REVISITING RESIDENTIAL DESIGN THROUGH VERTICAL FARMING

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

By
Jetse Vollema

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

Primary Thesis Advisor

May 9th 2014
Thesis Committee Chair

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REVISITING RESIDENTIAL DESIGN THROUGH VERTICAL FARMING

ABSTRACT

Jetse Vollema

This thesis is an investigation of the question, as a city's population continues to rise, how can residential design assist in meeting the increased demand for food, water, energy and shelter? The typologies for the investigation of this problem are a sustainable residential complex and urban agricultural facilities. The site for this investigation is Fargo, ND. The Unifying Idea is that by combining sustainable residential design and on site agricultural practices, residential design could increase the awareness within cities which are experiencing rapid population growth to the issue of successfully meeting the rise in energy and shelter demands. The Project Justification is that sustainable residential design combined with urban agriculture is a vital component in ensuring the continuity of our species' growth and survival.

Key Words – Residential design assist in meeting increased demands, sustainable residential complex, urban agricultural facilities, rapid population growth, energy and shelter

PROBLEM STATEMENT

As a city's population continues to rise, how can residential design assist in sustainably meeting the increased demands for food, water, energy and shelter?

STATEMENT OF INTENT

STATEMENT OF INTENT

PROJECT TYPOLOGY
Residential complex, agricultural facility
32,016 sq. ft. per building
4 Buildings
128,064 Total sq. ft.

THE CLAIM
Residential design could be a vital tool in meeting the needs of a city undergoing rapid population growth. Self sustaining residential complexes combined with agricultural facilities could provide food, water, energy and shelter in a space efficient manner.

Actors – Current and future generations
Action – Providing self sustaining residences
Object – Past conception of residential complexes

SUPPORTING PREMISES
In this time there are many cities across the world experiencing rapid population growth. Current generations, as well as future ones, will likely continue to deal with this pressing issue.

When a rapid population increase occurs, so do the number of needs of the city's inhabitants. Most of these needs are food, water, energy, and shelter. All of these could be provided through sustainable residential design.

By rethinking the way residential complexes function, residential design could be reconceived as a source of food, water and energy, rather than just a destination for them.

UNIFYING IDEA

Combining sustainable residential design and on site agricultural practices could increase the awareness within cities which are experiencing rapid population growth to the issue of successfully meeting the rise in energy and shelter demands.

SITE

Downtown Fargo, ND
(Parking lot directly east of both the Fargo Civic Center and Fargo Public Library)

PROJECT JUSTIFICATION

The current way that society meets the nutritional, energy and shelter needs for today's major metropolitan cities is a seemingly unrealistic long term solution for the rapid population growth many of them are currently experiencing. Almost all of these needs are created/obtained off site. This requires storage, transportation, means of distribution, and worst off all creates an immense amount of wasted products and energy, not to mention pollution. Adequate solutions, such as vertical farming, are available but the implementations of these solutions are relatively uncommon. Residential complexes are an excellent opportunity for designers to utilize as a means of obtaining food and energy by obtaining and producing these needs locally, on site. As larger cities continue to grow, so will the need for food and energy. Thus residential design must be more thoroughly investigated.

PROPOSAL

THE NARRATIVE

Almost every city around the world is experiencing a growth in population. In 2009 the urban population of the world was approximately 3.4 billion, and in 2050 the global urban population is expected to be about 6.4 billion. Moving forward with the assumption that the expected rise in population continues, we can assume that there will be increased shortages of food, water, energy and shelter. I say this mainly based on the current amount of arable land required to feed people, since it will be mathematically impossible to obtain enough land for that many people. For this reason many things need to be looked in to but I strongly believe residential design should be on top of the list.

I was born in Amsterdam, The Netherlands, and so big cities have been a part of my life from an early age. In 1996, age 8, I moved to Minneapolis, MN with my parents and older sister. Even at age 8 the differences in terms of residential design and expectations were clear to me. Americans cherish as well as expect a relatively, in terms of the world, large amount of land/property/space for their residence. In fact large our yard that wrapped around the whole house was one of the things I enjoyed the most about our new home in the US. Our house in the Netherlands was less than half the size of our new house and the new yard was roughly 10 times larger than that of its predecessor. It felt as if we had become millionaires overnight.

When we still lived in Europe my family would often travel to neighboring countries giving me the opportunity to experience an abundance of different places around the world. My father is a software consultant who travels around the world on a weekly basis working on projects for a variety of employers. Through this my family has had the luxury of cheap if not free airline services for the last 18 years. Through this luxury I have been lucky enough to have traveled to many areas within the US along with a few other countries as well. Although the US still has an incredibly large amount of unoccupied land, compared to most of the world, it has become apparent that the continuation of this type of residential design is unrealistic in terms of being adequately/efficiently capable of meeting the needs of the city's inhabitants.

What I believe to be the main issue regarding the large majority of global residential design is that almost all of the day to day needs are provided by an off site source. I understand how amazing it is that so many cities are even simply capable of providing these amenities/utilities at all, and I do consider myself very lucky to be living in a society that provides me with abundant access. Regardless I don't believe designers have pushed residential design, along with the general public's expected standards of residential design, to the level they will likely soon need to be.

Through the integration of agricultural facilities and sustainable systems within an apartment complex I believe that many, if not all, of the immediate needs can be met on site. This would greatly reduce shipping/transportation needs along with the reliance on outside sources. Instead of being endless consumers of food, water, and energy, a self sustaining residential complex could, in a space efficient manner, become a on site provider instead.

USER/CLIENT DESCRIPTION

There would be four primary types of people that would interact with the residential complex: The owner, the workers, the residents and visitors.

OWNER

The residential complex would be owned by a privet investor, developer or contractor. If the owner resides on site, then one of the units would be provided for him/her as well as parking needs.

WORKERS

The complex would need an on site property manager as well as maintenance and grounds keeping workers. They would need offices, and equipment storage spaces as well as parking needs. A designated unit would also be made permanently available for the property manager if so desired.

RESIDENTS

The residents who own or rent the units will be families or individuals with a desire for a new type of self sustaining residence. They would be provided with a, available residential unit, a designated part of the integrated agricultural facilities, and parking needs.

VISITORS

Visitors of the complex will be the friends, families, and business acquaintances of the residents along with potential renters. They would be provided with lounge spaces, and parking needs.

MAJOR PROJECT ELEMENTS

SUSTAINABLE RESIDENTIAL UNITS

There would be 4 types of residential units available to the renters. Each unit would have multiple sustainable systems installed on the interior and exterior and it would be constructed using mainly local material.

3 Bedroom / 2 Bath
2 Bedroom / 1 Bath
1 Bedroom / 1 Bath
Studio

INTEGRATED AGRICULTURAL FACILITIES

Each unit includes a predesignated agricultural space within one of the agricultural facilities located on site. There would also be a community agricultural space which renters can rent if there is a desire to obtain more agricultural space.

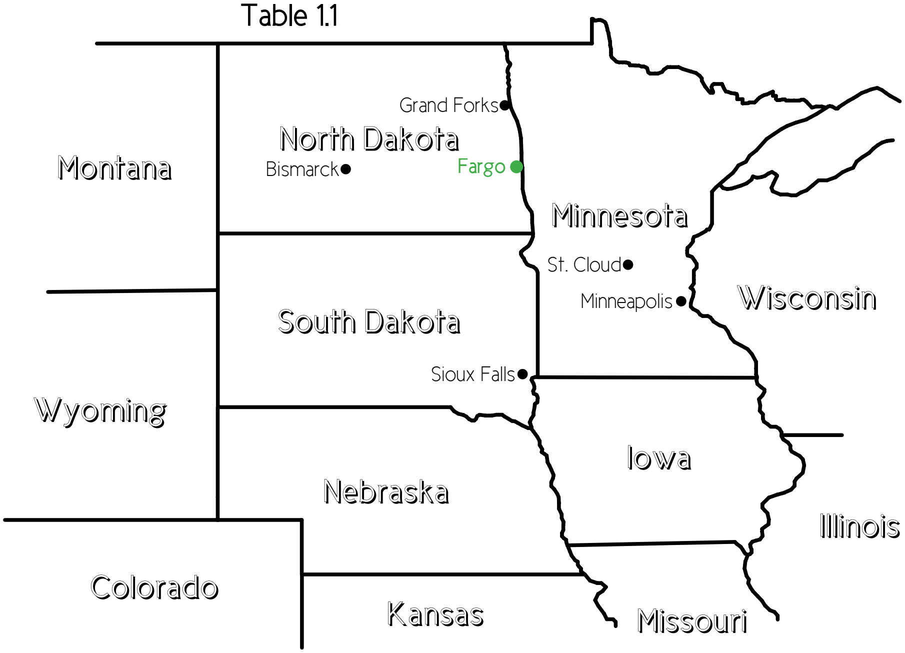
ON-SITE

Any space that is not used for the apartment buildings, agricultural facilities, or necessary walkways would be turned into public recreational spaces. The landscape for those spaces would mainly consist of local vegetation. Much of the roof and southern facade of the building would be utilized for solar energy gathering and other energy generation systems.

SITE INFORMATION

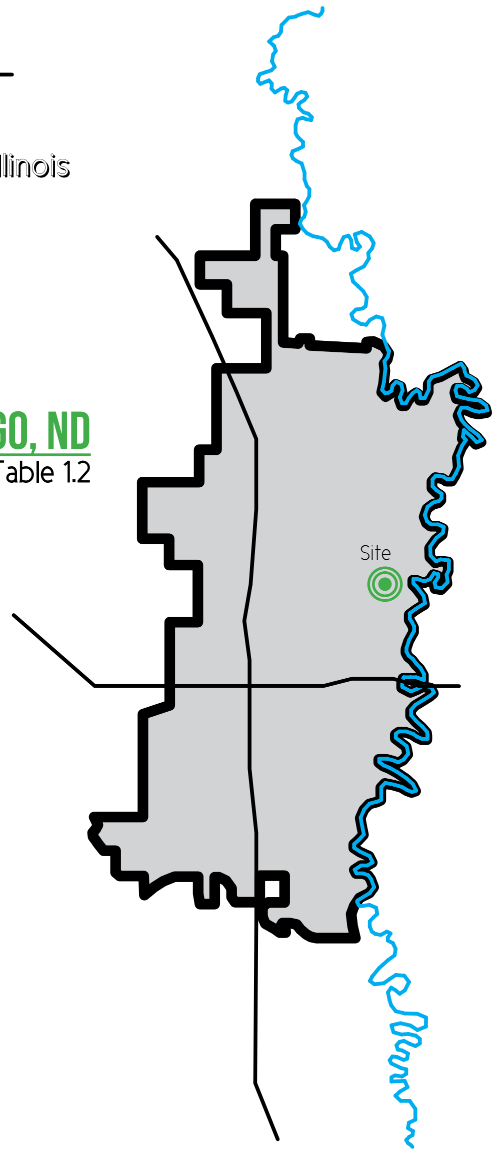
UPPER MIDWEST, USA

Table 1.1



FARGO, ND

Table 1.2



As a whole, North Dakota is currently experiencing a rapid population increase mainly due to the abundance of oil found in the western region of the state. Although the major population growth is within the western part of North Dakota, Fargo remains the city with the largest number of inhabitants (105,550). Fargo, despite being relatively small in comparison to other major cities across the country and the rest of the world, is North Dakota's largest city experiencing rapid population growth.

Figure 2a

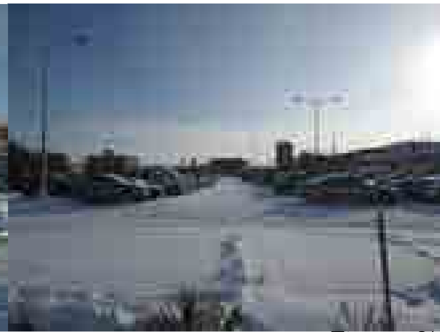


Figure 2b

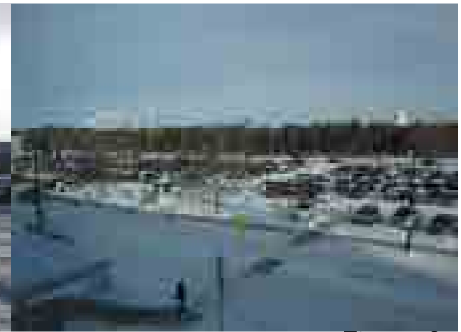


Figure 2c

THE SITE

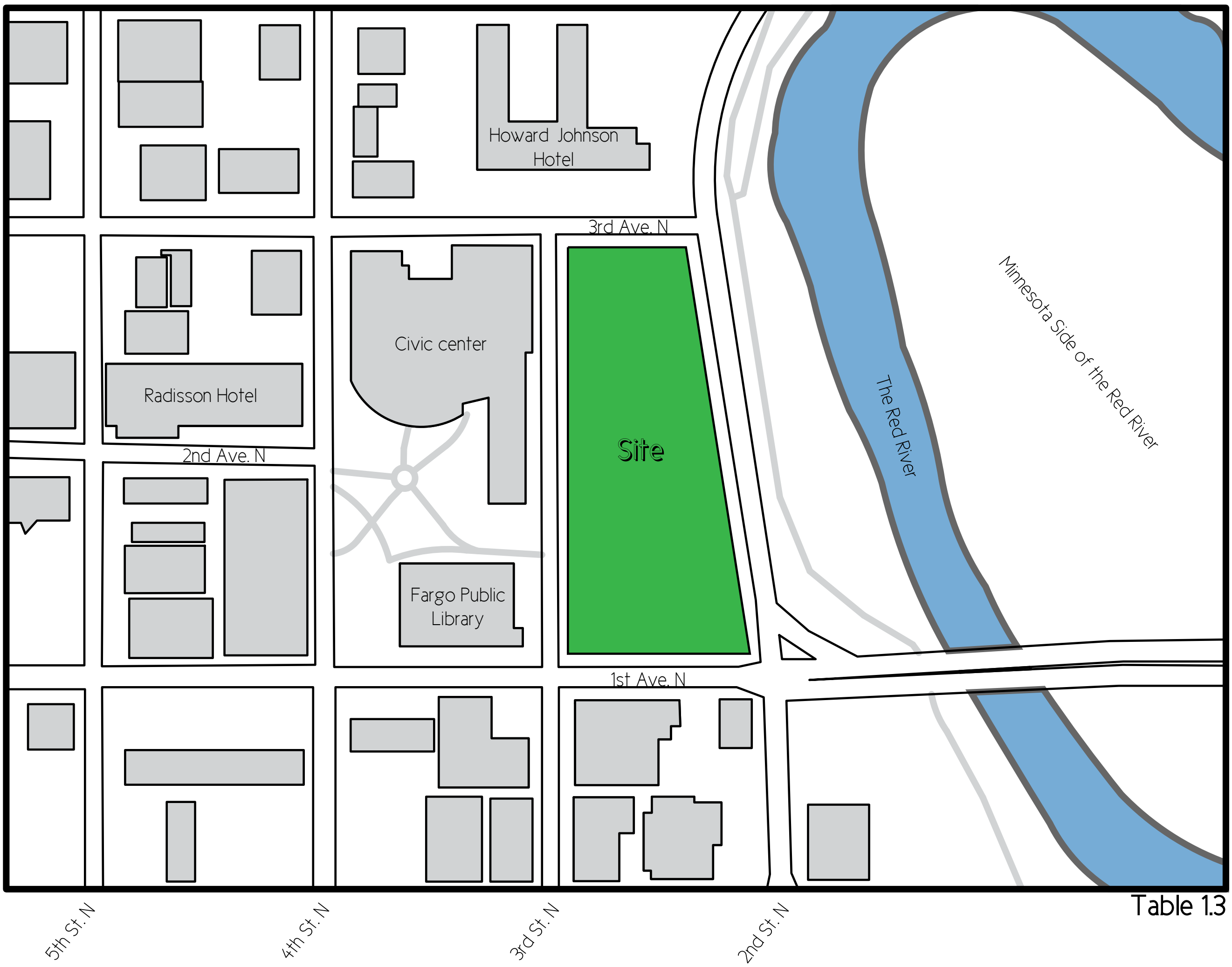


Table 1.3

The site is approximately 150,000sq. ft. It is currently the largest public parking lot in downtown Fargo. The parking lot serves the Civic Center, the Fargo Public Library, and many other smaller scale facilities nearby. The site is mainly accessible by car, but multiple bus routes run just south of the site on 1st Ave. N.

SITE INFORMATION

MIDWESTERN REGION

The site would be located in the Midwest region of the United States officially known as the North Central region. More specifically the site would be in the most north western state of the region, North Dakota. The climate in this area of the Midwest is well know for its harsh winter conditions as well as extremely humid summers. Both of these elements require a high degree of environmental control systems, such as heating and AC, thus emphasizing the need for sustainable design strategies.

FARGO, ND

Fargo is located on the east side of North Dakota adjacent to the North Dakota/ Minnesota border. Despite not being the capital of North Dakota, Fargo is the largest city in the state. The city holds roughly 16 percent of the state's total population with a population of about 105,550 inhabitants. Fargo has a population density of 2,162 people per square mile.

THESIS SITE

One of the main ideas behind this thesis is that the design would respond to the site chosen for its construction to meet both functional and sustainable needs. This means that the reasoning for the site selection for this thesis is less about why, and more so about how can this site, and its specific constraints, guide the design.

I chose to utilize a downtown parking lot located between 1st and 3rd avenue north, and 2nd and 3rd st. It is just east of both the Fargo Civic Center, and the Fargo Public Library and it is just west of The Red River. Due to the nearby Red River, this site has an annual flood risk. The orientation for the site is not optimal, but since there are no buildings nearby on the eastern side, and only 2-3 level buildings on the North, South and West side, this site receives an abundance of natural daylight throughout the day.


Radisson Hotel (Figure 3a)

Fargo Theater (Figure 3b)

THE SITE'S LANDMARKS

The page consists of some of the most well known landmarks located within a 5 block radius of the site. There are more notable landmarks in the area but the ones chosen for this page are the ones that have the largest impact on the site and surrounding area.


Fargo Civic Center (Figure 3c)


Fargo Public Library (Figure 3d)


The Red River (Figure 3e)


US Bank Plaza (Figure 3f)

PROJECT EMPHASIS

This thesis project is an investigation into how residential design can be used as a tool to reconceive how to meet many of the needs of current and future rapid population growth within cities.

This project will dive deeply into how integrating agricultural facilities and sustainable systems into an apartment complex could provide the increased needs for a city experiencing an increased abundance of inhabitants. The study of active/passive systems, agricultural techniques, and residential needs will be used to further the understanding how future urban residential design could be conceived.

A PLAN FOR PROCEEDING

RESEARCH DIRECTION

Research will be used to increase the understanding of current population information and trends, urban agricultural techniques, project typology, the site, historical context, and any other requirements related to this project's program. The research is intended to be conducted for the entire duration of the thesis.

DESIGN METHODOLOGY

Since I intend to conduct research for the duration of the project the mixed method approach appears to be the most appropriate. The mixed method approach includes quantitative and qualitative research and is obtained using a concurrent transformative strategy. This will allow for a constant back-and-forth between the research and the design. The investigation of qualitative data will be mainly through direct observation of the site. The quantitative data will be obtained through appropriate equipment and instruments. The process of analyzing the research will displayed in the form of text, graphics and physical models.

DOCUMENTATION OF DESIGN

Documentation of the project will occur throughout the entire duration of this thesis. Documentation will occur for each completed task that is listed on the schedule. Documentation will be presented in the form of drawings, sketches, and photographs. Upon completion of the documentation of a specific task, the information will be organized in a manner adequate for review. This will allow the thesis staff to consistently be able to review my work, as well as give me the opportunity to articulate my findings.

