17.68 acres growing space	÷ 4	192,525 sf floor space
Chemical Tanks	500 sf		
Mixing station	200 sf		
Tool Storage	1,000 sf		
Vegetable Support Space Total		1,700 sf	
Fruit Plots	1.4 acres growing space	÷ 4	15,245 sf floor space
Chemical Tanks	200 sf		
Mixing station	200 sf		
Tool Storage	1,000 sf		
Fruit Support Space Total		1,400 sf	
Dairy Cattle Pen	.25 acres		10,890 sf floor space
Grain Silo	500 sf floor space		
Plant waste Feed Storage	10,000 sf		
Milking Station	5,000 sf		
Cattle Support Space Total			15,500 sf
Chemical Storage			3,000 sf
Miscellaneous Storage			16,000 sf
8 Storage Rooms	2,000 sf each		
Agriculture Control Station			1,000 sf
Offices			1,500 sf
10 offices	150 sf each		
Conference Room			1,000 sf
Break Room			1,000 sf
		Total	**393,534 sf**

Building Total **535,234 sf**

Program Interaction Matrix



Interaction Net



Final Design

Initial Concept Models

West Perspective

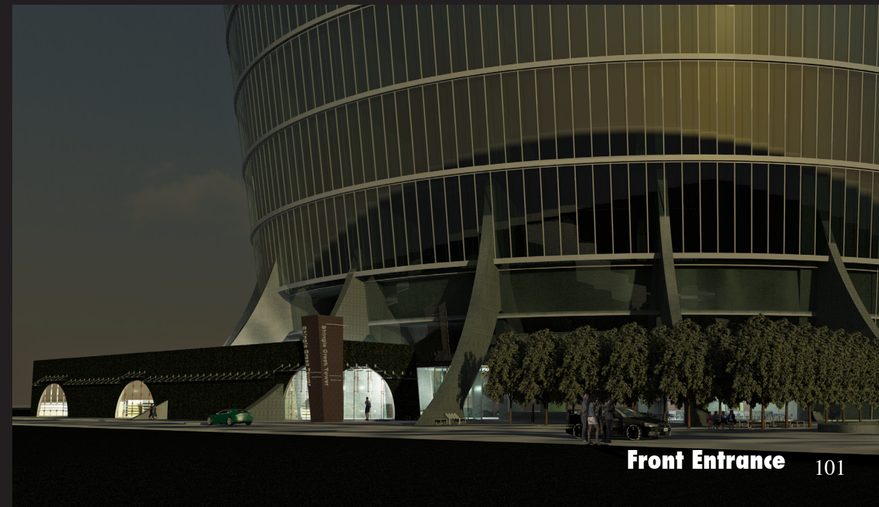
100 Grocery Perspective

Ground Level

Suburban sprawl has been the mode of development throughout the last 50 years. This development has created cheap impersonal places and an inefficient way of life. To sustain growth and our future, people need to live in more dense communities. From this need to live more compact lives came the idea for Shingle Creek Tower. A vertical farm for Brooklyn Center, Minnesota.

This building was designed to create a place where people can live within a dense community with the smallest footprint on the earth as possible. In less then 2 acres this building provides 200 people with homes and the food they need. This building will create a self sustaining community and a gathering place for the city of Brooklyn Center.