SPRING SCHEDULE

TASK	DURATION	DATES
Project Documentation	89 days	1/14/14 – 5/16/14
Context Analysis	5 days	1/14/14 – 1/20/14
Conceptual Analysis	9 days	1/14/14 – 1/24/14
Spatial Analysis	11 days	1/17/14 – 1/31/14
MLK Holiday	1 day	1/20/14
ECS Passive Analysis	11 days	1/21/14 – 2/4/14
ECS Active Analysis	11 days	1/21/14 – 2/4/14
Structural Development	8 days	2/5/14 – 2/14/14
Materials Development	8 days	2/5/14 – 2/14/14
President's Day	1 day	2/17/14
Floor Plan Development	10 days	2/18/14 – 3/3/14
Context Redevelopment	10 days	2/18/14 – 3/3/14
Section Development	9 days	3/4/14 – 3/14/14
Midterm Reviews	5 days	3/10/14 – 3/14/14
Spring Break	7 days	3/15/14 – 3/23/14
Structural Redevelopment	5 days	3/24/14 – 3/28/14
Envelope Development	5 days	3/31/14 – 4/4/14
Project Revisions	5 days	4/7/14 – 4/11/14
Preparations for Presentation	10 days	4/14/14 – 4/25/14
Presentation Layout	10 days	4/14/14 – 4/25/14
Plotting and Model Making	10 days	4/14/14 – 4/25/14
Spring Recess	2 days	4/19/14 – 4/21/14
Exhibits Installed on 5th Floor	1 day	4/28/14
Thesis Exhibit	3 days	4/28/14 – 4/30/14
Final Thesis Reviews	6 days	5/1/14 – 5/8/14
CD Due to Thesis Advisors	1 day	5/12/14
Final Thesis Documentation Due	1 day	5/16/14
Commencement	1 day	5/17/14

SPRING SEMESTER 2013

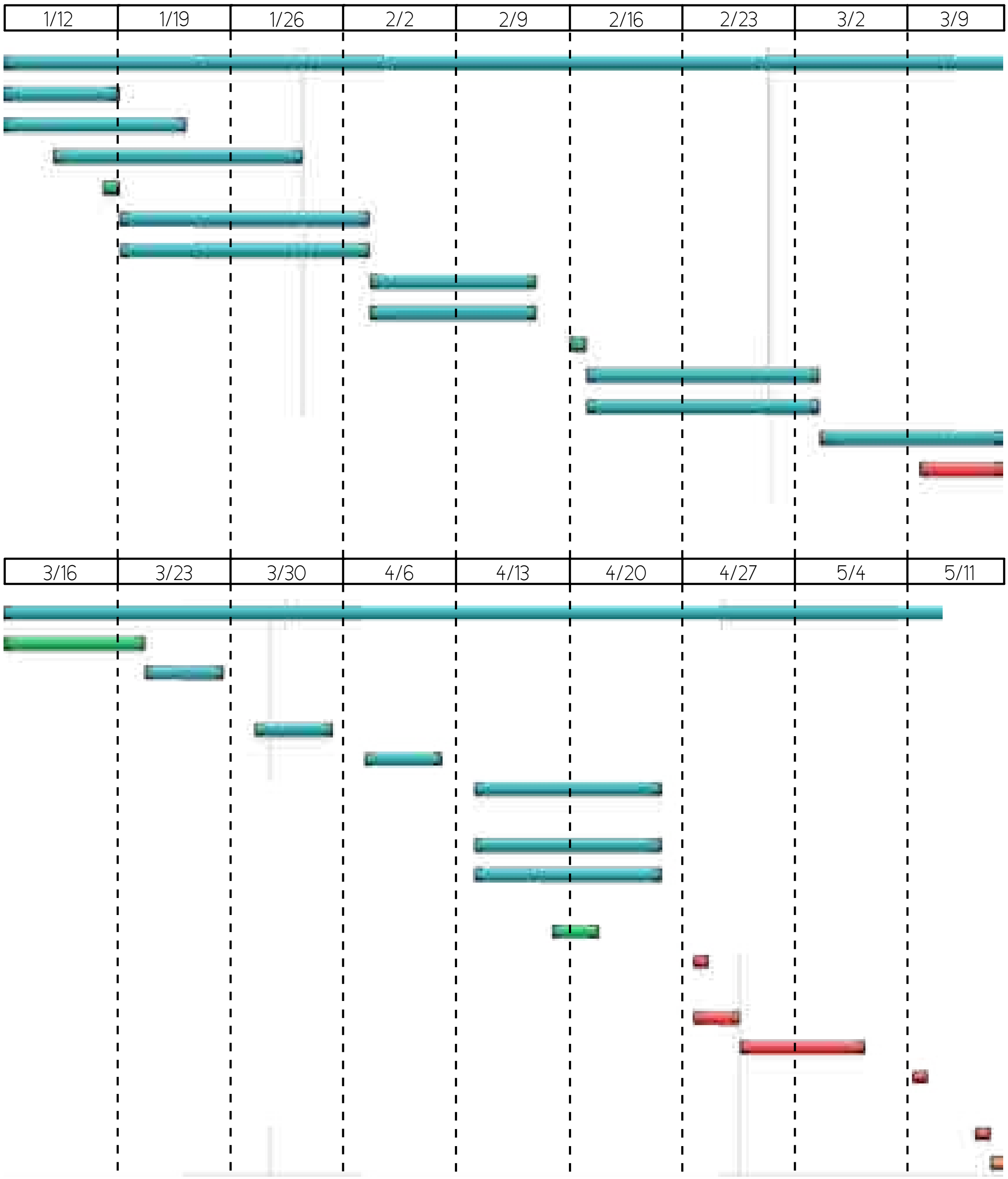


Table 2.0

PREVIOUS STUDIO EXPERIENCE

ARCH 271 ARCHITECTURAL DESIGN I - FALL 2010
Daryl Booker

Projects:
Tea House
Boat House

ARCH 272 ARCHITECTURAL DESIGN II - SPRING 2011
Cindy Urness

Projects:
Montessori School
Dwelling

ARCH 371 ARCHITECTURAL DESIGN III - FALL 2011
Mike Christenson

Projects:
Corbusier Museums Investigation

ARCH 372 ARCHITECTURAL DESIGN IV - SPRING 2012
Milton Yergens

Projects:
Agricultural Research Facility
Urban Infill

ARCH 471 ARCHITECTURAL DESIGN V - FALL 2012

Don Faulkner

Projects:
High Rise

ARCH 472 ARCHITECTURAL DESIGN VI - SPRING 2013

Don Faulkner
Frank Kratky

Projects:
Ghanian School
Marvin Windows Competition

ARCH 771 ADVANCED ARCHITECTURAL DESIGN - SPRING 2013

Mike Christenson

Projects:
The Time's Building Investigation

PROGRAM DOCUMENT

Overpopulation

Definition:
-The condition of having a population so dense as to cause environmental deterioration, an impaired quality of life, or a population crash. ("Overpopulation - Definition and More from the Free Merriam-Webster Dictionary", 2013)

-To fill with an excessive number of people, straining available resources and facilities. ("Overpopulation | Define Overpopulation at Dictionary.com", 2013)

World Population Milestones:
In 1804 the population had reached 1 billion, in 1923 it reached 2 billion, in 1960 it reached 3 billion, in 1974 it reached 4 billion, in 1987 it reached 5 billion, in 1999 it reached 6 billion, in 2011 it reached 7 billion. ("7 Population Milestones for 7 Billion People | October 31, The Day of 7 Billion | Population Growth | LiveScience", 2013)

It took all of mankind's history up until about the 1800's for mankind to reach a world population of 1 billion. In about only 130 years after that first billion, the second billion was reached in 1923. Only 37 years later, the third billion was reached in 1974. The fourth billion was a small 15 years later, in 1974. 13 years later, in 1987, the fifth billion mark was recorded. Twelve short years later, 6 billion was achieved in 1999. The most recent recorded benchmark was in 2011, when the world population reached 7 billion. Again this billion took twelve years.

http://news.medill.northwestern.edu/chicago/news.aspx?id=213990&print=1

Overpopulation (Figure 4)

http://macders.files.wordpress.com/2012/11/istanbul-city-golden_horn-overpopulation-population_density-urban_area-urbanization-hd.jpg

Overpopulation (Figure 5)

Speculation:

> *"According to the most recent United Nations estimates, the human population of the world is expected to reach 8 billion people in the spring of 2024."* ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

If this ends up being accurate, then it will mean that the human population growth rate is declining. The world population will continue to grow, but at a slower rate. However, since the world population has increased to a relatively much larger number, even a very small percentage increase in the world's population will increase the population dramatically. (Ex: 1% of 7 billion is 7 million)

> *"The latest United Nations projections indicate that world population will nearly stabilize at just above 10 billion persons after 2062."* ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

North Dakota Population:

In 2012, the population of North Dakota was recorded to be 699,628. In 2010, the population was 672,591. This means that in 2 recent years, North Dakota's population experienced a 4 percent growth. ("North Dakota QuickFacts from the US Census Bureau", 2013)

Fargo, ND Population:

In 2012, the population in Fargo, ND was recorded to be 109,779. In 2000, the population of Fargo was 90,576. This implies that there has been a population growth of 21.2 percent in Fargo in twelve recent years. Although the world population's growth as a whole seems to be declining, there are many places like Fargo, North Dakota where the population continues to boom. ("Fargo, North Dakota (ND) profile: population, maps, real estate, averages, homes, statistics, relocation, travel, jobs, hospitals, schools, crime, moving, houses, news", 2013)

Urban Agriculture

<u>Definition:</u>
-It refers to the system of cultivating, processing and distributing food in a town or city. ("Urban Agriculture Law & Legal Definition", 2013)

<u>Average Amount of Land Required to Continuously Feed a Single Adult:</u>
The average adult needs at least 0.07 hectares, or 7,500 square ft. to be capable of continuously growing the minimum amount and types of food required for a healthy human diet. ("Amount of land per person? (community forum at permies)", 2013)

> *"So in a more southern climate, you could theoretically support about 5 people per acre. This means about 0.2 acres per person, or roughly 8,712 square ft."*
> ("Urban Farming – The Future of Agriculture?", 2013)

<u>Required Daylight (Daily):</u>
The general consensus is that 8 hours of daylight is a "safe" amount of light for most vegetable types typically grown in the US. There are vegetables to require less, 6 Hours, and there are vegetables that require more. Strategic placement of vegetable types within a garden will allow for some leniency for vegetables growing in areas that might be lacking in light. ("Clover's Garden Centers – Resource Center – Urban Farming Resources – Sunlight & vegetables", 2013)

http://environment.nationalgeographic.com/environment/photos/urban-farming/

Raised Bed Growing (Figure 6)

Types of Urban Gardens:

Roof gardens- are a current popular global trend. They can be used to grown necessary products and/or providing spaces for inhabitants to relax and take a break. Additionally environmental and sustainable benefits are present in roof gardens as well. Biomass creates a layer of insulation for the building, improves air quality, and utilizes/retains rainwater more efficiently.

1. Backyard Gardens- are essentially just spaces on the building's property used for gardening/ growing practices. Again this utilizes rainwater efficiently and also provides nice spaces for people to enjoy. It is also a great way to ensure that if adequate daylight is available, that it is used as efficiently as possible.

2. Allotment Gardens- are areas of public or government owned land that is given to individuals or households to access and use for gardening purposes. It can be on site or off site of where one resides/works. Typically a set up like this is creates a sense of community between the users of the gardens.

3. Community Gardens- are very similar to allotments except that the products grown are cultivated collectively rather than individually designated segments of land. ("Urban Gardens: urban gardening, guerilla gardening, community gardens", 2013)

4. Vertical Gardens- are defined as hydroponic food production in cities in multi-story greenhouses. Water is recycled very efficiently and the output ratio of hydroponic growing techniques consistently surpasses soil growing techniques be a minimum ratio of 4:1. ("What is Vertical Farming? | OnEarth Magazine", 2013)

http://www.agri-tecture.com/page/70

Vertical Farming (Figure 7)

Growing Techniques:

1. Field Growing/Truck Farming– The cultivation of crops often performed on a large area of land. Field growing is currently the most common form of agriculture in the world. This is typically used for commercial purposes.

2. Raised Bed Gardening– is the gardening by raising the plants and the soil in which they are grown above the surrounding ground. They allow for less soil compaction, earlier planting due to the ability to easily warm the soil, frost protection since it's easy to cover, convenient soil manipulability, and great accessibility for people with limited mobility. ("Block Style Layout in Raised Bed Vegetable Gardens", 2013)

3. Hydroponic Gardening– "The dictionary's definition of hydroponics is; "cultivating plants in water." But a more practical definition is: "growing plants in a water and nutrient solution, without soil." Hydroponics allows a gardener to grow plants, fruits and vegetables in a more efficient and productive manner... and with less labor, time and gardening area needed."

Some advantages to hydroponic gardening are that it is a relatively simple process compared to soil cultivation, as in no weed pulling. It uses 2/3 less water and yet there is a higher yield. Only a very small amount of square footage of land is necessary. The produced vegetables tend to taste better, and have higher nutritional content. They can be grown year around. Without soil, there are no soil-borne diseases. ("Hydroponic Gardening", 2013)

http://upload.wikimedia.org/wikipedia/commons/7/7f/CDC_South_Aquaponics_Raft_Tank_1_2010-07-17.jpg Hydroponic Growing (Figure 8)

Sustainable Techniques

<u>Definition:</u>
-of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged. ("Sustainable - Definition and More from the Free Merriam-Webster Dictionary")

-the quality of not being harmful to the environment or depleting natural resources, and thereby supporting long-term ecological balance. ("Sustainability | Define Sustainability at Dictionary.com")

<u>Sustainable Architecture Definition:</u>
-Sustainable architecture, also known as "green architecture," holds the philosophy that the design of a building or home should have the least impact on its environment possible. Every component in a building or home, whether it is affected by its environment or whether it affects its environment, can comprise sustainable architecture. These green architecture components can include passive and active heating and cooling, renewable building materials, water conservation methods, building design, and natural and artificial lighting. ("Green Living | Building and Remodeling Tip: Sustainable Architecture Defined")

http://www.simonsparrowdesign.com/sustainability-is-cool/

Sustainable Architecture (Figure 9)

Building Massing:

This refers to the overall size/shape of the building. Some ways this can vary are tall or short, long and thin, cutouts or solid. Proper massing minimizes energy needs by maximizing energy from the sun and wind.

Massing for Visual Purposes:

Avoid placing the larger faces of the building in either east or west directions. Daylight from either of those directions tends to be inconstant and glare also tends to be an issue. Instead have the larger faces of the building facing north or south. In the northern hemisphere, the southern face of the building receives the most light and any unwanted light, such as glare, can be strategically controlled with overhangs, light shelves, or louvers. The northern face of the building receives little or no glare at all.

Massing for Thermal Purposes:

> *"As with massing for daylighting, massing for thermal comfort is often helped by extending the east-west axis of buildings to take advantage of the consistent sun on the northern and southern exposures. Unlike daylighting, though, thinner buildings may not be better. It depends on the climate and the program."* ("Building Massing | Sustainability Workshop")

Natural Ventilation:

Thin buildings have a high surface area to volume ratio. This allows for utilization of natural, passive cooling.

Tall buildings also increase the efficiency of natural ventilation, since wind speeds are faster at greater heights. This assists both cross ventilation, and stack effect ventilation.

http://archinect.com/people/project/24462906/design-thesis-project/24468930

Natural Ventilation (Figure 10)

http://www.fairfaxcounty.gov/dpz/designawards/2013/

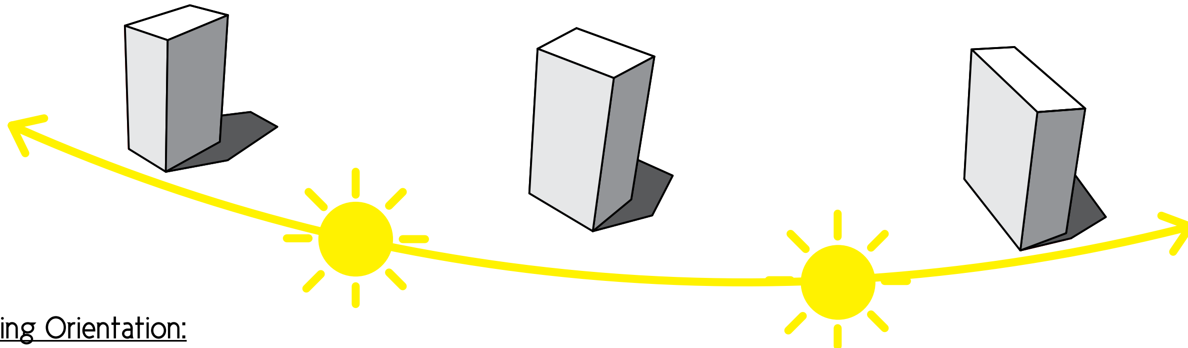
Sustainable Design (Figure 11)

<u>Solar Radiation and Heat Transfer:</u>

Although thin and tall buildings improve the efficiency of natural ventilation cooling a building, they also increase the area exposed to heat transfer via the building's envelope. This could be either a desired trait, or problematic one.

In cold climates minimizing the surface area to volume ration, thus creating a cube or hemisphere, can avoid unwanted heat loss. However, solar heat is advantageous and if more of the surface area faces the sun, passive heating will occur. So it might be best to increase the surface area of the side facing the sun while simultaneously reducing the exposed areas of the other faces of the building.

In hot climates thin buildings with the largest face aiming towards the sun can result in undesired heat gain. Shading devices and high quality windows can be used to lessen this effect while still benefiting from natural ventilation. Tall building might also be desired for hot climates since the sun hits the roof more in these scenarios, and tall buildings have a relatively low roof surface area. ("Building Massing | Sustainability Workshop")



Building Orientation:

Orientation refers to the compass direction of the building faces. Along with massing, orientation is one of the most important aspects in terms of providing a building with optimal passive thermal and visual levels. Orientation design choices should occur simultaneously with massing choices. The proper combination of the two allows for both aspects to be optimized.

> *"Orientation is measured by the azimuth angle of a surface relative to true north."*
> ("Building Orientation | Sustainability Workshop")

Orientation for Visual Purposes:

Just like massing for visual comfort, buildings should be oriented east-west. This way daylight can be harnessed while controlling the glare. Glare from the rising or setting sun would also be considerably reduced.

Orientation for Thermal Purposes:

Orientation for thermal purposes is very similar to orientation for visual purposes. There are a few differences though.

Solar Heat Gain:

The amount of sunlight optimal for natural light utilization is most likely not optimal for solar heat gain. Unlike daylighting benefits, solar heat gain only occurs when a building's face correlates to the solar path. If it does not, then there will be no heat gain. Lastly the sun's heat can be absorbed and stored by thermal mass, while the sun's light cannot. This can be most effectively utilized in west facing walls to allow for heat to be stored and distributed throughout the building at night.

Glazing and Materials:

Glazing and materials can allow the building to avoid unwanted solar heat gain or they can be used to store the sun's heat through thermal mass. Orientation that supplies the desired amount of daylight often conflicts with the amount of desired solar heat gain.

To balance the temperature swings during sunrise and sunset, the east face of the building likely benefits from larger window areas to allow for more direct solar heat gain, while the west face benefits more from having small windows allowing for more area of thermal massing materials to absorb the heat which the building then utilizes throughout the night.

Orientation for Natural Ventilation:

The building's design ought to orientate in a manner where the building is sheltered from undesired cold weather winds, while also benefitting from cooling winds in hot weather seasons. Wind roses are the best tool from which a designer can see what winds to utilize or avoid.

> *"Generally, orienting the building so that its shorter axis aligns with prevailing winds will provide the most wind ventilation, while orienting it perpendicular to prevailing winds will provide the least passive ventilation.*
>
> *For buildings that feature a courtyard and are located in climates where cooling is desired, orienting the courtyard 45 degrees from the prevailing wind maximizes wind in the courtyard and cross ventilation through the building."*
>
> ("Building Orientation | Sustainability Workshop")

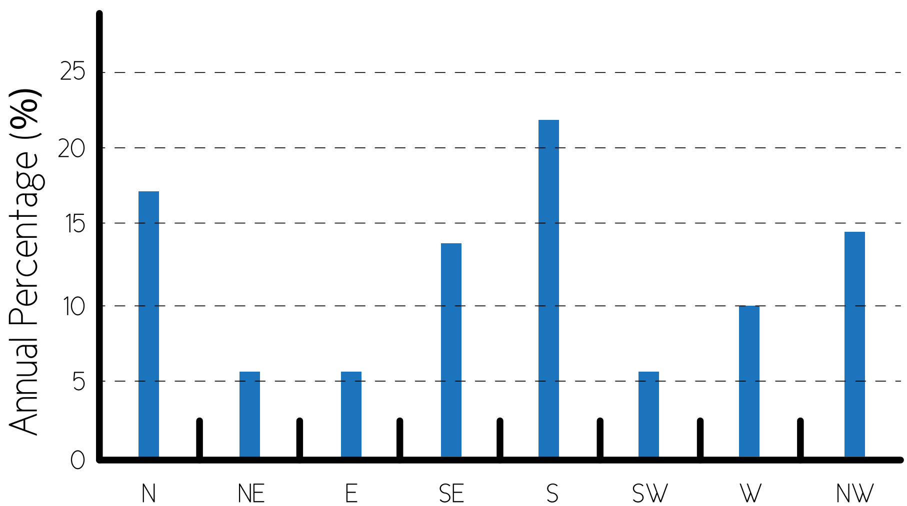


Table 3.0

Fargo, ND Wind Diagrams

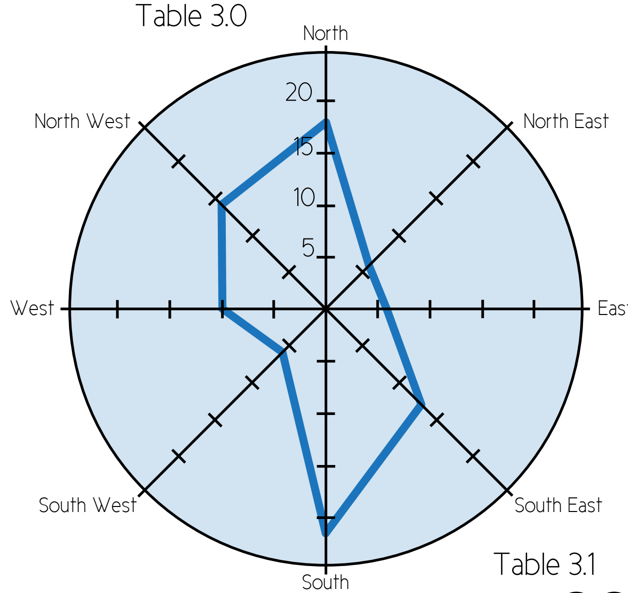


Table 3.1

Conclusion

I began my research by taking a thorough look into population statistics, population trends, and overpopulation. Overpopulation is one of the main reasons that there are such high energy, food, and shelter demands across the globe. I wanted to be sure that I was correct in the fact that overpopulation is indeed threatening to negatively impact our society's ability to provide the needs for its inhabitants. I also wanted to be sure that overpopulation was a contributing fact for the current damaged state of our environment. I then followed that up by diving deeper into agricultural techniques, with some emphasis on urban agriculture and community gardening aspects, since I believe that on site urban agriculture is a necessary step to provide food for a city's residents and to reduce environmentally harmful actions such as the over-excessive transportation of food products. I then wrapped up my initial research by investigating sustainable techniques. These techniques that were investigated mainly revolve around initial building design decisions.

Global overpopulation is indeed an issue since although the rate of growth has begun to stabilize, there are now so many people on this planet that even a small annual percentage increase threatens to strain our resources even further. As mentioned in the overpopulation section of the research, a 1 percent annual increase in our current global population of roughly 7 billion would result in 7 million additional people. Unfortunately this is also a best case scenario since we are experiencing a higher annual global increase than 1 percent. This will undoubtedly add additional strain the current in place systems that provide our food and energy needs.

To provide food for every single inhabitant we have to consider how much land is required for our current food producing and gathering practices. The numbers vary slightly from source to source but overall to continuously feed a single adult; roughly 0.2 – 0.7 acre of land is necessary. At this point in time it is questionable if that is mathematically possible given the limited amount of land available for agricultural purposes. As the population increases, people will continue to require the use of land for shelter purposes, thus taking even more land away from agricultural needs. It is simply a matter of time before there is not enough agricultural land available to feed everyone. Another related issue is the waste produced by shipping and storing food, since much of what we consume is produced off site or even imported. There are also other inefficiencies related to the common agricultural practices such as soil borne diseases, the amount of water necessary to keep crops alive, and the reliance on adequate weather conditions. For all of these reasons controlled environment vertical farming seems to be something that we need to begin utilizing as soon as possible. Vertical farming requires very little labor, energy, water, and space. Since vertical farming utilizes hydroponic growing techniques, there is no soil so soil borne diseases will not be a factor. Vertical farming is designed to be utilized on site, so all of the waste resulting from shipping and storing food from off site sources will be eliminated, not to mention the environmental and energy consumption factors involved in shipping and storing. The yield for hydroponic growing, compared to using soil bases techniques, is on average 4:1 and since it can easily be done in a controllable interior environment, relying on proper weather conditions would no longer be a concern. It is hard to find a reason not to move forward into the future with vertical hydroponic farming facilities across the globe.

The last section of my research focuses on sustainable techniques regarding building design. Just as the needs for food and water increases with a rise in population, so does the need for energy. Currently buildings are generally considered to be endless energy consumers, when they could easily be energy producers instead. Of course buildings will still consume energy, but this can be reduced as well as provided on site by utilizing sustainable systems and techniques. Many sustainable systems respond to the certain conditions of the building as well as the site, it makes more sense to look into the initial sustainable design strategies at this point of this thesis, since I have not yet begun to design yet, and then dive deeper into specific systems as the design develops further next semester. This is why I looked mainly into passive sustainable strategies such as building massing and orientation. These two elements of initial design set the potential for every other sustainable decision that follows.

By furthering my understanding of the current world population, overpopulation, agricultural techniques, and sustainable building design strategies I will be ready to confidently begin the design process.

RESULTS OF THE TYPOLOGICAL RESEARCH

CASE STUDY #1: AGRO HOUSING

The Agro Housing Project by Nkafo Klimor Architects is a well designed blend of sustainable techniques and pleasant residential spaces and amenities. There are plenty of green spaces throughout the design, along with other well thought out interactive community spaces. The main reason this project was designed was to address overpopulation in a sustainable space efficient manner, very similar to the idea behind this very thesis.

The Agro Housing is a high-rise apartment complex concept that utilizes vertical gardening strategies, and also contains efficiently planned compact residential units with their own grow spaces. Some of the community spaces within the design include a kindergarten, a "sky club" on the green roof, and spaces for meetings and gatherings.

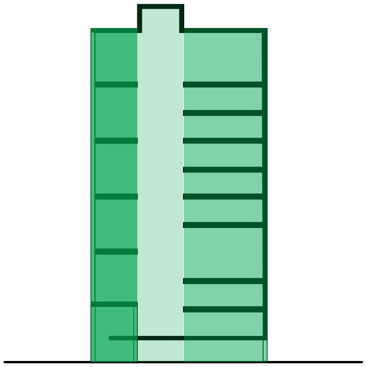
The design was intended to be constructed with multiple sustainable techniques. The numerous green spaces help reduce carbon dioxide while simultaneously providing cooling and shading. Drip irrigation is used to water the plants and the resulting grey water is used for gardening. The first fully inhabitable floor is located on the second level, allowing for the ground floor to be used for shaded bicycle parking. Any needed heating or cooling is applied by passive solar energy and ground source heat pumping systems.

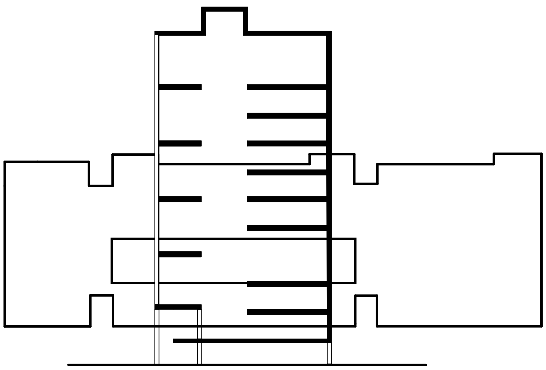
From all of this the inhabitants could receive freedom, an increased level of health, and a sense of community. Space efficient urban design like this can also lower living costs due to the lessened need for infrastructure and transportation systems. Commuting times can also be reduced, allowing the community to become more familiar with the benefits/importance of sustainability.

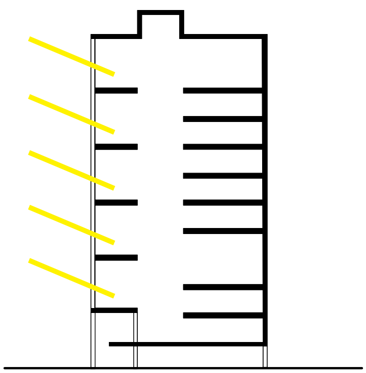
The main structure of this design is composed of prefabricated steel which is to be installed on site. Steel is a common recycled building material, which makes obtaining it more sustainable. If the building would need to be deconstructed for any reason, the steel could be recycled for a future purpose. ("Agro-Housing for a Sustainable Urban China | Inhabitat - Sustainable Design Innovation, Eco Architecture, Green Building")

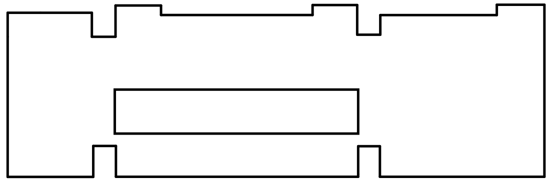
Overall the building is thin, narrow and tall. This allows for a large amount of solar gain for both natural daylighting and solar heat gain. This is beneficial in terms of obtaining necessary amounts of daylight for gardening purposes, and also reducing the inhabitant's electrical energy needs by providing adequate amounts of daylight throughout the whole design. The building envelope contains some screening of the sun in extremely solar abundant areas to reduce an unwanted level of heat or visual glare.

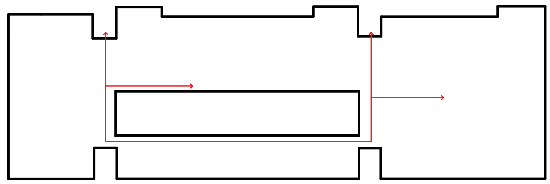
The use of raising the lowest level of inhabitable space one level above ground level is very similar to what I predict will occur in my thesis as well. My thesis's reasons, such as flood risk and vehicular parking needs, are different than the Agro Housing but the procedure and benefits would be the same.

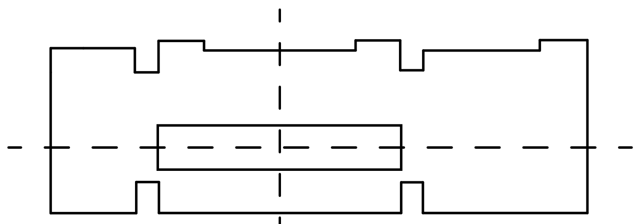

Hierarchy

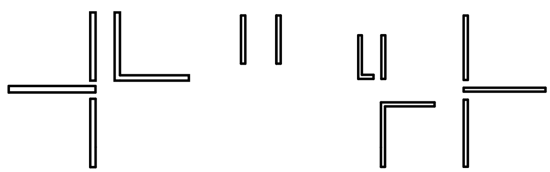

Plan To Section


Natural Light


Massing


Circulation


Symmetry/Balance


Structure

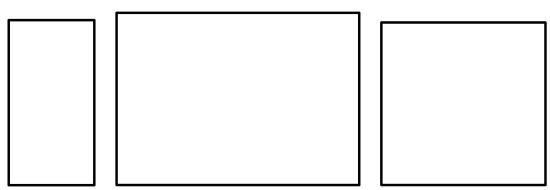

Geometry

Table 4

CASE STUDY #2: GARDEN RIBBONS

The Garden Ribbons is a design created by the Dutch office ShaGa Studio along with Shyovitz Architects. This design was intended to be like a ribbon that transforms a horizontal landscape into a vertical climatically efficient structure. The design was to represent a future hope for society that fully embraces a sustainable urban lifestyle for all of its inhabitants and visitors.

The building was to serve as a city hall and urban park. This was accomplished through its sustainable public character, and mix of leisure and culture. The identity was to represent both urban regeneration and a city landmark.

A city hall has to both function for its intended purposes as well as capturing and representing a city's identity. Therefor this design combines the structure of the public, culture and municipal programs, while avoiding giving too much emphasis on hierarchy and instead focusing more on environmental responsibility.

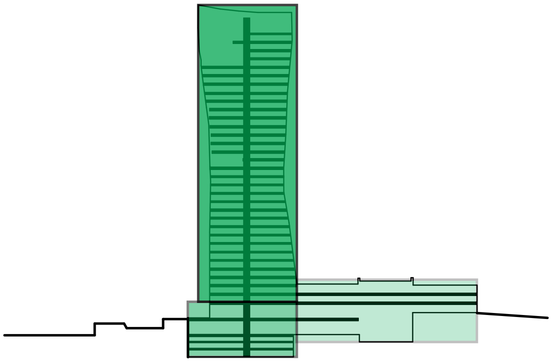
This design acts as an urban generator as well as an example of the expected level of standards. This gives the design he ability to connect to the city's inhabitants by providing techniques and a hopeful image or message for the future.

The vertical ribbon consists of 10 climatic atriums, each defining a cluster of 4 floors and functions as an orientation point for both visitors and staff. There is also a unique jigsaw like façade along the atriums gives way for air to enter the building through integrated façade vents based on the external air pressure differences. This is visually externally represented by a continuous flow of colors, due to a varying air pressure and temperatures. This flow of colors performs as a shading element as well as reflecting a site specific solar path and color. ("Garden Ribbons' – A City Hall and Urban Park / ShaGa Studio | ArchDaily")

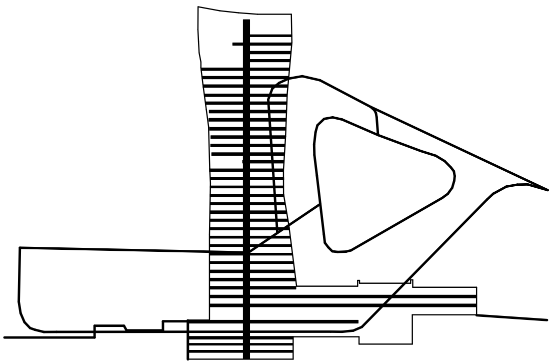
Although this design is for a city hall and urban park, there are still many similarities between this design and my thesis. This design partially acts as a symbol for standards and expectations in terms of sustainable design. I intend on creating a design for my thesis so that it can be used as a tool for increasing the understanding or sustainable design techniques and also for it to be perceived as a level of residential design standards, standards that I believe we need to be at if we expect our species to continue to be capable of inhabiting and populating this planet. There are also great ventilation, agricultural and community integration techniques used throughout the design which will act as mental points of reference for my thesis.

The vertical part of the Garden Ribbons design is triangular in massing terms, avoiding a major noticeable hierarchy and also balancing out the amount of solar gain throughout most of the tower. This idea could be useful in creating equally priced residential units for my thesis while simultaneously providing a relatively equal amount of light to the units. I foresee myself not using many specific physical attributes from the Garden Ribbons, but using many of the mentioned conceptual aspects instead.

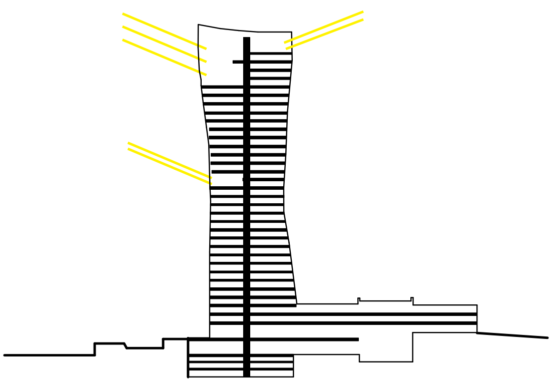
GARDEN RIBBONS DIAGRAMMATICAL ANALYSIS



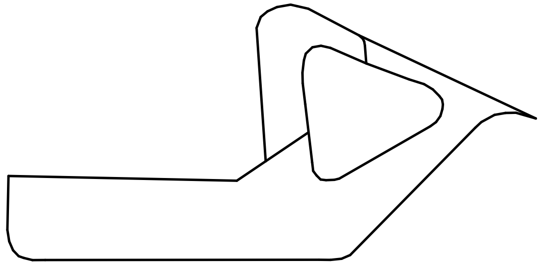
Hierarchy



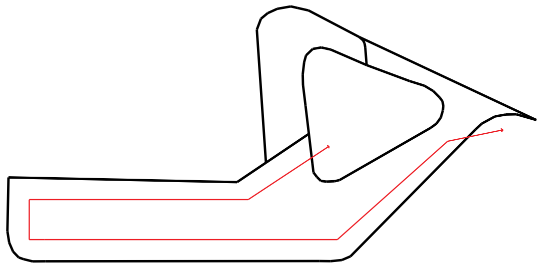
Plan To Section



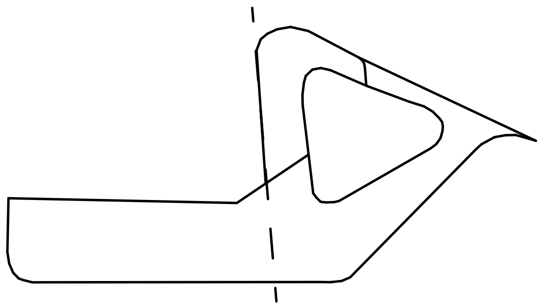
Natural Light



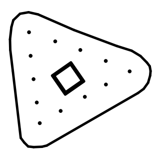
Massing



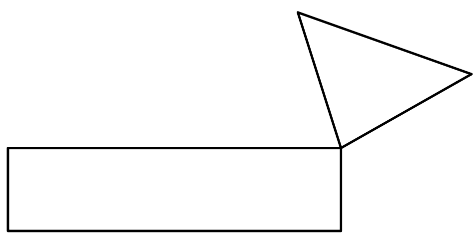
Circulation



Symmetry/Balance



Structure



Geometry

Table 5

CASE STUDY #3: COLORADO COURT

Colorado Court, designed by Pugh Scarpa Kodama in 2002, is located on a perimeter point of Santa Monica, California at a corner position adjacent to a main off-ramp of the Santa Monica freeway. This building contains 44 units, five levels, and it's 100 percent energy neutral. It is also well known as the first affordable energy neutral housing project in the United States.

The Colorado Court project has made a major impact on changing regulations and policies regarding energy efficient design. This project brought many things together such as technologically advanced design, politically provoking regulation changes, economic success, social responsibility and urban development. The project even solves urban problems by affecting public policy at state and local levels. The architect as well as the city of Santa Monica pressured the state of California to increase net metering for sustainable energy systems by an incredible one thousand percent.

The building itself is positioned to maximize passive solar and sustainable potential. All but one mature palm trees were able to be left as they were, minimizing unnecessary site impact. The landscape is fully native and due to its high drought tolerance it only relies on drip irrigation systems. The design has three sections that reach out to prevailing breezes inducing cross ventilation for every unit. The massing and orientation is designed so that over 90 percent of the glazing is on north and south facades. All of the southern facades are shaded by abstract fins and solar panels.

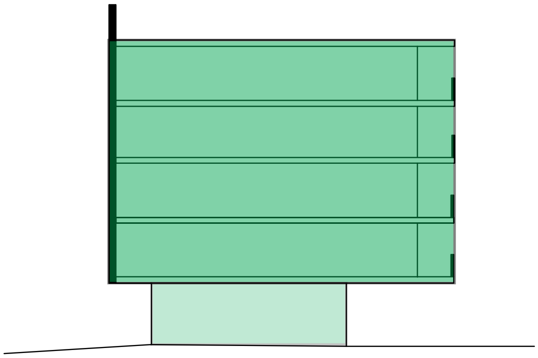
The design produces on-site electricity by utilizing solar panels and a natural gas fired micro turbine. These two systems provide 100 percent of the building's electrical energy consumption needs. There is still a utility grid connection to the building in case of unfavorable weather causing the rare need for additional electricity. Unnecessary heat created by the operation of the micro turbine is used to create hot water for domestic use and space heating through the use of a hydronic radiator heating system.

The residential units within the building, while having a relatively small floor area, each have 10ft. high ceilings, large windows, and abundant cross ventilation. Interior air quality has considered by minimizing off-gassing. All of the storm water runoff from the entire city block is collected on-site in an underground chamber system and naturally percolates back into an aquifer. The toilets are all low-flow along with the shower controls.

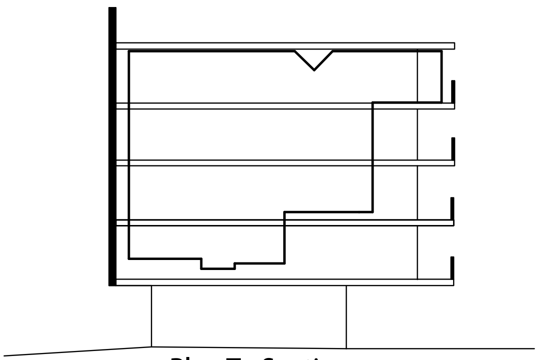
The units are kept comfortably cool through cross ventilation thanks to proper window placement. The windows are all double glazed, krypton-filled, low-e windows with blown in recycled cellulose insulation that increases the wall 75 percent above a conventional wall while also minimizing envelop infiltration. ("Colorado Court Affordable Housing | AIA Top Ten")

There are many sustainable systems, techniques and strategies located in this design that I intend on utilizing for the design of this thesis. The major differences will be the importance of some of the techniques used due to the difference in climatic characteristics between Santa Monica, California and Fargo, North Dakota.

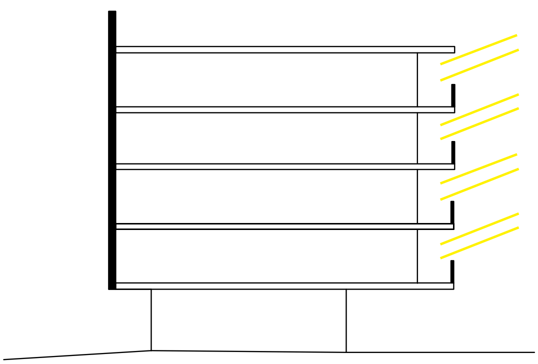
COLORADO COURT DIAGRAMMATICAL ANALYSIS



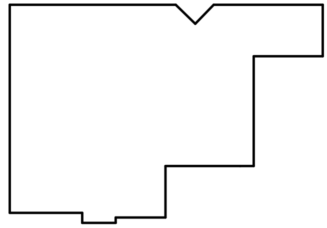
Hierarchy



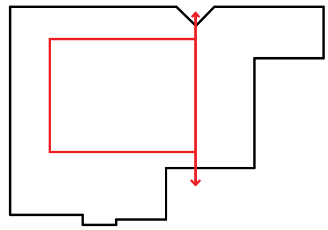
Plan To Section



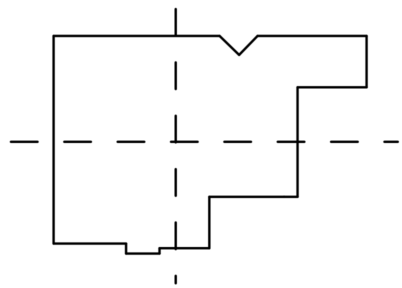
Natural Light



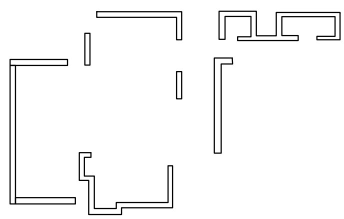
Massing



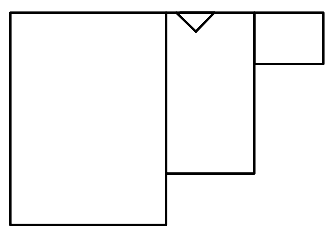
Circulation



Symmetry/Balance



Structure



Geometry

Table 6

CASE STUDY SUMMARY

Each one of the three case studies brings an important aspect into consideration while all applying the use of sustainable strategies. The Agro Housing project emphasizes the community aspect of modern urban residential living in an overpopulated setting, the Garden Ribbons design acts as a symbol, and the Colorado Court project offers the ability for affordable residential design potential.

There are countless examples of residential buildings throughout the world which contain very little or no community potential. In an urban setting one will likely and frequently interact with others. Since it is almost inevitable that people living in urban setting will be interacting it is important to create spaces where interaction can comfortably and efficiently occur. The Agro Housing project offers excellent examples how this can be done.

http://mili.vn/threads/china-knafo-klimor-architects-agro-housing.1347/

Agro Housing Project (Figure 12)

http://archinect.com/firms/project/25256176/colorado-court/5451514

Colorado Court (Figure 13a)

Colorado Court (Figure 13b)

I do not believe that my thesis could possibly be the end all solution for residential design but I do believe it can be a tool used to provoke thought towards the importance of reconsidering how architects can create future residential designs. The Garden Ribbons design represents this important aspect of my thesis by acting as a symbol to the community. Hypothetically, if my thesis was to actually be constructed I would aim for it to also act as a symbol to the city of Fargo. I would want it to both represent the capabilities of current residential design techniques as well as act as a symbol for the standard for future residential design for the entire city and possibly even the surrounding region.

Often times when designing sustainable projects the upfront cost of the construction of the building tends to be higher than average mainly due to the complexities of integrating the sustainable systems. As a result, the cost of renting units likely increases as well. This means that people with lower incomes can often times not afford to live in an environmentally friendly building. Consequently people who cannot afford to live in a sustainable building will likely not care much about sustainable design. So by creating more affordable sustainable residential design options we can begin to include the entire low income population. Creating a single energy efficient residential design complex has little chance of making much of an impact on the community if it doesn't financially apply to every potential inhabitant of the city. This is why it is very important that my thesis design also contains at least some affordable residential options.