Residential Entrance



Front Entrance 101

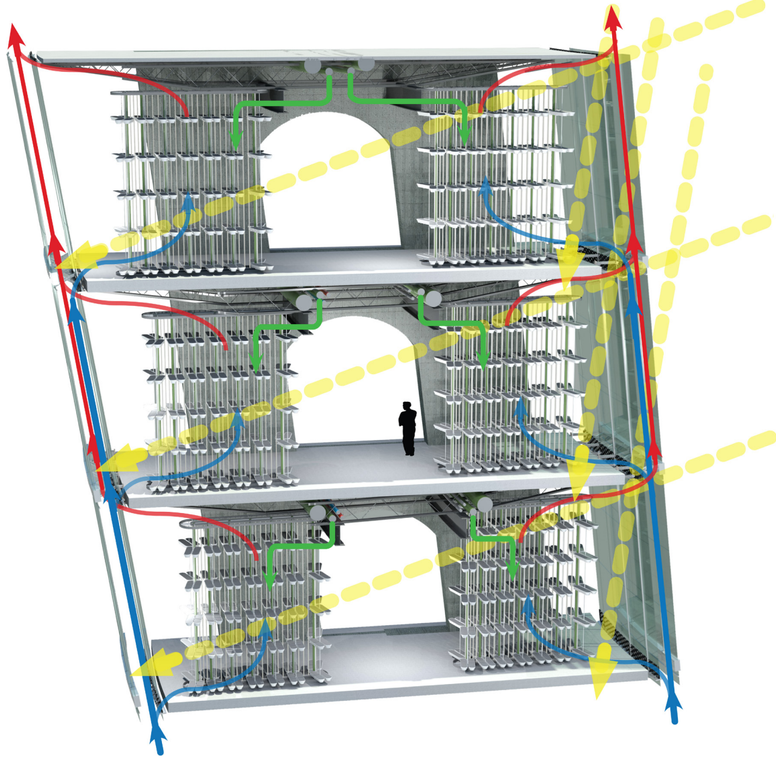
The Farm

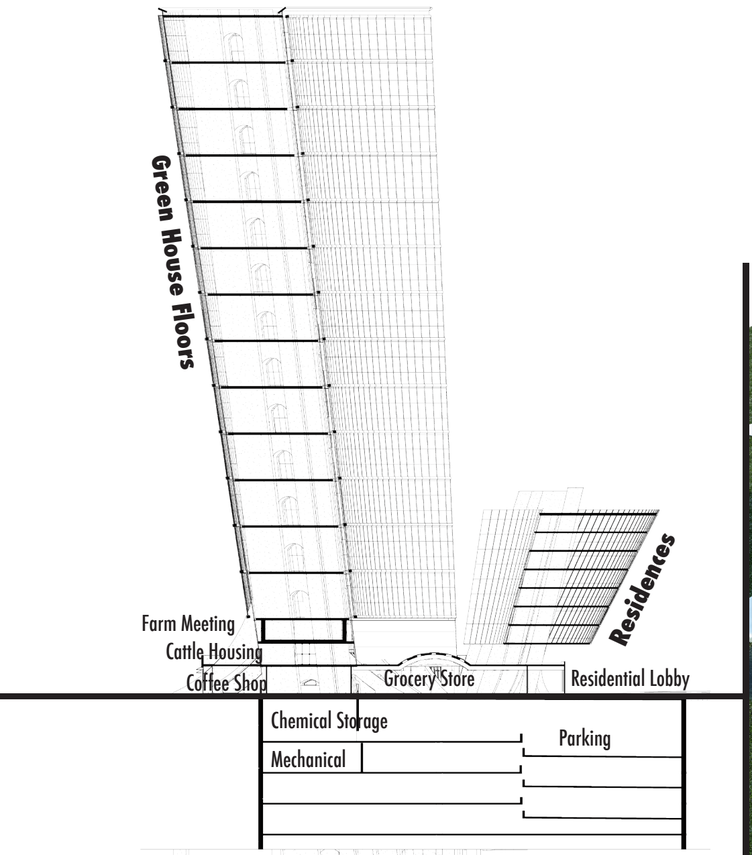
The Vertical Farm works on the principal of growing food where people need it in order to reduce spoilage and energy spent in transportation. This farm encompasses 344,000 sqft of floor space, but through stacking the growing surface on racks provide 33 acres of growing space.

The farming tower uses aeroponics, currently the most productive and efficient growing method. Through aeroponics a solution of water and essential nutrients is sprayed onto the suspended roots of plants. This method uses substantially less growing medium, water, chemicals, and minerals, then other growing methods because they are delivered directly to the root and not lost in dirt or other growing mediums.

The design of this vertical farm was influenced by efficiency and flexibility. The north farming tower relies on sunlight, natural ventilation, and rain water harvesting to reduce energy and costs. Using these natural processes is the most efficient way of growing. With this being said, the layout of the farm was designed to be flexible. The growing area is essentially empty with tall ceilings. This allows adjusting the space for different crops or new, more efficient techniques in the future.