I will undoubtably be using many of the sustainable techniques and systems from each of the three case studies, especially the Colorado Court project since, unlike the other two case studies, it is 100 percent energy neutral. Each of the three projects has unique elements that I want to use within my thesis and so discovering a way to blend the best aspects of each of the elements will be the key in accomplishing the creation of a design that can be used as a tool to raise the standards and expectancies of urban residential design.

THE HISTORICAL CONTEXT OF THE THESIS

Historically, most of the buildings constructed in the past were quite sustainable. Before electricity became utilized or even wide spread, non-sustainable design simply wasn't much of a choice for designers. Architects typically only created spaces without utilizing natural daylight unless a constant supply of candles or oil lanterns was expected to be available. Before mechanical systems could heat or cool the air, architects were forced to rely on the ability to manipulate the natural movement of air throughout their designs.

Roughly fifty years ago, global architectural design began to take a major shift into the direction of relying almost entirely on energy consuming mechanical systems due to sealed envelope designs that often required permanent artificial lighting along with constant air conditioning. This was a major shift from designs that relied on natural daylight and natural ventilation. Although in hindsight this might seem like an incredibly embarrassing and irresponsible architectural shift, we must remember that around that time new energy production facilities, such as nuclear power plants, gave the appearance that energy would soon be virtually limitless. We have now learned that this is not the case and although we can produce immense amounts of energy, it comes with a cost. We are needlessly replacing naturally obtainable energy and ventilation with manmade energy, which seems redundant, as well as globally creating a harmful amount of greenhouse gasses, which is destroying our ecosystem.

http://www.ecocenter.org/newsletters/ecolink/energy-efficiency-could-reduce-need-polluting-coal-power-plants

Coal Pollution (Figure 14)

Another thing that is important to consider is that there are times and places where we do benefit from energy consuming systems, such as in extreme climates or at times when natural daylight is not as abundant as we might need it to be. For these conditions mechanical and electrical systems are very beneficial, the problem lies in how the energy for these systems is obtained. Currently most of these systems are powered off site by various types of power producing facilities. Using this method, much energy is lost during as it transfers from the power producing facility to the designated site, and often times the power producing facilities themselves are quite harmful to the environment due to the various methods in which they obtain and transfer energy. Instead of using off site sources, every single architectural design that requires additional energy to power its necessary systems could utilize energy obtaining systems directly on site, such as wind turbines and solar panels.

http://www.exploratorium.edu/press-offi ce/press-releases/10-facts-about-exploratorium E2 80 99s-sunpower-solar-power-system

Solar Panel Utilization (Figure 15)

Sustainable design is definitely a current hot topic in the architectural world. It is stressed in the architectural field as well as in architectural education such as at North Dakota State University. Globally, people are generally aware that there are environmental problems due to the manner which we have been designing the build environment in which we live. We seem to have finally come to accept that resources and energy are not limitless, and they come with a price. If we want to be able to support all of the future inhabitants of the world, we have to make a shift in how we expect to step into the future.

> *"As we progress on initiatives to alleviate poverty (necessary and admirable in their own right, of course) humans will have no choice but to reconcile increased living standards with a still expanding population and more importantly from a sustainability perspective, with a finite supply of resources."* (""Global Trends 2030: Alternative Worlds"– does sustainability stand a chance?")

It has recently been estimated that in the next twenty years, the global population of the middle class will increase from the current estimate of roughly 1 billion people, to about 3 billion.

> *"Globalization's impact on the consumption patterns of this new class, which will likely be modeled after the 'overdeveloped' consumer lifestyle, does not promise to yield positive results for the environment."* (""Global Trends 2030: Alternative Worlds"– does sustainability stand a chance?")

http://en.wikipedia.org/wiki/File:Traffic_jam_on_Phu_Nhuan_district.JPG

Overpopulation (Figure 16)

http://biomasshub.com/resource-wars-3-constraints-make-break-biofuels/

Pollution and Waste (Figure 17)

If the current consumption method for the middle class continues, and the expected rise in population of that class is correct, then the strain on resources and the environment will be beyond the world has seen to date.

However, just as the middle class population increase threatens our future, they also provide hope. The middle class is generally well educated and their increased numbers could provide them with the numbers they need to have an even greater voting, political, and social influence. The combination of these elements gives the middle class an opportunity to make an impact on an unprecedented level.

Fargo, ND is a city that is currently undergoing a rapid population growth. The population is rising so fast that despite the relative abundance of architectural firms and construction companies, residential development simply cannot keep up with increasing demand. As a result many of the residential buildings that are being designed and constructed seem emphasize quantity over quality. Although they meet the demand for shelter, they appear to be generic, repetitive, lacking a community aspect, also absent of many sustainable system opportunities. The interior aspect of these designs is of a relative high degree of quality, and the cost for living is extremely low, but that is pretty much where the quality aspect ends. In other words, the buildings function just fine, but I feel that with all of the tools available and education that architects receive, the standard that architects have should be at a higher level than simply meeting a desired function.


http://cherishthescientist.net/tag/fargo-2/

Fargo Winters (Figure 18)

Another thing to take into consideration regarding sustainable design its level of importance in regards to the design's intended site. Fargo, ND has some of the coldest winter weather in the US and also experiences quite humid summers. Consequently buildings in this city consume a large amount of energy to power their heating and cooling systems. Since there is a large demand for energy, there is also debatably a higher level of importance in integrating sustainable systems into the design to allow for environmentally friendly energy production, transfer and consumption.

One of the ways the city of Fargo could push for sustainable design would be by enacting some sort of law or building code requiring for at least a certain percent of the building's total energy consumption to be produced or obtained on site. Although this might seem like a simple solution, there are some obstacles to be taken into consideration. To force the public and the professionals to live or design following such strict guidelines would involve increased government involvement, such as the above mentioned codes or laws. The problem with that is that Fargo, ND is in large majority, a very conservative city and typically conservative cities desire very little government control. So to enact some sort of building code or law to attempt to force sustainability into action might be necessary, and it could theoretically happen in the future, it conflicts with the values and beliefs of the larger majority of Fargo's residents. I want to stress that I am not saying that this is a good or bad thing in terms of political standings or beliefs, it is simply an obstacle that a solution like a code or law implementation would likely deal with in this particular city.

Based on the history of this thesis I feel that we must take a step back conceptually and a step forward technologically. We need to design buildings the way we used to by emphasizing passive sustainable design strategies. We can then implement current technological systems, materials, and techniques to increase the efficiency of the passive and active systems required by buildings.

http://pavements.lab.asu.edu/?q=APL

Technologically Advanced Design (Figure 19)

There are many people that believe we need to take a step back all together. They believe that modern technological advancements are the reason for the environmental problems we are experiencing today. Although this is partially true, what needs to be considered is that maybe the things that are harmful to the environment are outdated systems or methods for which we already have alternative more modern solutions for. Some examples of systems I believe to be outdated are: field growing/truck farming, purely gas powered vehicles, and buildings that rely purely on off site produced energy. There are simply too many better solutions and methods available at this point in history to needlessly continue to use these environmentally destructive alternatives.

THE GOALS OF THIS THESIS

ACADEMIC

Academically I want this thesis to allow for the utilization and combination of all of the skills and techniques acquired in the past 5 years at North Dakota State University. I expect some skills to be more evident than others but all are expected to be used to some degree. I also want to use this opportunity to increase my knowledge of sustainable design system and strategies, and use design software as a means to both explore and represent my ideas and solutions. I intend to use all of my design skills to not only complete my thesis, but also as a last chance to sharpen my skills as a student at NDSU.

PROFESSIONAL

In terms of the current professional world this thesis is very relevant. Many architectural firms are already heavily emphasizing the service of providing sustainable/environmentally friendly design and many other firms are beginning to follow this trend as well. The firms that are deeper into involving sustainable design tend to have entire divisions of their firms solely dedicated to this very subject. I am not saying this is what I plan on focusing on for my future career as an architect, but it does expand my list of available tools thus making me more flexible in terms of how I can make myself useful in the field.

Another professional tool I intend to strengthen is my ability to utilize design software. I am currently familiar with various design software such as Revit, AutoCAD, SketchUp, Rhino, and Grasshopper, but I want to push my knowledge and utilization of these tools to the next level.

Almost every time I ask any practicing architect what I could do to increase my chances in the workforce, I receive a different answer. There are of course some answers that come up more than others, such as knowing how to use a variety of software, creating high quality renderings, having strong communication skills, understanding construction documents and their formats, etc. Besides those predictable expectations, being "flexible" seems like the trait that firms are really looking for in today's architectural world.
By increasing my understanding of residential design, sustainable practices, and the use of software I am increasing my list of usable tools, making me more flexible. I strongly believe that through my thesis, I will become a valuable asset to the professional architectural field.

PERSONAL

This thesis is without a doubt very personal to me. I was born in The Netherlands and moved, along with my direct family, to the Minneapolis, MN in 1996. When me moved here the US economy was performing well, and the general public lived as if energy sources were limitless. Because of this me along with many other people in my generation were raised with the illusion that the social and economic system which we followed during that time would also be the systems that we maintained in our future.

The world is currently recovering from an economic recession, unemployment is high, many retirement benefits are becoming extinct, gas is constantly reaching record high prices, and our atmosphere is suffering from the current way most of the technologically advanced nations obtain and transport their resources and energy. Since the economic recession hit in 2008, my generation's future has considerably changed.

Although the current state of the world is not great, I am hopeful that things will change. I often think about how the world could and possibly should be. I consider myself a Techno-centric person. That is I feel that through technological advancements we can continue to refine our way of living into a manner that is extremely efficient and environmentally friendly. Because of this belief I am convinced that the idea behind my thesis, a fully self-sustaining residential complex, can assist in making the world a better place in so many ways. It addresses environmental issues, energy concerns, nutritional needs, and I could go on but what I believe is most important is that my thesis could be a tool through which the perception of our expected standards of residential design could reach a new height. This is a height that we are currently fully capable of achieving, and I want to see it happen.

SITE ANALYSIS
(QUALITATIVE)

Views

The grid that surrounds the site consists of streets and sidewalks. Fargo's street layout is a very well organized Cartesian (x-axis and y-axis) type grid. However this site is so close to the river that it is forced to contain a part of 2nd Street N. that deviates slightly from the grid. Directly around the grid are a variety of 2-3 level buildings ranging from hotels to the Fargo Public Library.

The nearby area has a decent variety and a high amount of contrast. To the east is a collection of green from the various trees along the riverbank. To the north is a concrete hotel. To the west is a combination of concrete from the Fargo Civic Center, and glass facades from the Fargo Public Library. To the south are some brick buildings. This collaboration of varying colors and materials accurately reflects the large variety of functional purposes from the surrounding area.

The views on the site that have the most potential are to the northeast, east and southeast. These views contain the Red River and much of the surrounding green spaces, such as a bicycle/pedestrian path. Since there is a busy street on the east side as well, elevating the inhabitable levels of the design would assist in reducing that visual distraction.

The Site (Figure 20a)

The Site (Figure 20b)

Light Quality

Since the surrounding buildings are only 2-3 levels tall, and the east side does not have any buildings, there is an abundance of light in the mornings and throughout the afternoon. Near sunset some light is lost due to the majority of the city being just west of the site. The site itself, being a parking lot, contains very little shade.


The Site (Figure 20c)


The Site (Figure 20d)

Wind

The wind in Fargo is definitely something to take into consideration. During the humid summers, welcomed cooling breezes come from the south/ southeast. During the harsh winters, extremely strong and cold winds come from the northwest. The site is partially blocked from the northwest winter winds due to the surrounding buildings, but the Red River allows for a wind tunnel giving way for the summer winds from the south/southeast.

Human Characteristics

This site contains a lot of human interaction on a daily basis. The parking lot currently located on the site is constantly in use for both public and official parking needs. The ground is completely level due to the existence of the parking lot, even though it is so close to a major river. The site's appearance seems run down due to the old parking facilities located on the site as well as being bare but after all, it is a parking lot.

Distress

The only noticeable distresses are some buildings located to the south and the underpass of the bridge to the southeast. The buildings to the south are still in use, but their appearance could use some updating. The bridge underpass seems to attract unsafe and illegal behavior due to the difficulty of monitoring its off street location.

Soils

The main type of soil located on the site consists of Typic Epiaquerts or Typical Pendon soil also referred to as plastic silt or organic clay. The slope of these soils is less than 1/10 percent. Soils like this have also often been referred to as appearing to have a clay like substance.

From 0-8 inches the soil contains black or very dark gray silty clay, with dry moderate fine blocky structure. From 8-13 inches crushed and rubbed silty clay structure soil is found. Between 13-21 inches black and dark grayish brown crushed and rubbed soil is located. 21-32 inches down is olive grey, and black redoximorphic concentrations occur. From 32-48 inches grayish brown silty clay very fine blocky structure is found. 48-68 inches below the surface very fine blocky structure as well as very hard and firm plastic like soil is found. 68-80 inches deep very hard and fine sub angular blocky structure soil is located. ("Official Series Description - FARGO Series")

Utilities

Available utilities on this site are electrical and water. The city of Fargo provides and bills for the water and water pressure and Excel Energy is the main energy provider for this region.

Vehicular and Pedestrian Traffic

There is vehicular traffic that occupies and surrounds the site. 2nd St. N. and 1st Ave. N. are considerably busier than 3rd St. N. and 3rd Ave. N. The pedestrian traffic is light in the area and most often occurs on the west side as people use 3rd St. N. to get to the library and civic center.

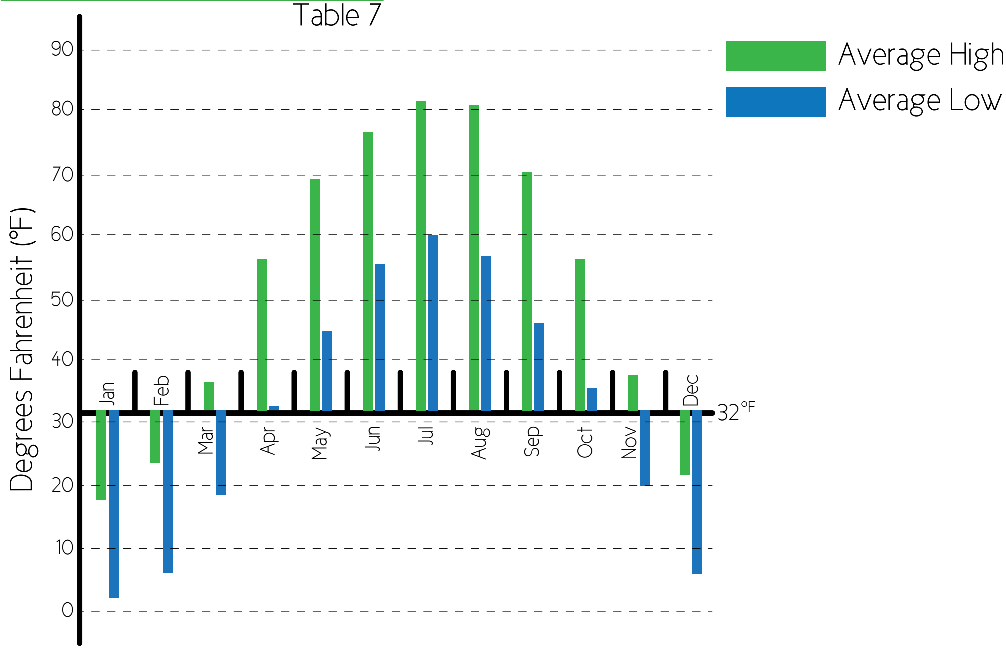
The Site (Figure 20e)

The Site (Figure 20f)

SITE ANALYSIS
(QUANTITATIVE)

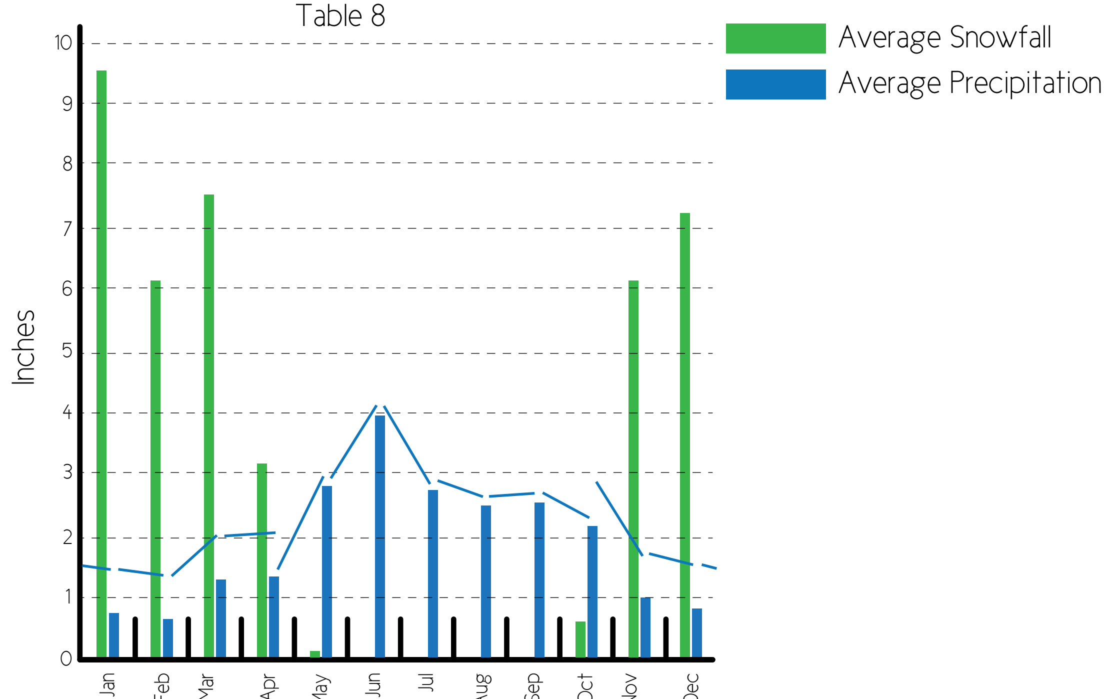
AVERAGE TEMPERATURE

Table 7



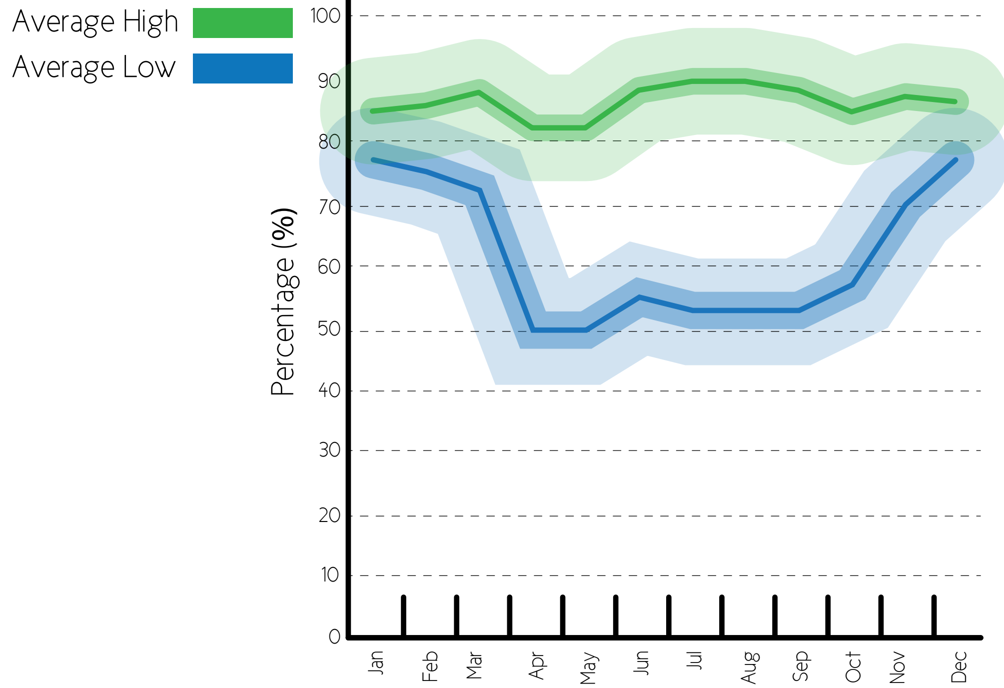
AVERAGE PRECIPITATION

Table 8



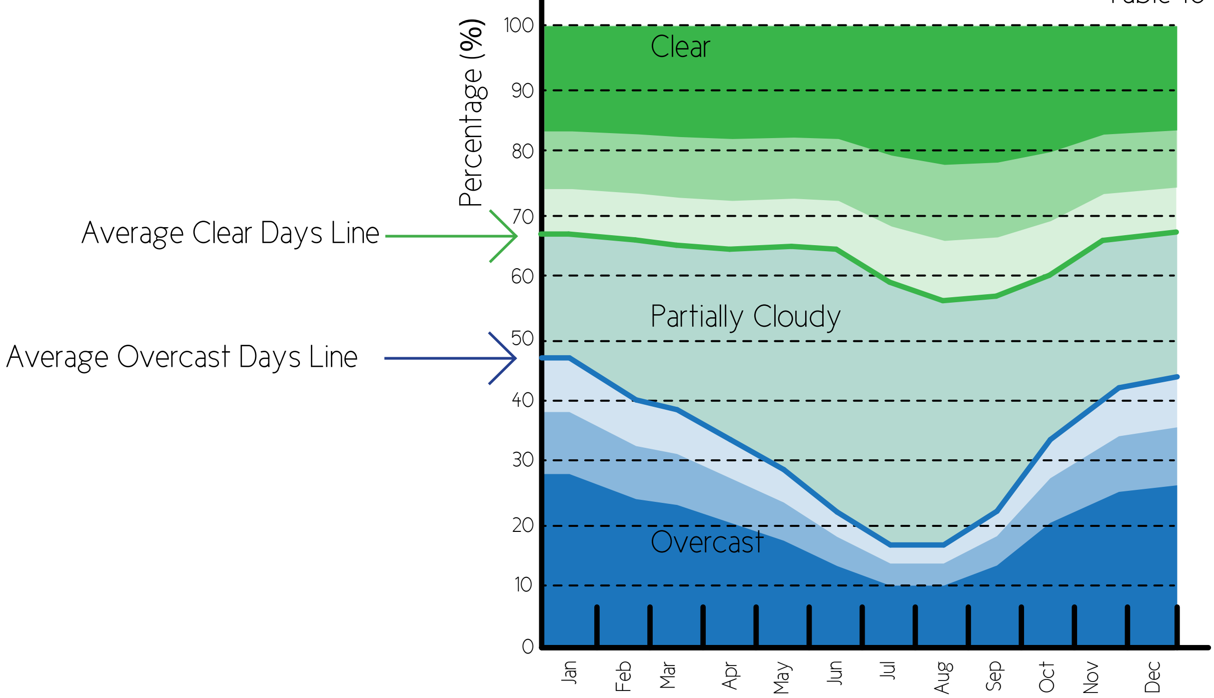
AVERAGE HUMIDITY

Table 9



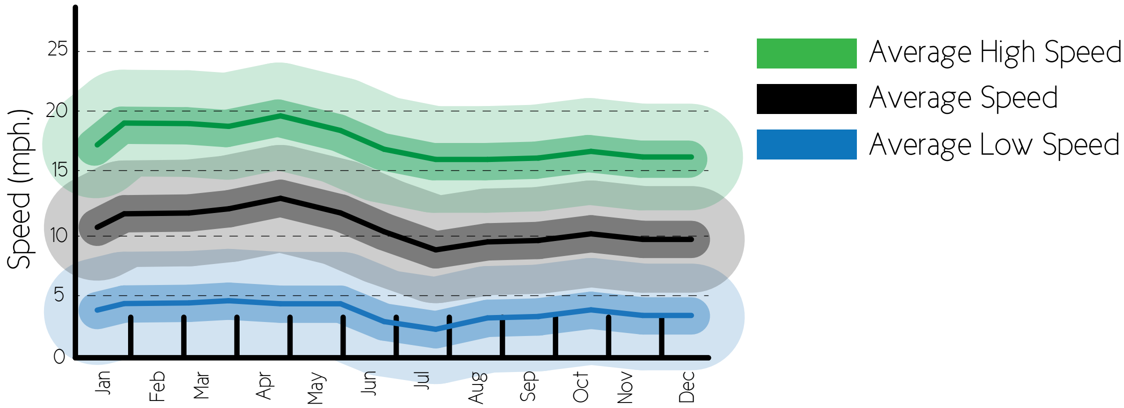
AVERAGE CLOUDINESS

Table 10



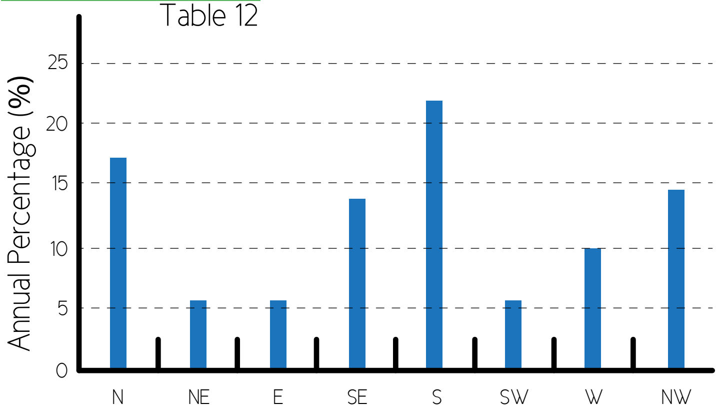
WIND SPEED

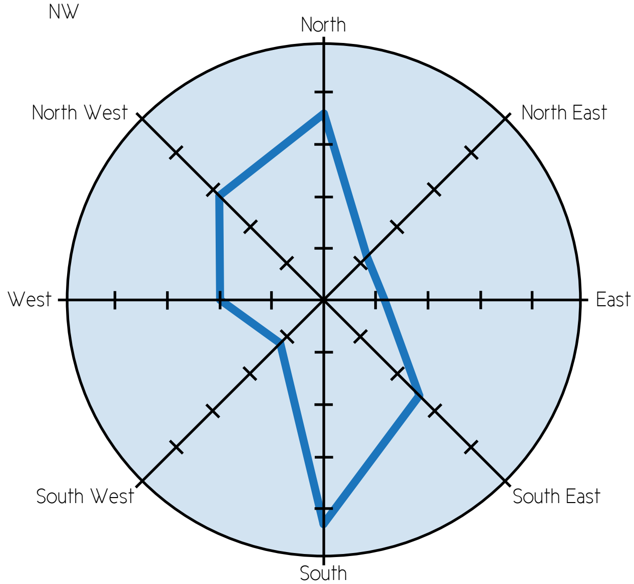
Table 11



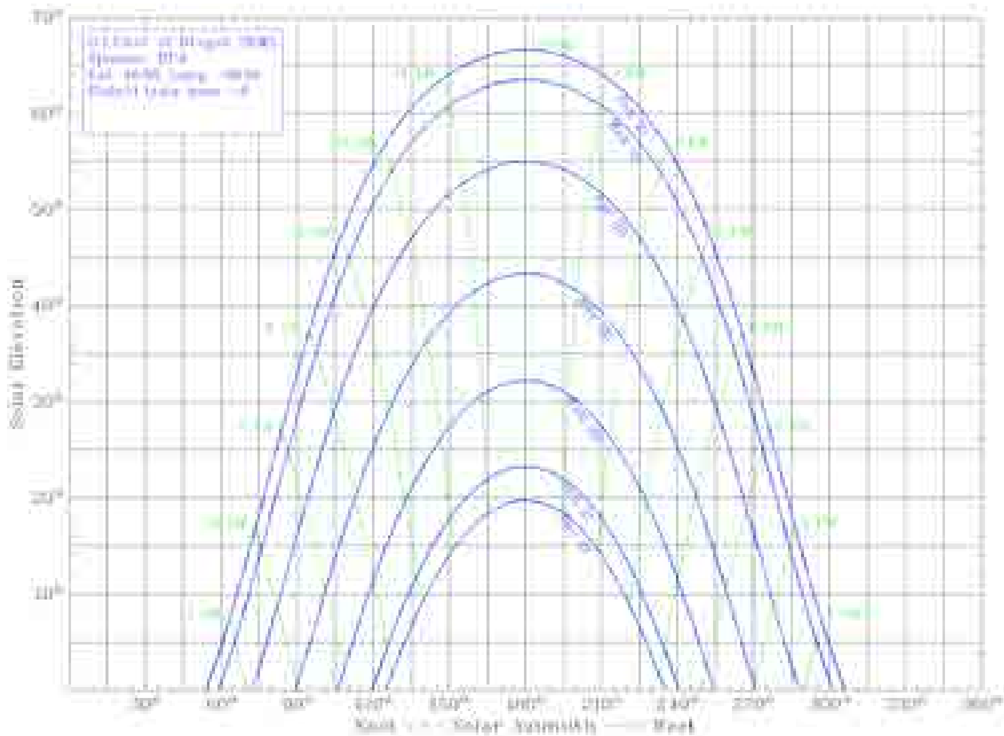
WIND DIRECTION

Table 12



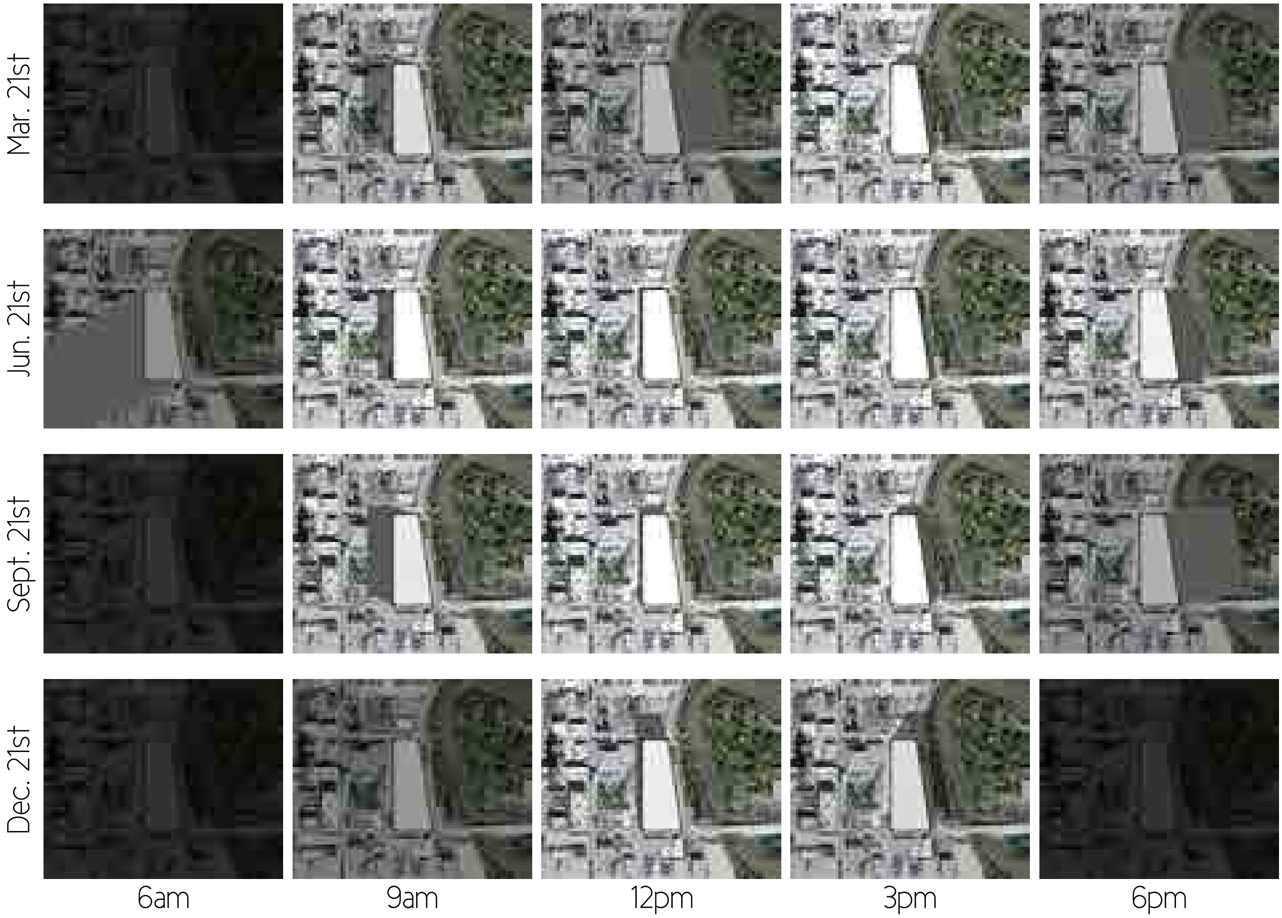


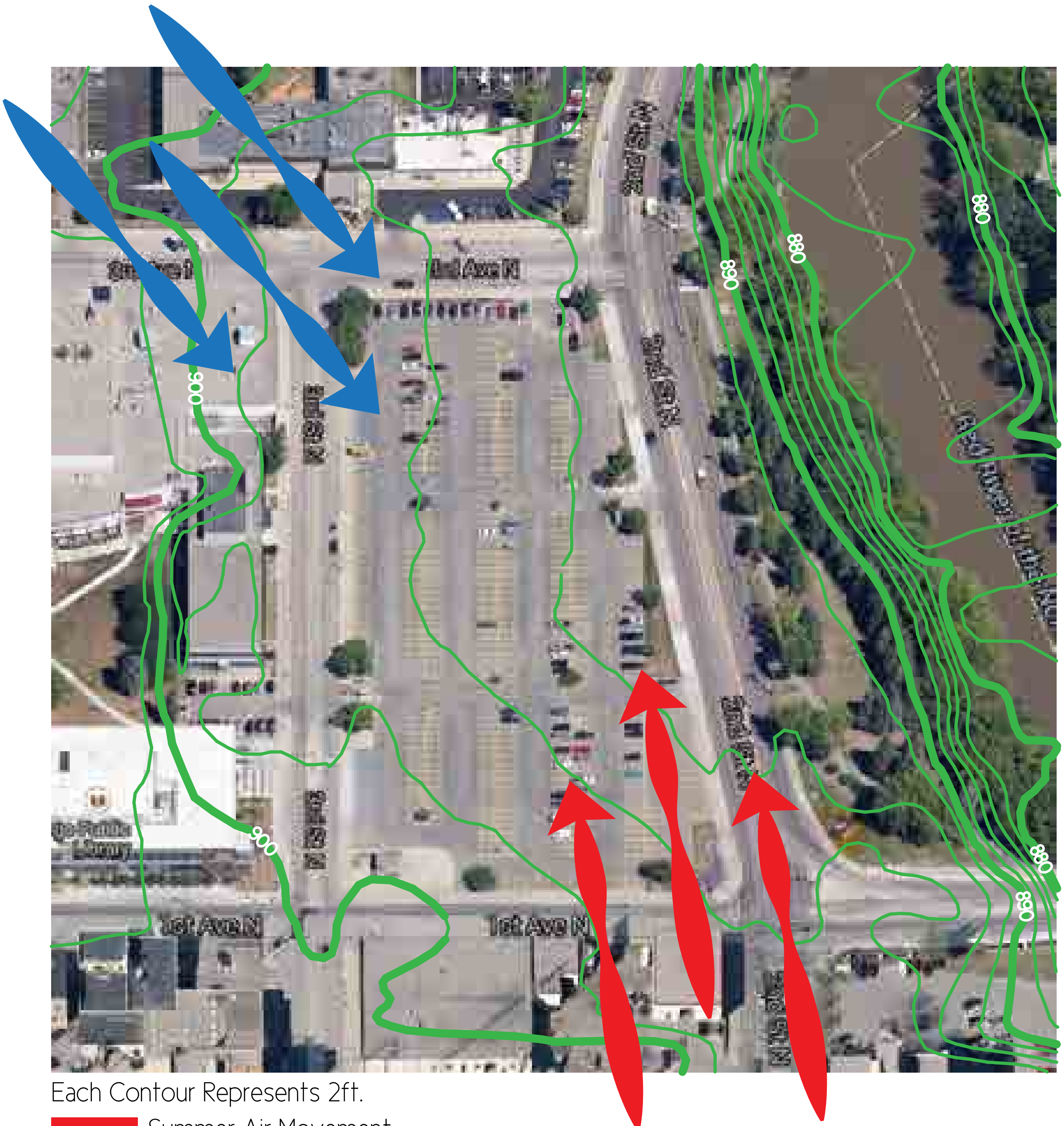
SOLAR PATH
Table 13



SHADING

Table 14



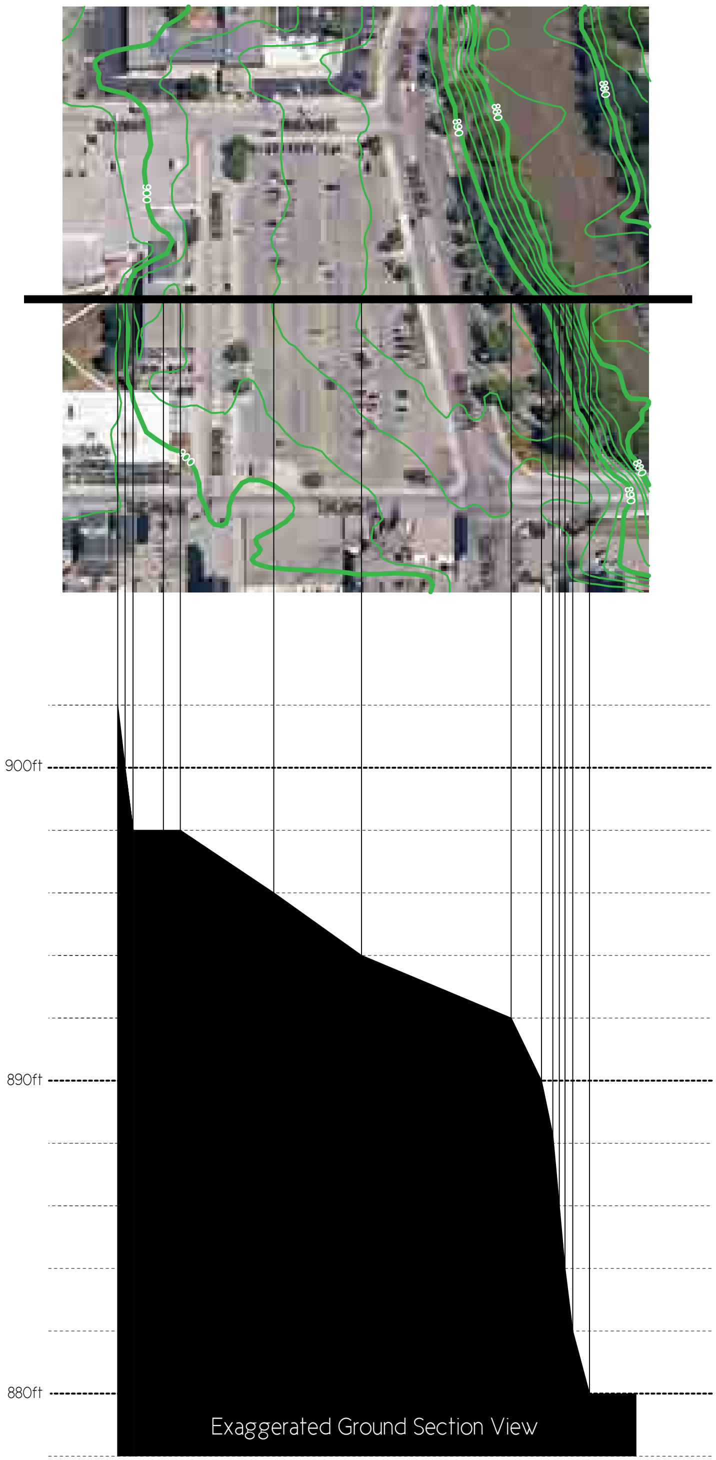


Each Contour Represents 2ft.