Essential to this growing environment is the growing racks. They are adjustable to accommodate different crops. The 1 1/2' x 4' growing shelves are easily moved by hand. This reduces the need for heavy equipment. The racks are also responsible for the distribution of nutrient solutions and artificial light, if necessary. Everything the plants need is provided in the growing rack assembly.



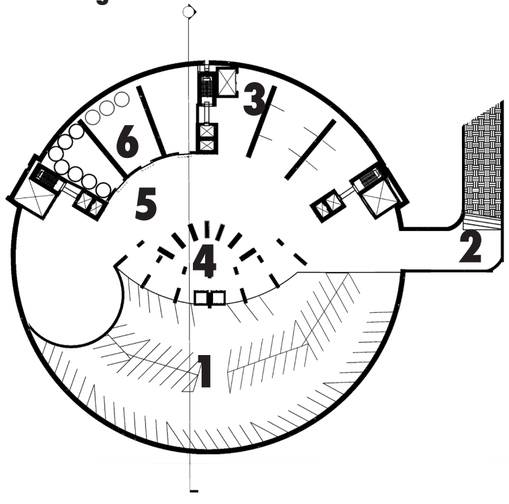


 Section

West Birds Eye

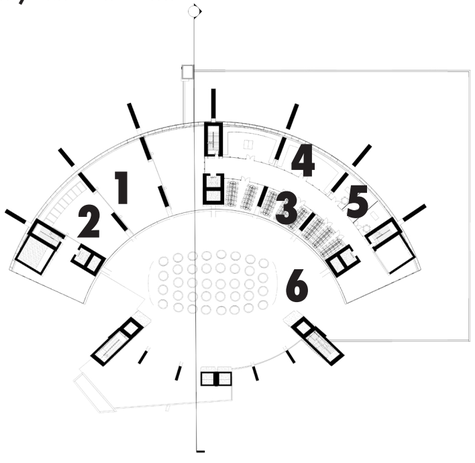
First Floor Plan

First Garage Floor



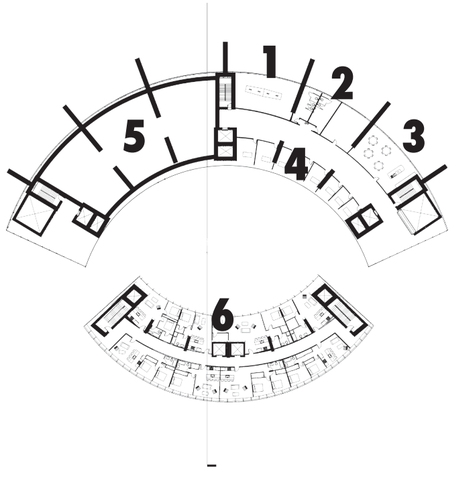
1 Daily Parking
2 Parking Entrance Ramp
3 Grocery Elevator
4 Residential Elevators
5 Delivery Area
6 Chemical Solution Storage and Mixing Station

Cattle / Control Floor



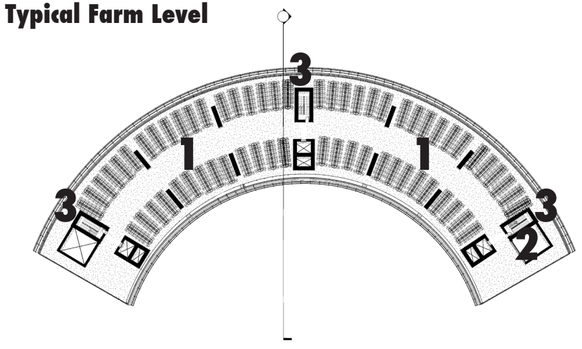
1 Cattle Housing
2 Milking Station
3 Experimental Crop Lab
4 Farm Control Rooms
5 Offices
6 Lobby Roof & Cattle Grazing Area