Summer Air Movement

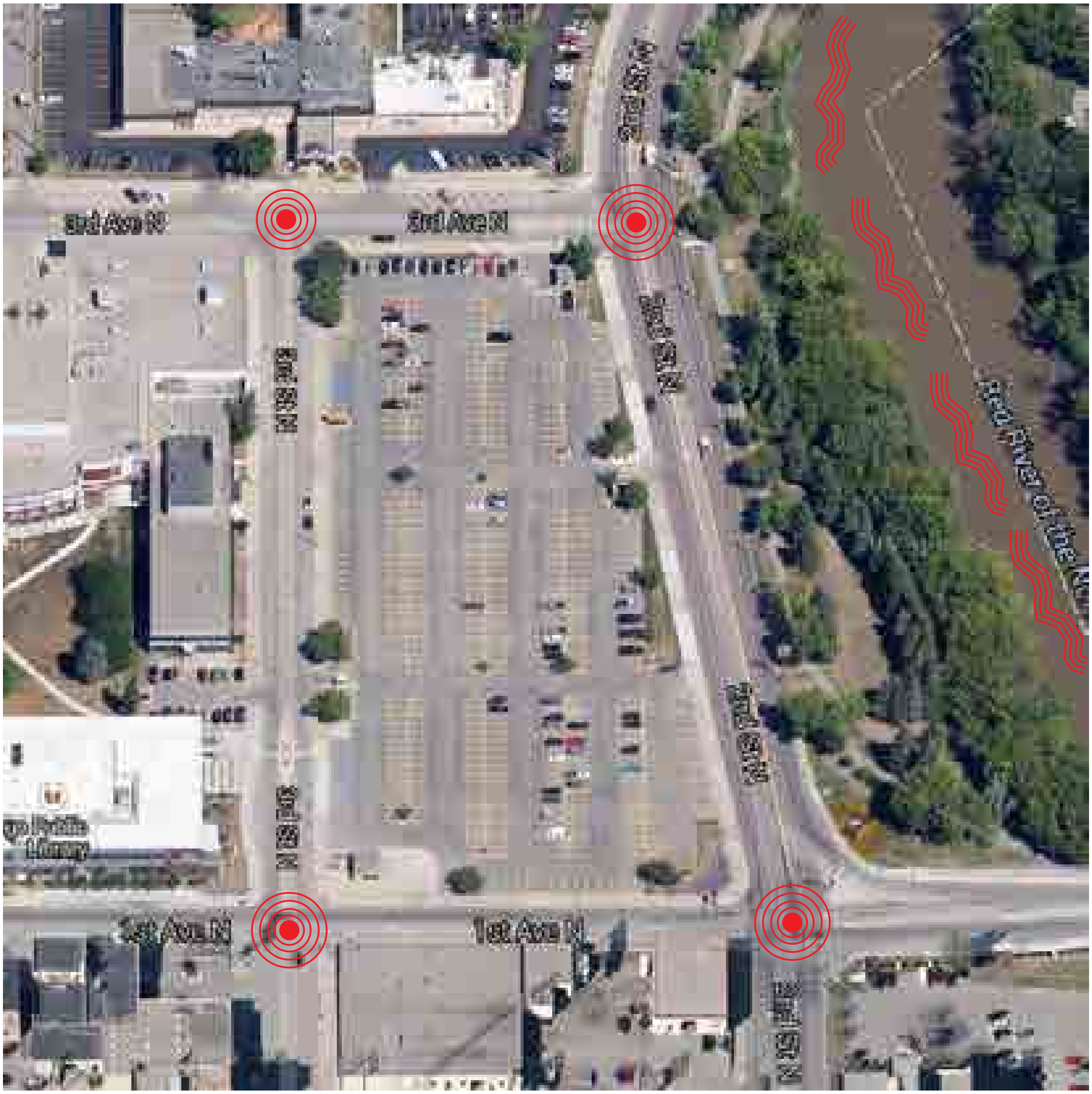
Winter Air Movement

SLOPE
Table 16

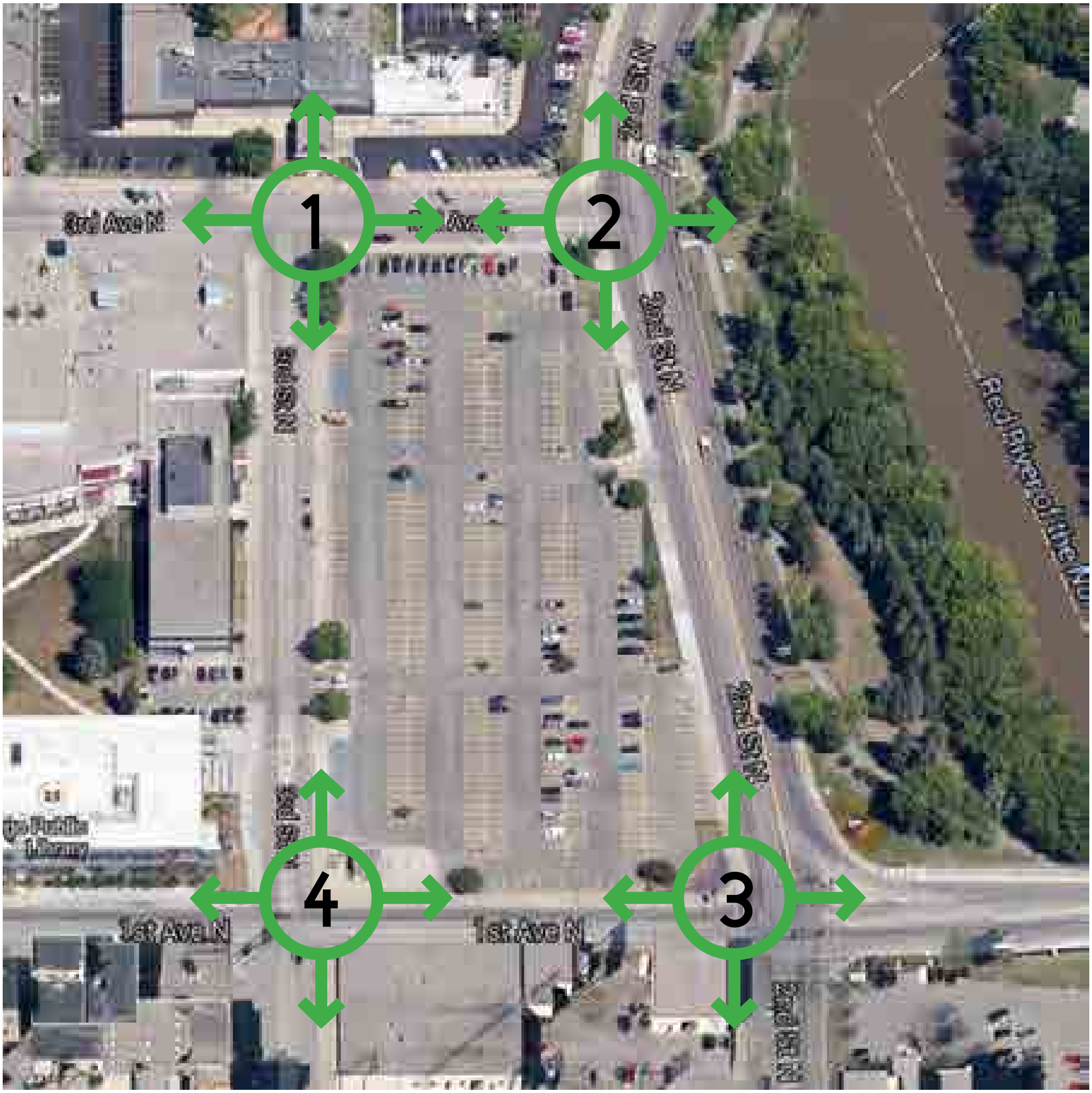


HUMAN AND NATURAL NOISE

Table 17



SITE RECONNAISSANCE
Table 18

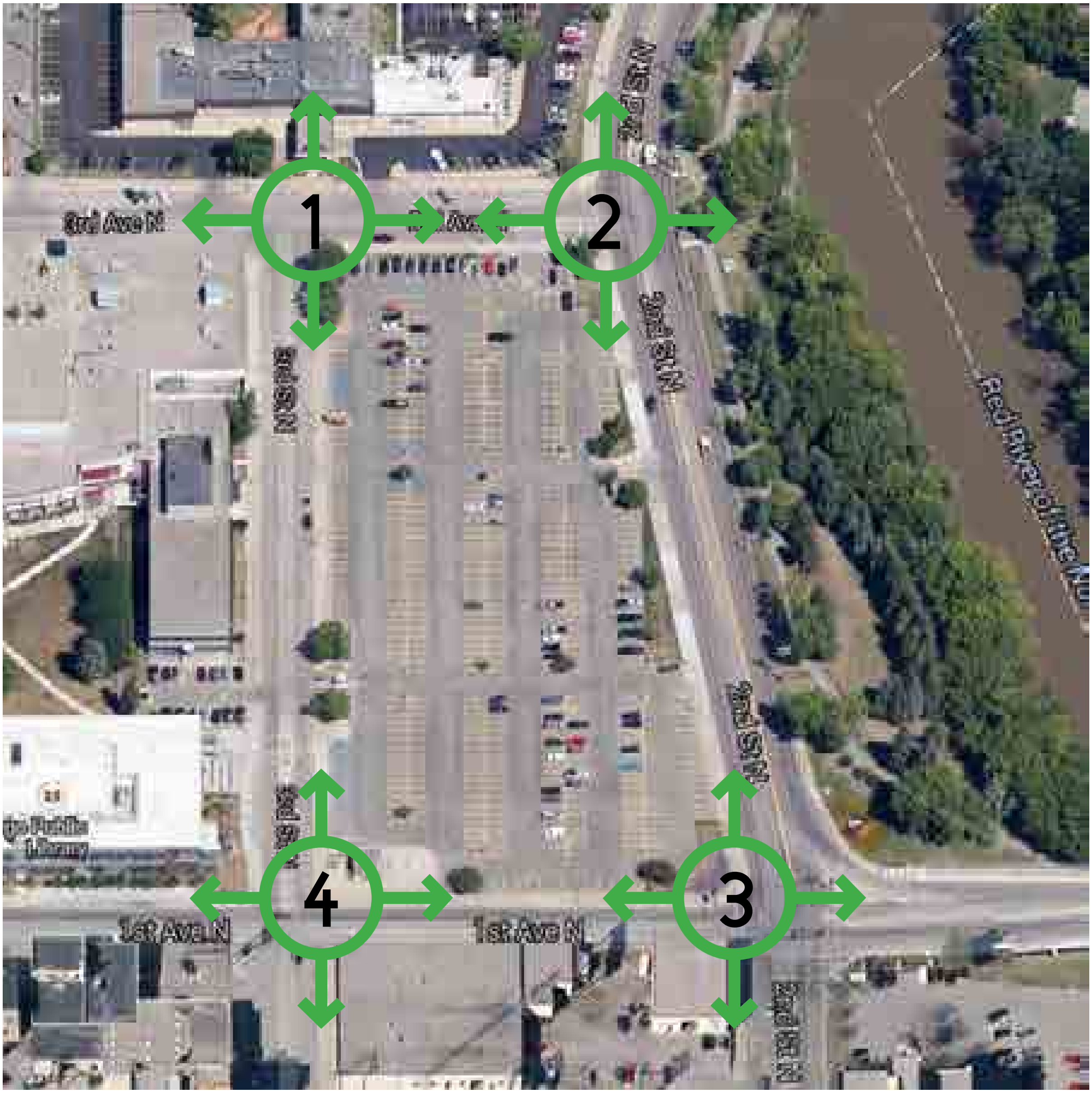


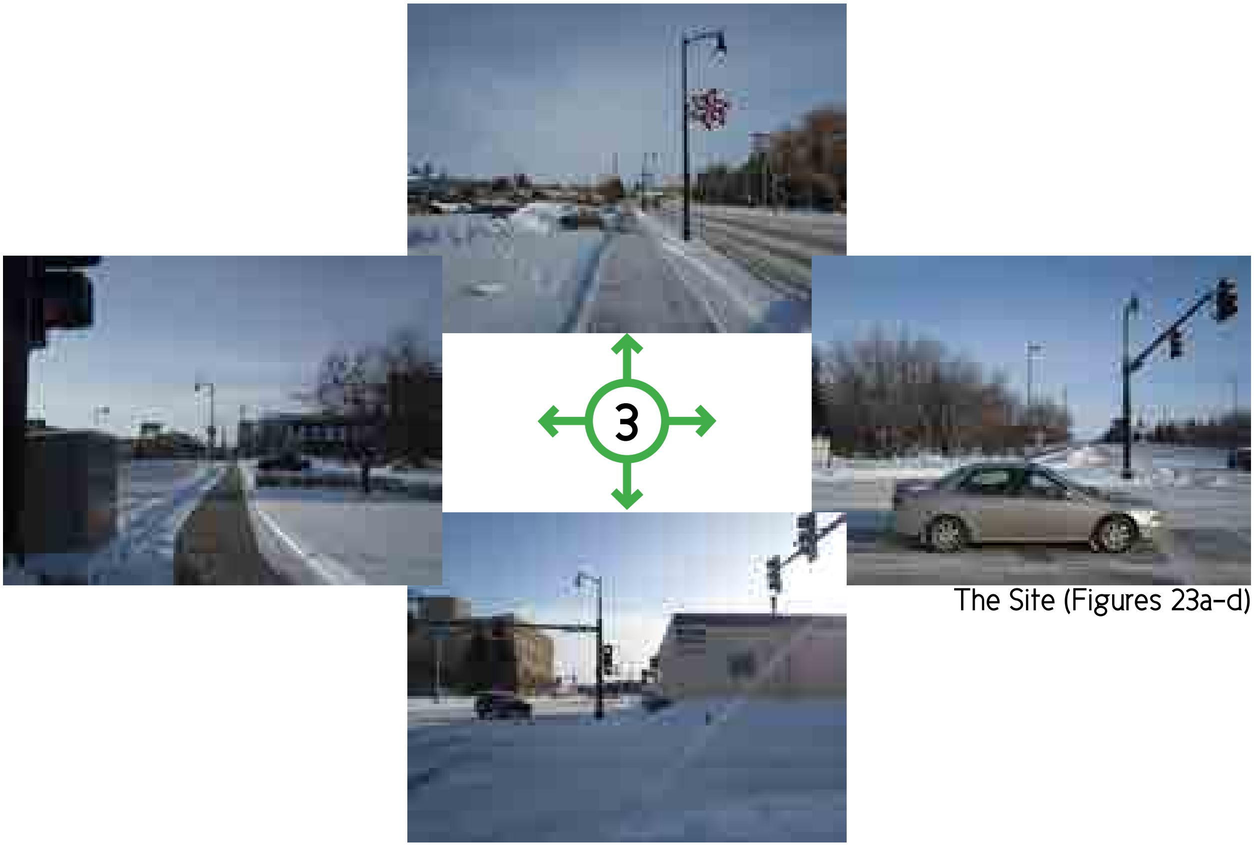
SITE RECONNAISSANCE

The Site (Figures 21a-d)

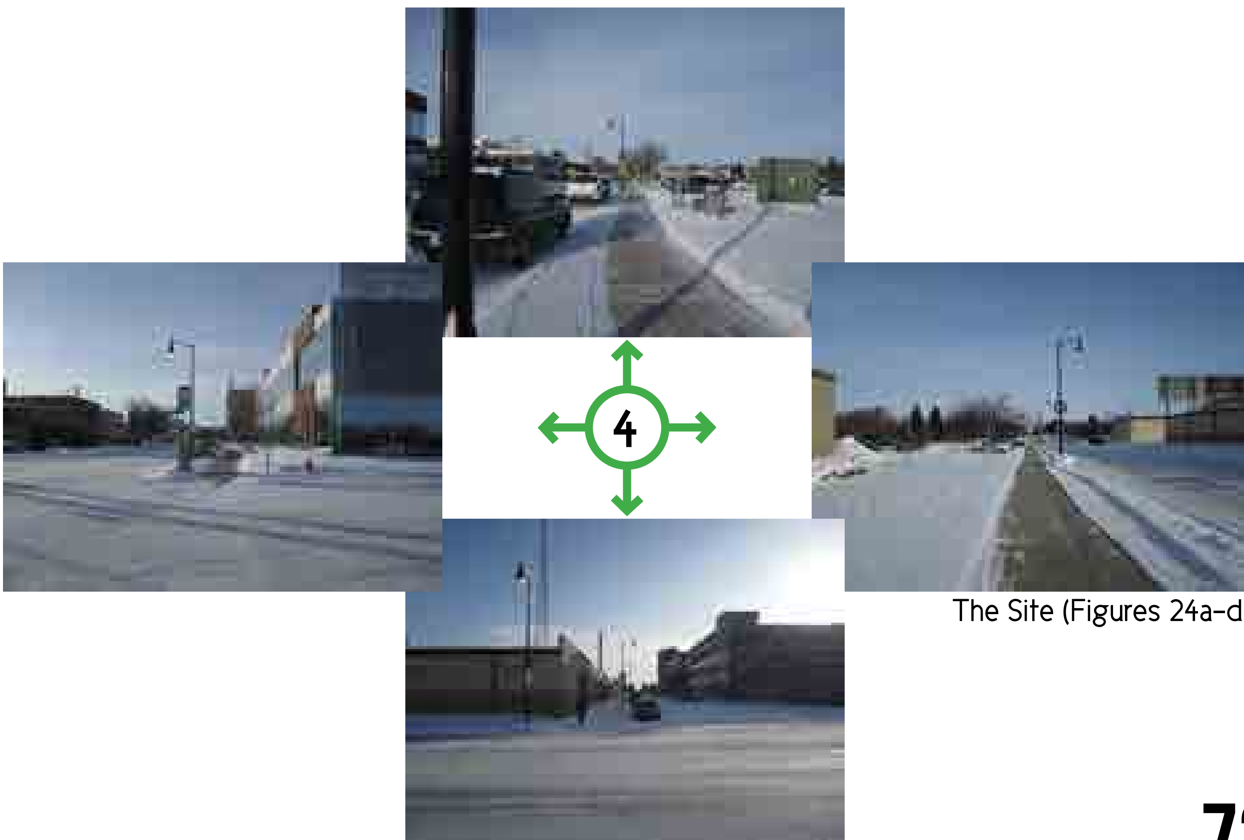
The Site (Figures 22a-d)

SITE RECONNAISSANCE





The Site (Figures 23a-d)



The Site (Figures 24a-d)

PROGRAMMATIC REQUIREMENTS

SPACE ALLOCATION

STUDIO APARTMENTS
250 sq. ft. each

ONE BEDROOM APARTMENTS
300 sq. ft. each

TWO BEDROOM APARTMENTS
400 sq. ft. each

THREE BEDROOM APARTMENTS
900 sq. ft. each

LAUNDRY FACILITIES
150 sq. ft. each

COMMUNITY SPACES
3,000 sq. ft. total

AGRICULTURAL FACILITIES
3,000 sq. ft. total

INDIVIDUAL AGRICULTURAL SPACES
50 sq. ft. each

FITNESS CENTER
3,000 sq. ft. total

PUBLIC RESTROOMS
150 sq. ft. total

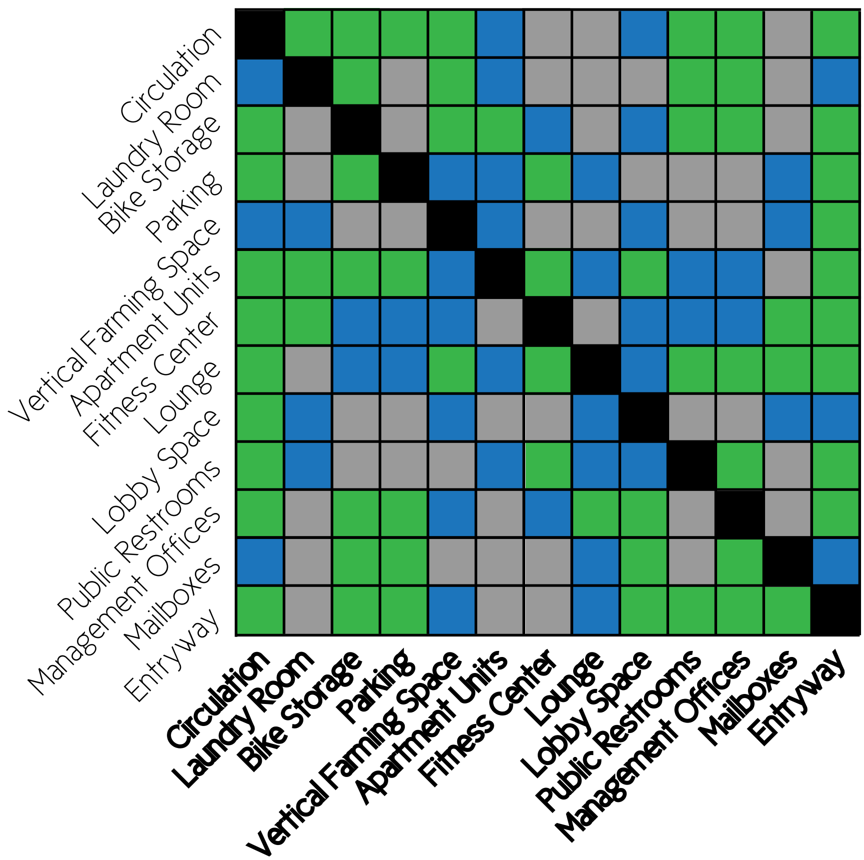
BICYCLE STORAGE
1,200 sq. ft. total

PARKING
100,000 sq. ft. total

MANAGEMENT FACILITIES
450 sq. ft. total

INTERACTION MATRIX

Table 19



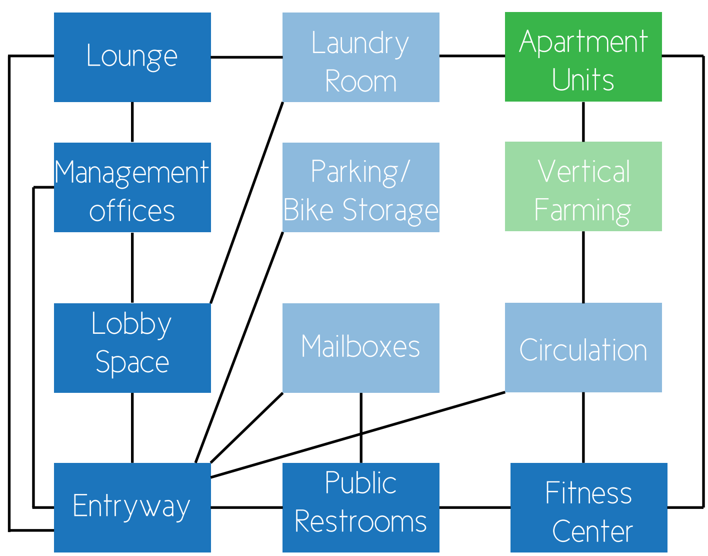
Necessary

Desired

Unnecessary

INTERACTION NET

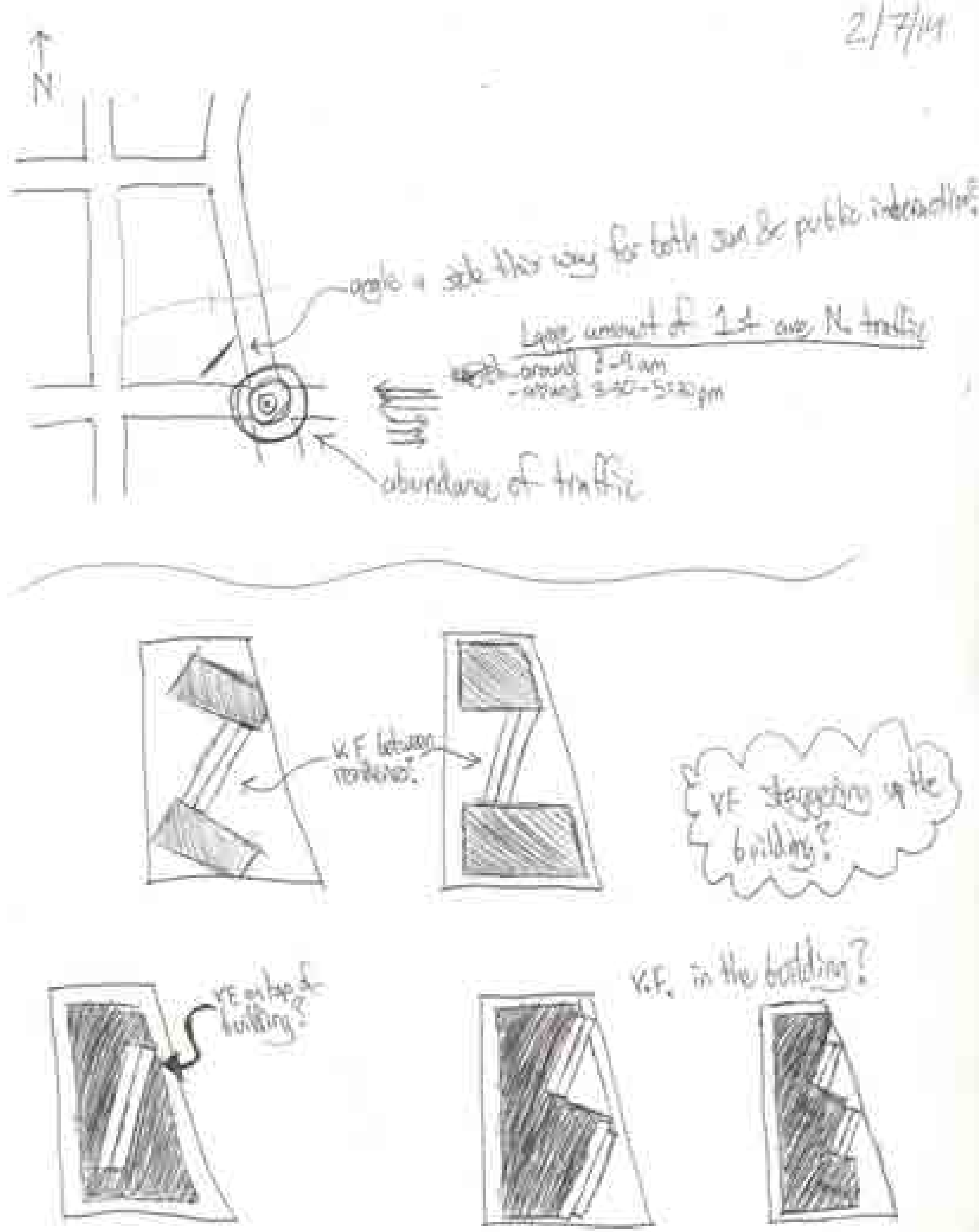
Table 20



Private

Public


2/3/14
site
Red River
bike path
continuation
potential
entrance
locations


2/7/14
N
angle + side this way for both sun & public interaction?
Large amount of 1st ave N traffic
-around 8-9 am
-around 3:30-5:30 pm
abundance of traffic
V.F between
V.F staggering up the building?
V.F on top of building?
V.F. in the building?

2/7/14

Mike

- Site Model
- emails
- floating "Parameters"

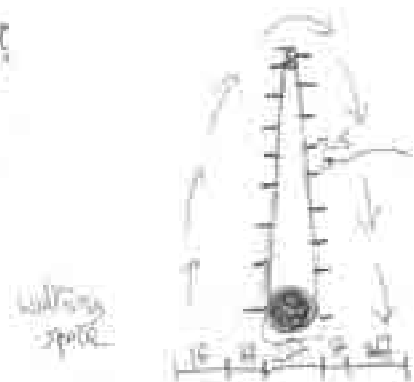
Spatial requirements for growing lettuce

1 person needs [illegible] of lettuce per year?

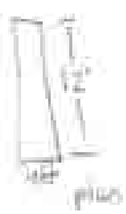
- grown in 2 inch pvc pipe about 10 ft long
- 6 inch centers (apart) holes ~~are~~ drilled
- 1 tube/pipe planter ~~=~~ 19 lettuce plants
- 2 tubes per 1' x 10' planter bed
- each bed contains ~~[illegible]~~ lettuce plants 38
- (5-6) weeks harvest cycles (40 days)
- (10-12) plants per person per year?
- 4-5 plants
- 16 plants

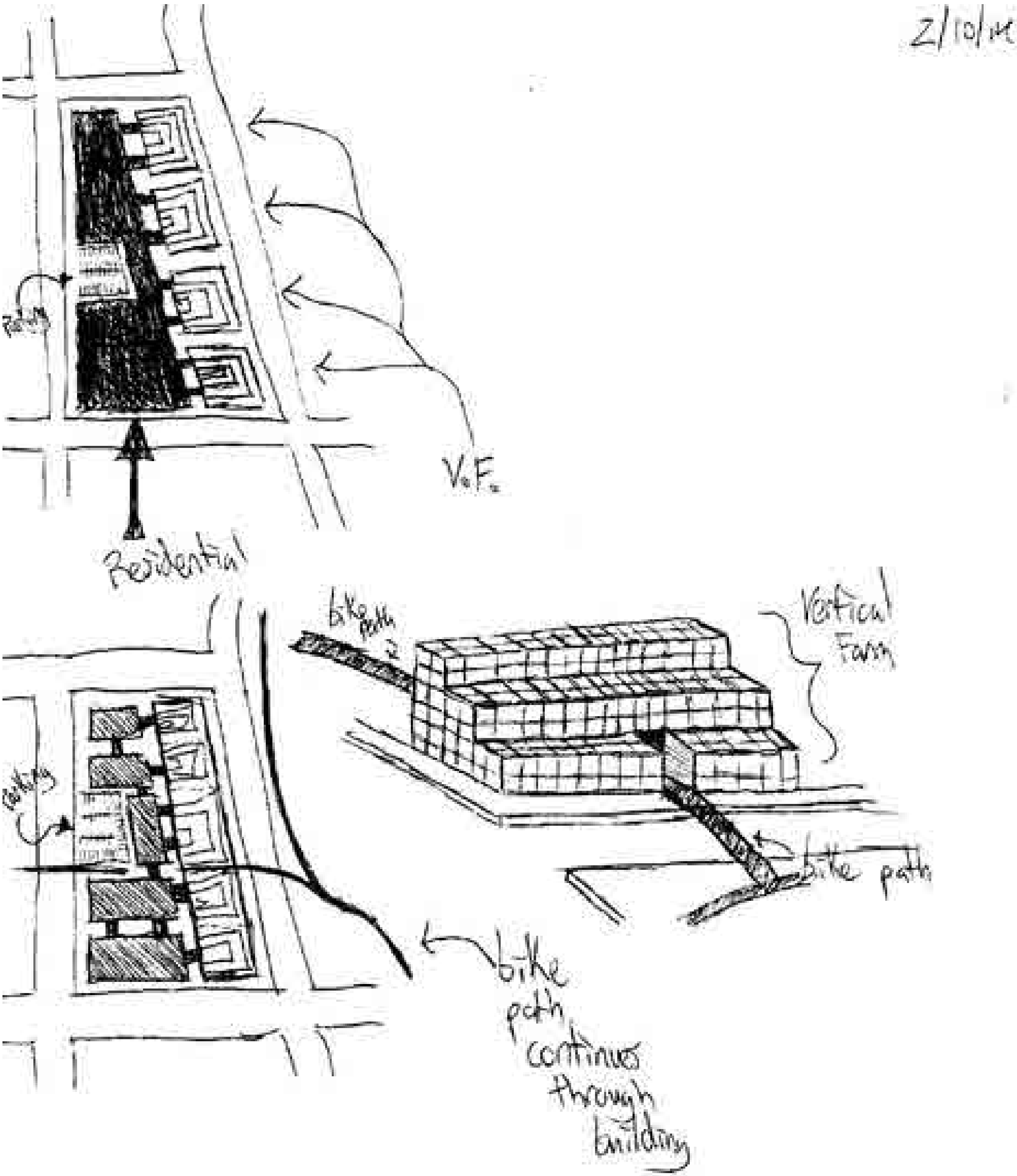
readers Aged

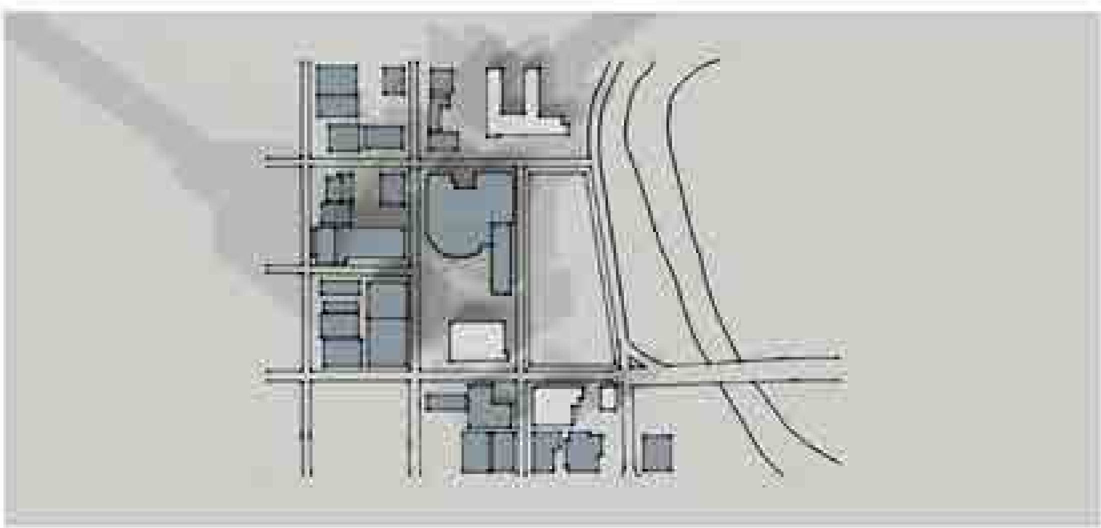
- record keeping?



6-7 beds height (=)
for 12' height floor

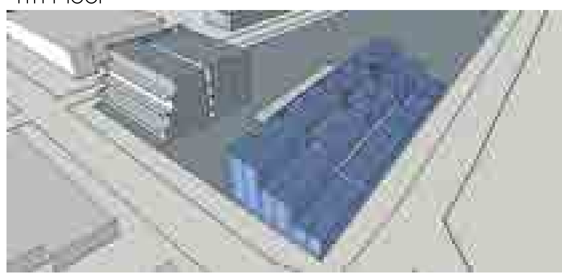



2/10/14
Parking
V.F.
Residential
bike path
Vertical Farm
Parking
bike path
bike path continues through building

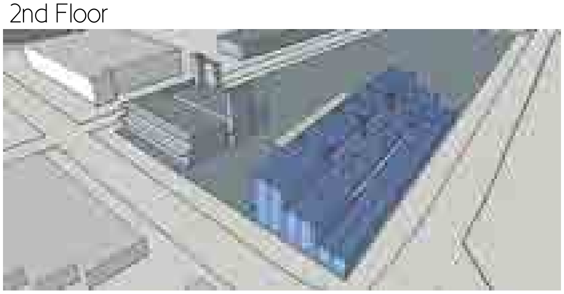


1st Floor

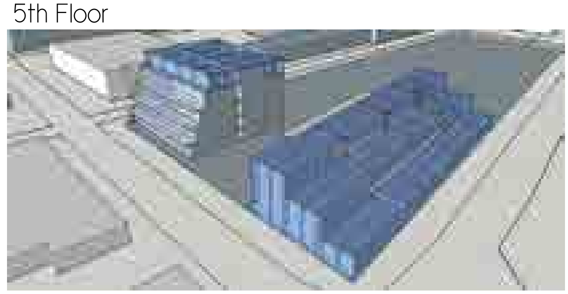
4th Floor



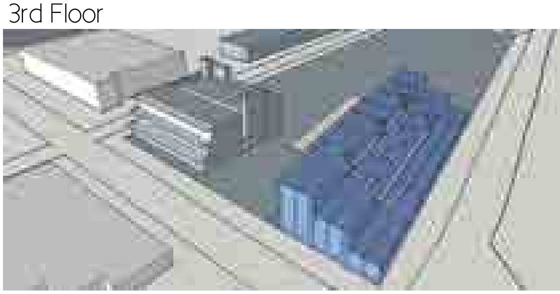
2nd Floor



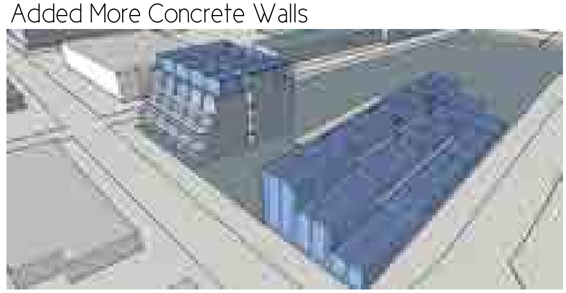
5th Floor

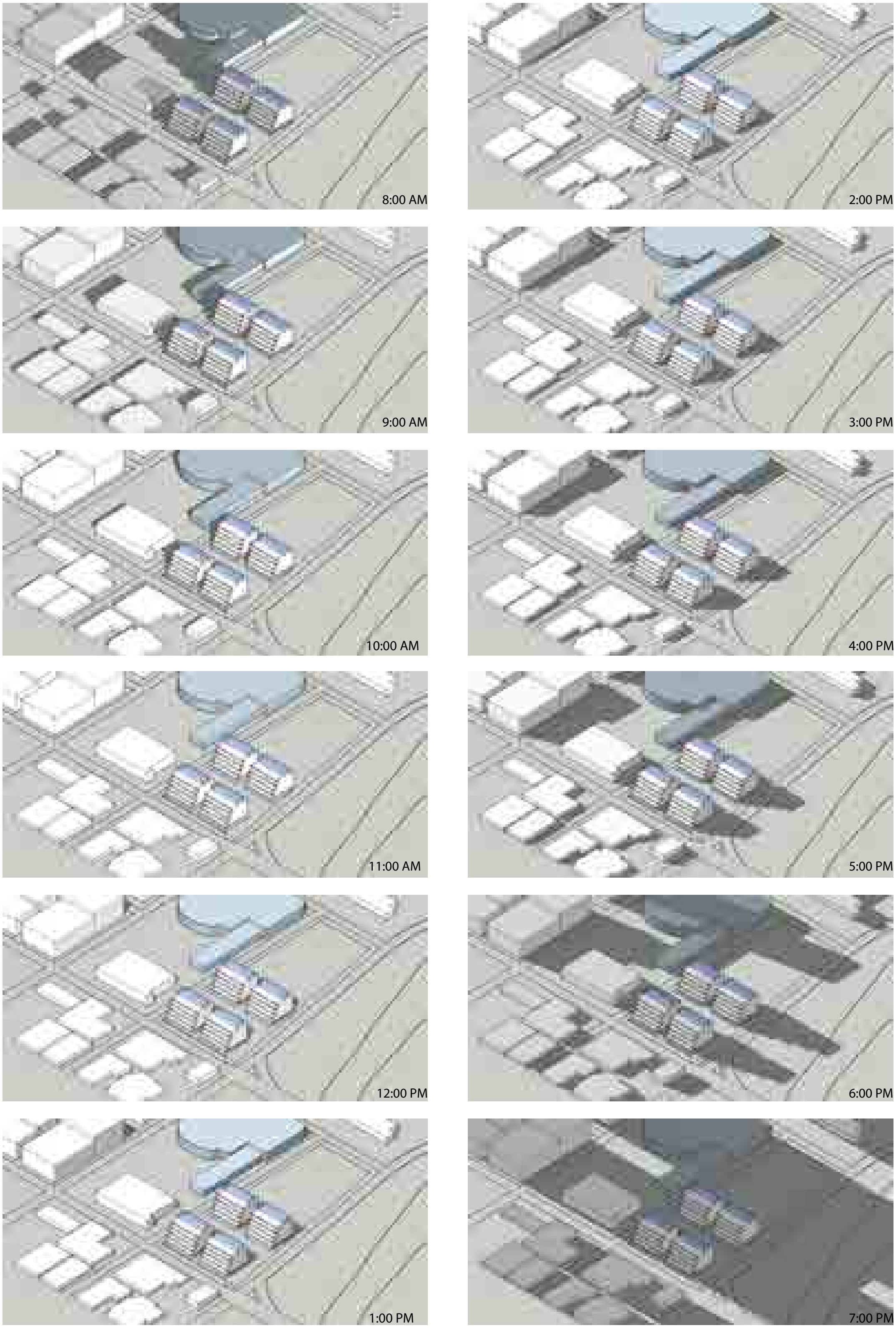


3rd Floor



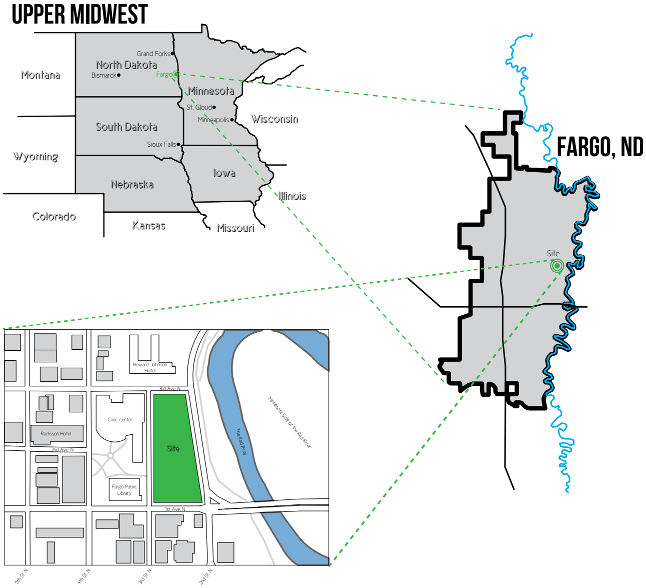
Added More Concrete Walls




8:00 AM
2:00 PM
9:00 AM
3:00 PM
10:00 AM
4:00 PM
11:00 AM
5:00 PM
12:00 PM
6:00 PM
1:00 PM
7:00 PM

DESIGN PROCESS AT MIDTERM

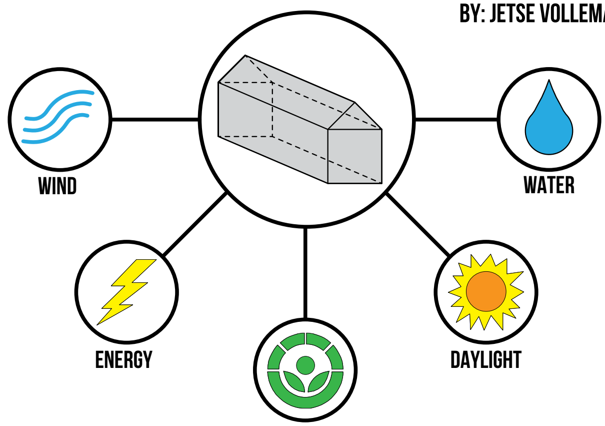
UPPER MIDWEST

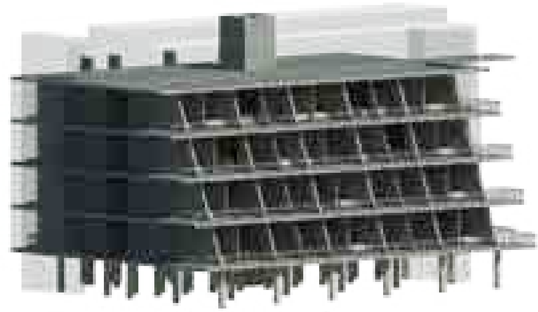


DOWNTOWN FARGO, ND

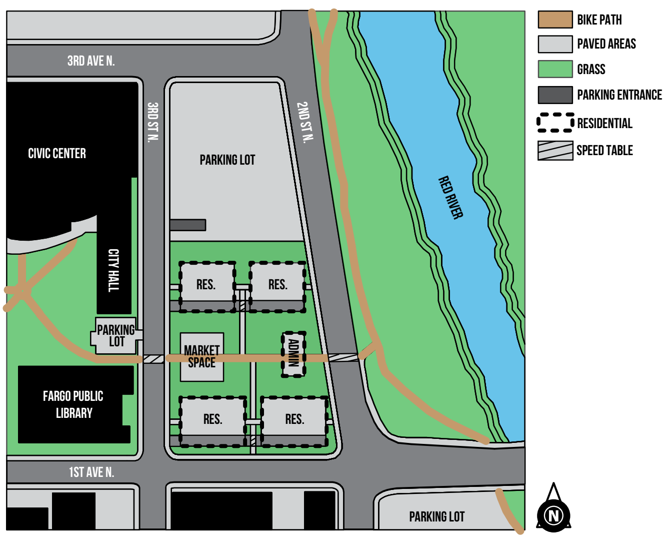
SUSTAINABLE & AGRICULTURAL RESIDENTIAL COMMUNITY

BY: JETSE VOLLEMA

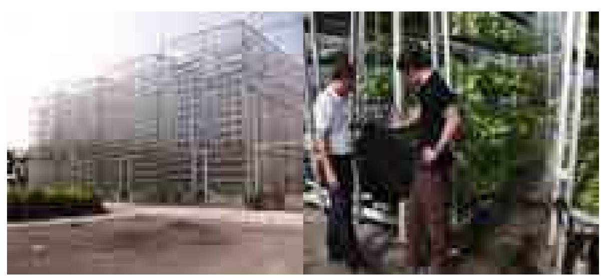




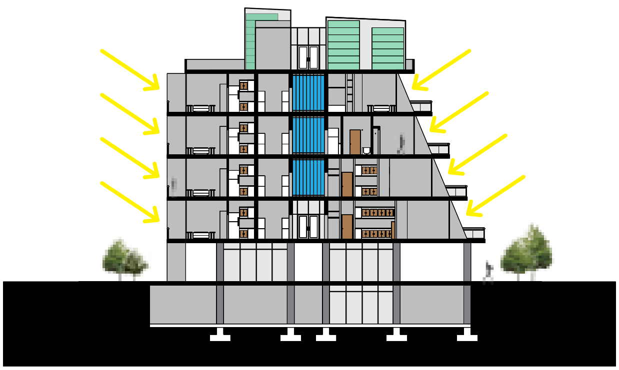
RESIDENTIAL TOWER PERSPECTIVE



SITE PLAN



VERTICAL FARMING

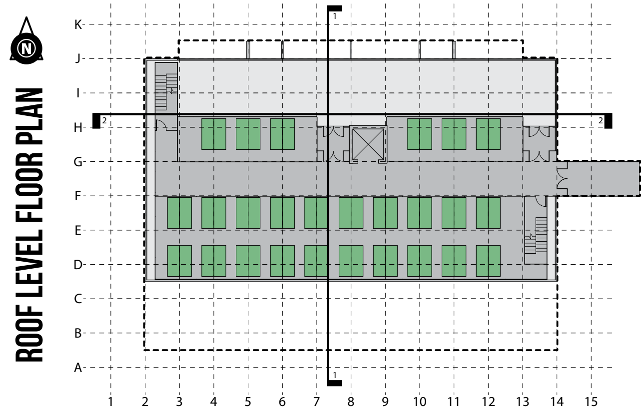


SECTION 1

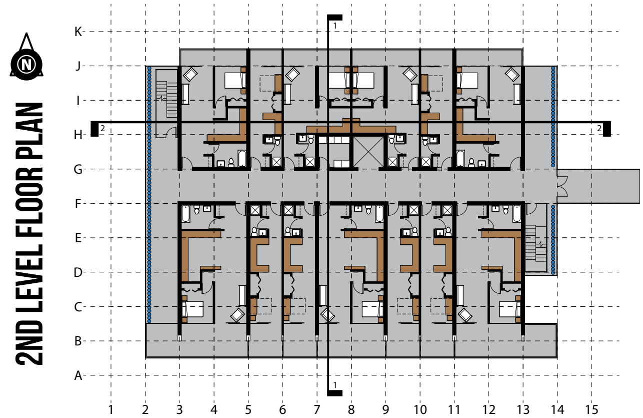
SCALE 1/8" = 1'