Typical Residential Floor And Meeting Level

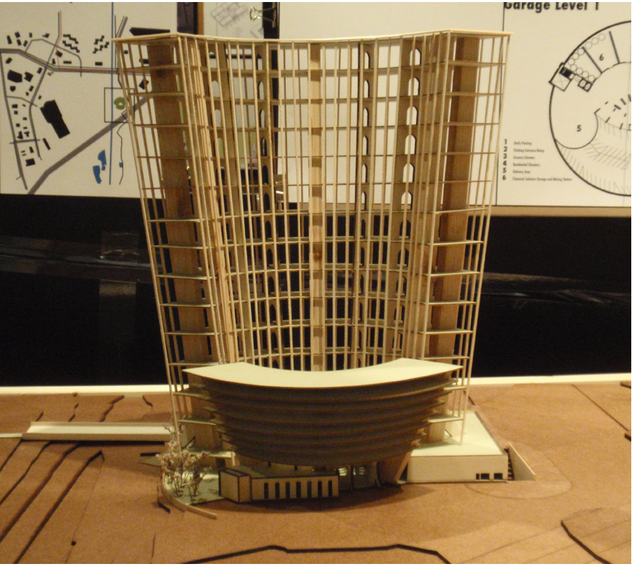


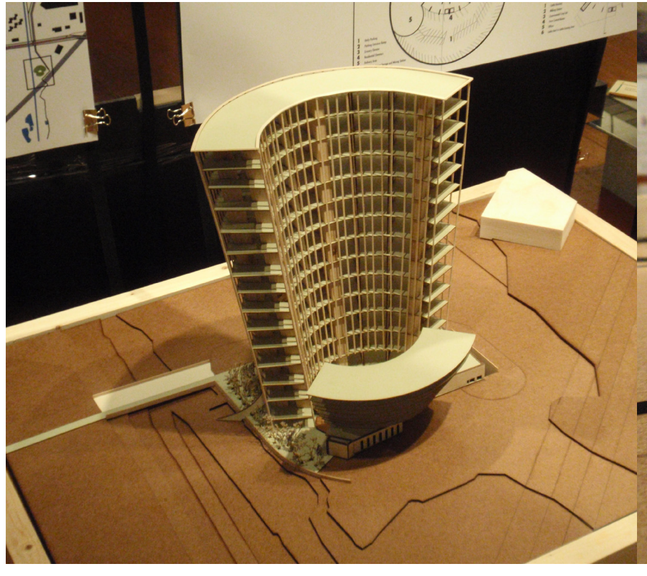
1 Farm Conference Room
2 Rest rooms
3 Break room
4 Offices
5 Cattle Feed Storage
6 Residential Units

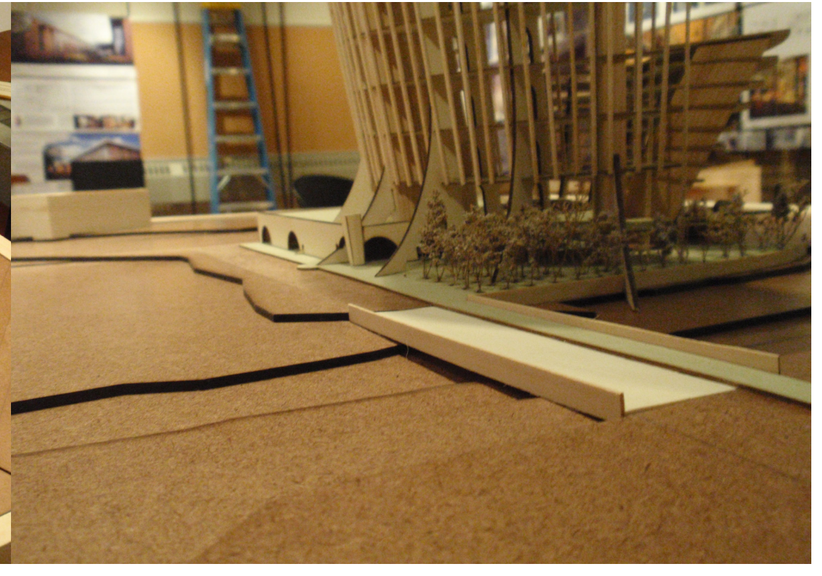
Typical Farm Level



1 Growing Shelves
2 Freight Elevator
3 Egress Stairs


Parage Level 1





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