SECTION 2

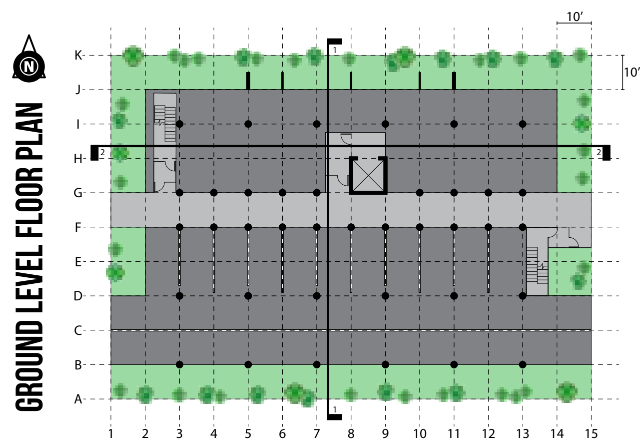
SCALE 1/8" = 1'



ROOF LEVEL FLOOR PLAN



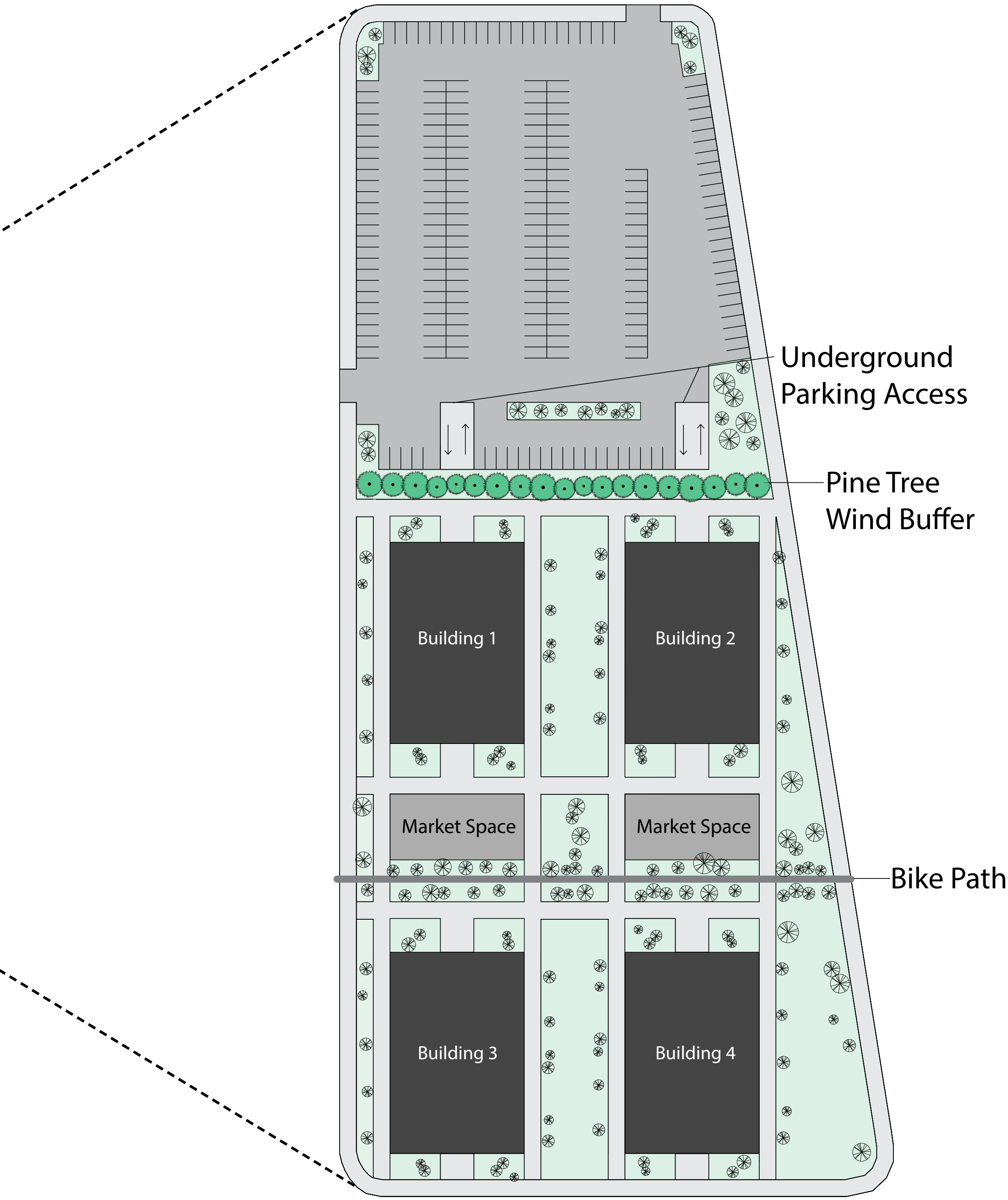
2ND LEVEL FLOOR PLAN



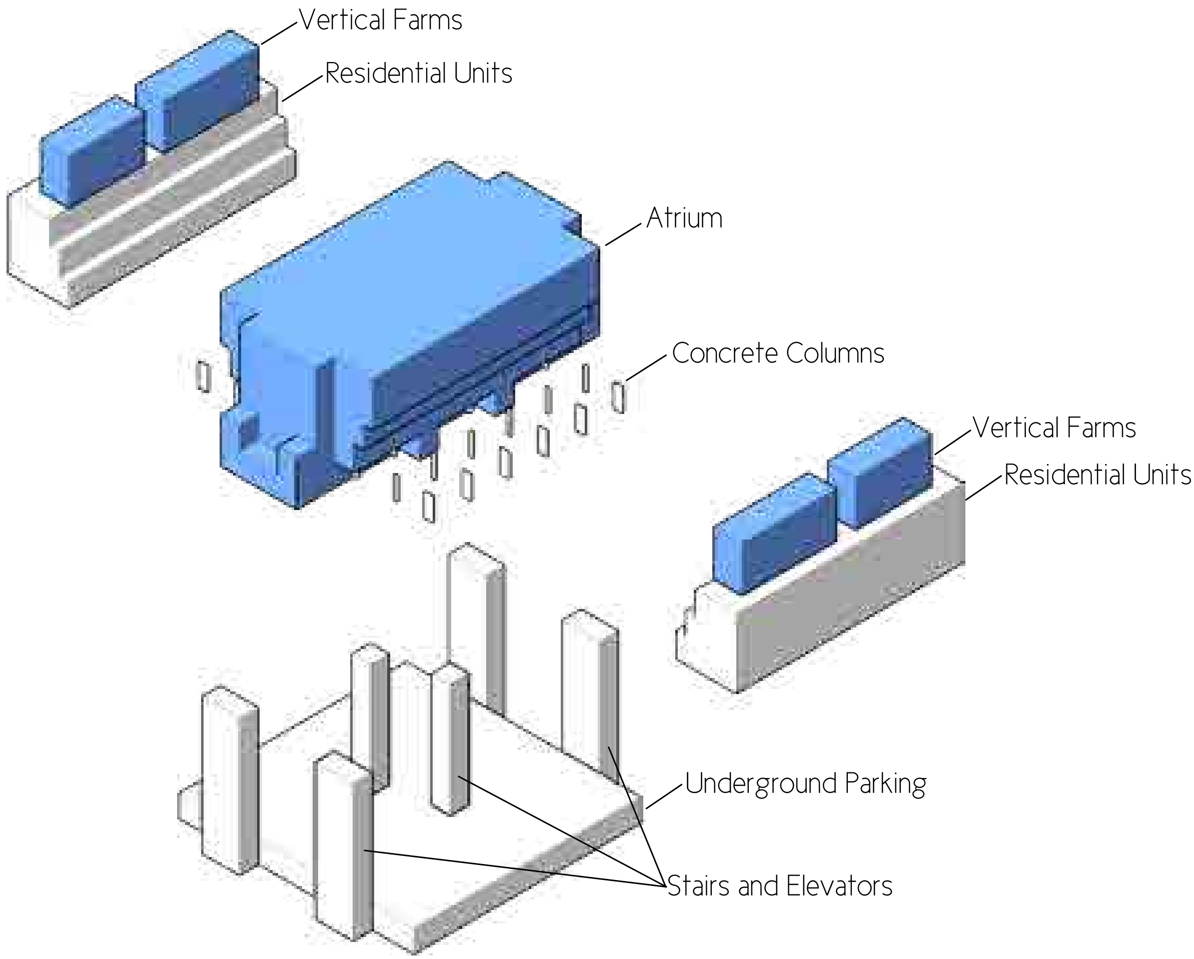
GROUND LEVEL FLOOR PLAN


FARGO, ND
Howard Johnson Hotel
3rd Ave. N
Civic center
Radisson Hotel
2nd Ave. N
Site
Fargo Public Library
1st Ave. N
The Red River
Minnesota Side of the Red River
5th St. N
4th St. N
3rd St. N
2nd St. N

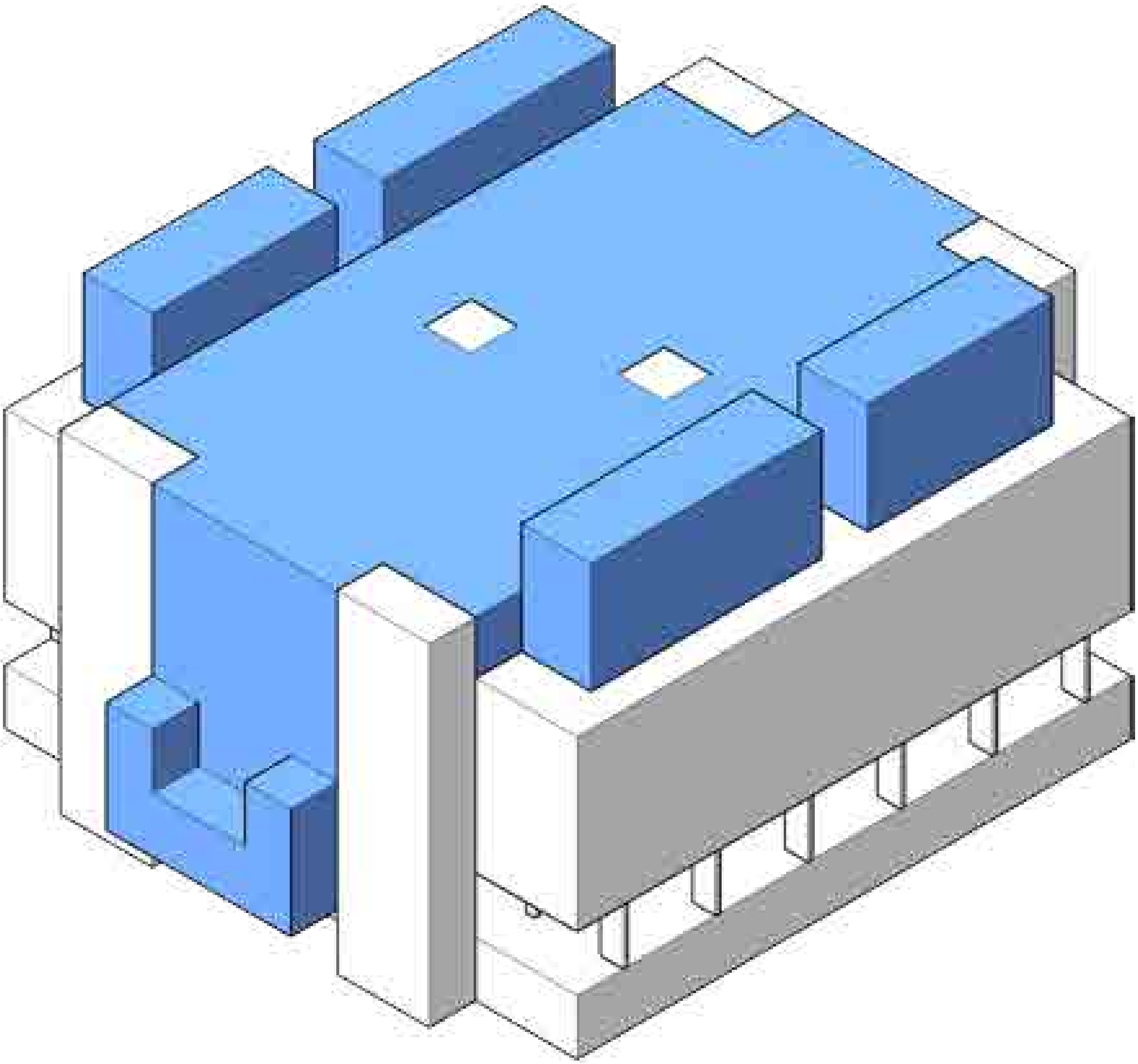
Site Plan


Underground
Parking Access
Pine Tree
Wind Buffer
Building 1
Building 2
Market Space
Market Space
Bike Path
Building 3
Building 4

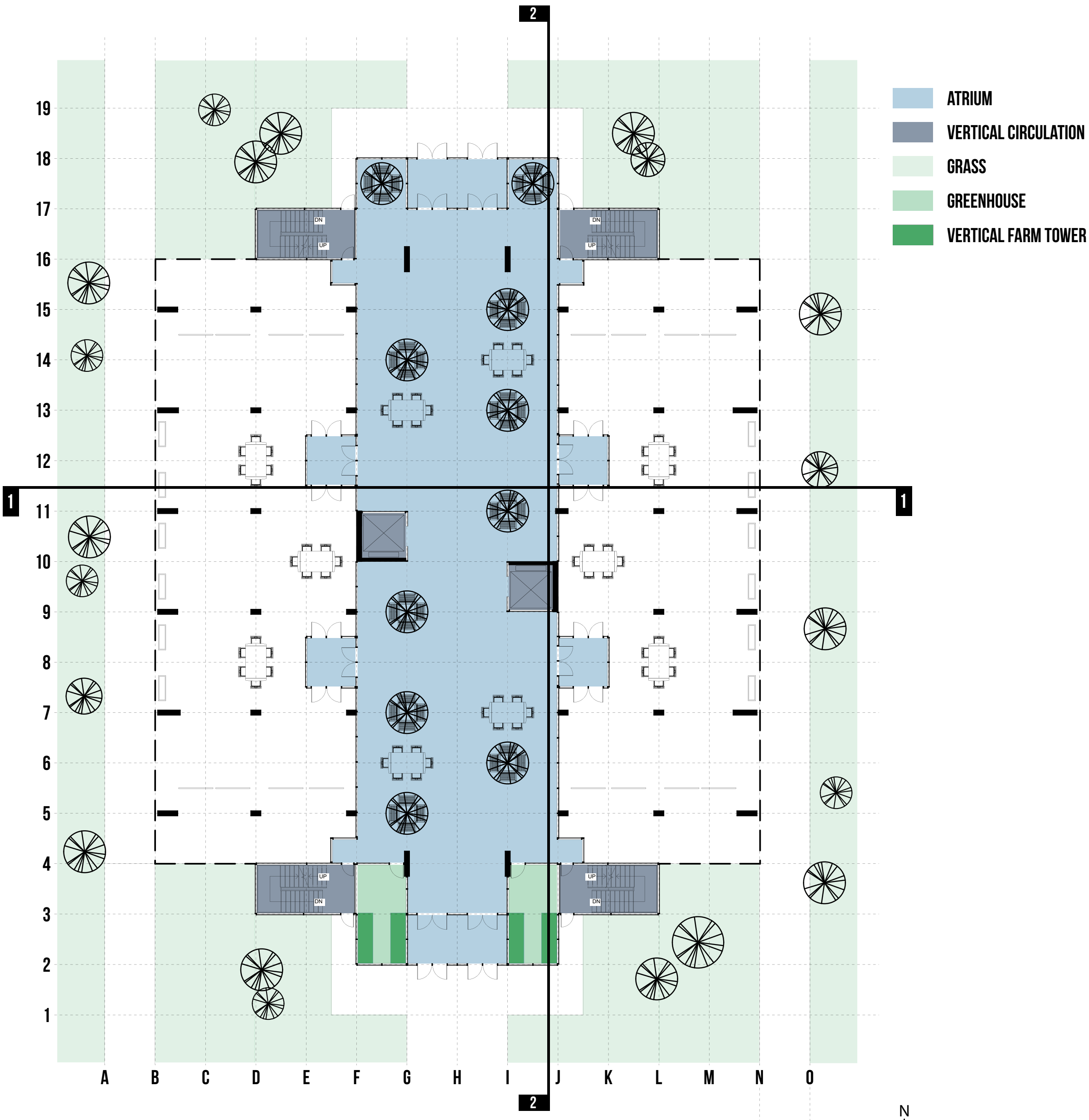
Site Plan



Exploded Axonometric



Axonometric



LEVEL 1 FLOOR PLAN

Level 5
-Concrete Floor Slab
-Vertical Farms
-Garden Space
-Energy Towers
-Perimeter Water Collection

Level 4
-Concrete Load Bearing Walls
-Concrete Floor Slab
-3 Bedroom Apartment Units

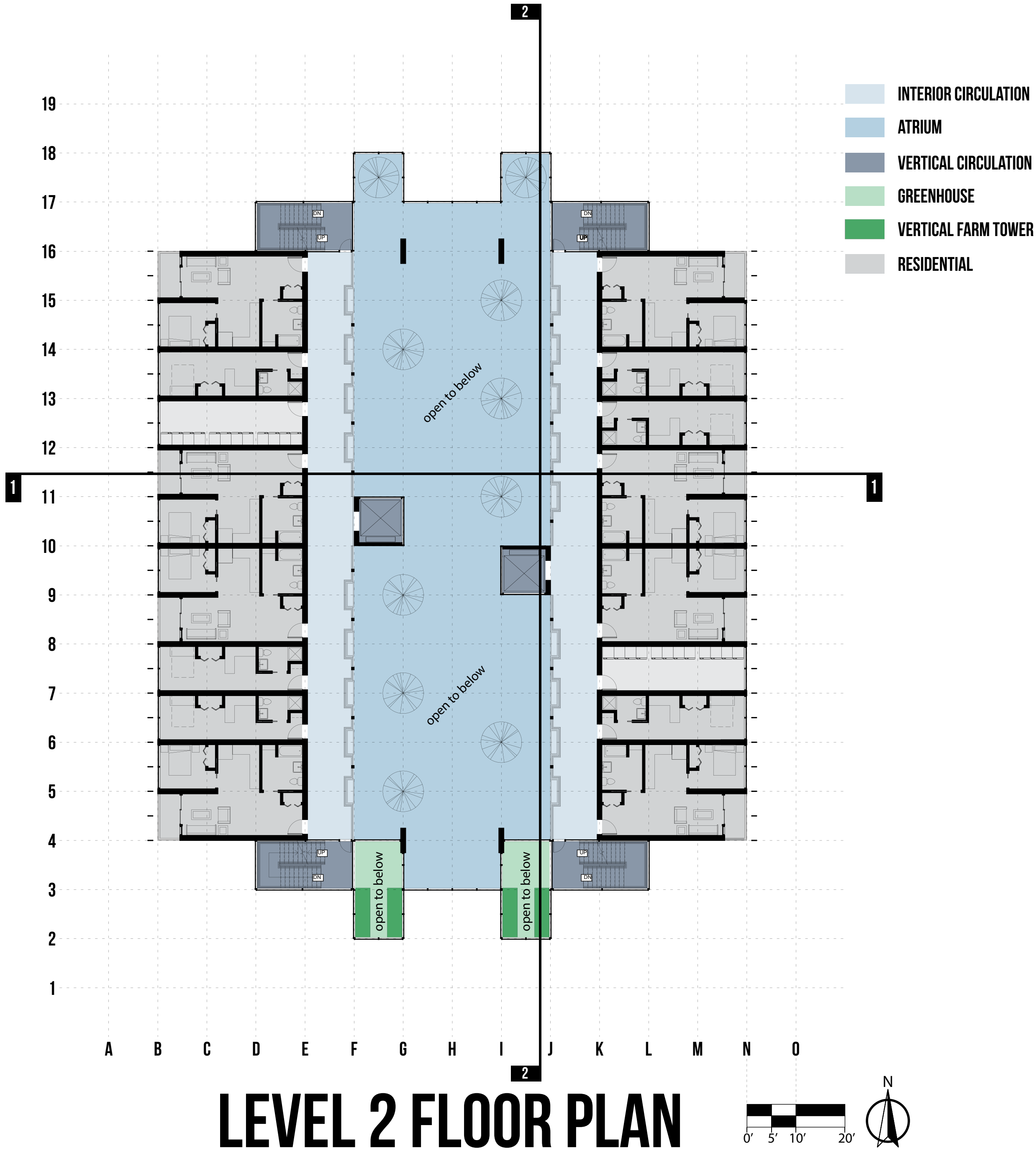
Level 3
-Concrete Load Bearing Walls
-Concrete Floor Slab
-2 Bedroom Apartment Units
-Vertical Farms

Level 2
-Concrete Load Bearing Walls
-Concrete Floor Slab
-Studio Apartment Units
-1 Bedroom Apartment Units

Level 1
-Concrete Floor Slab
-Rectilinear Concrete Columns
-Ground Floor Atrium Entrance
-Vertical Farms

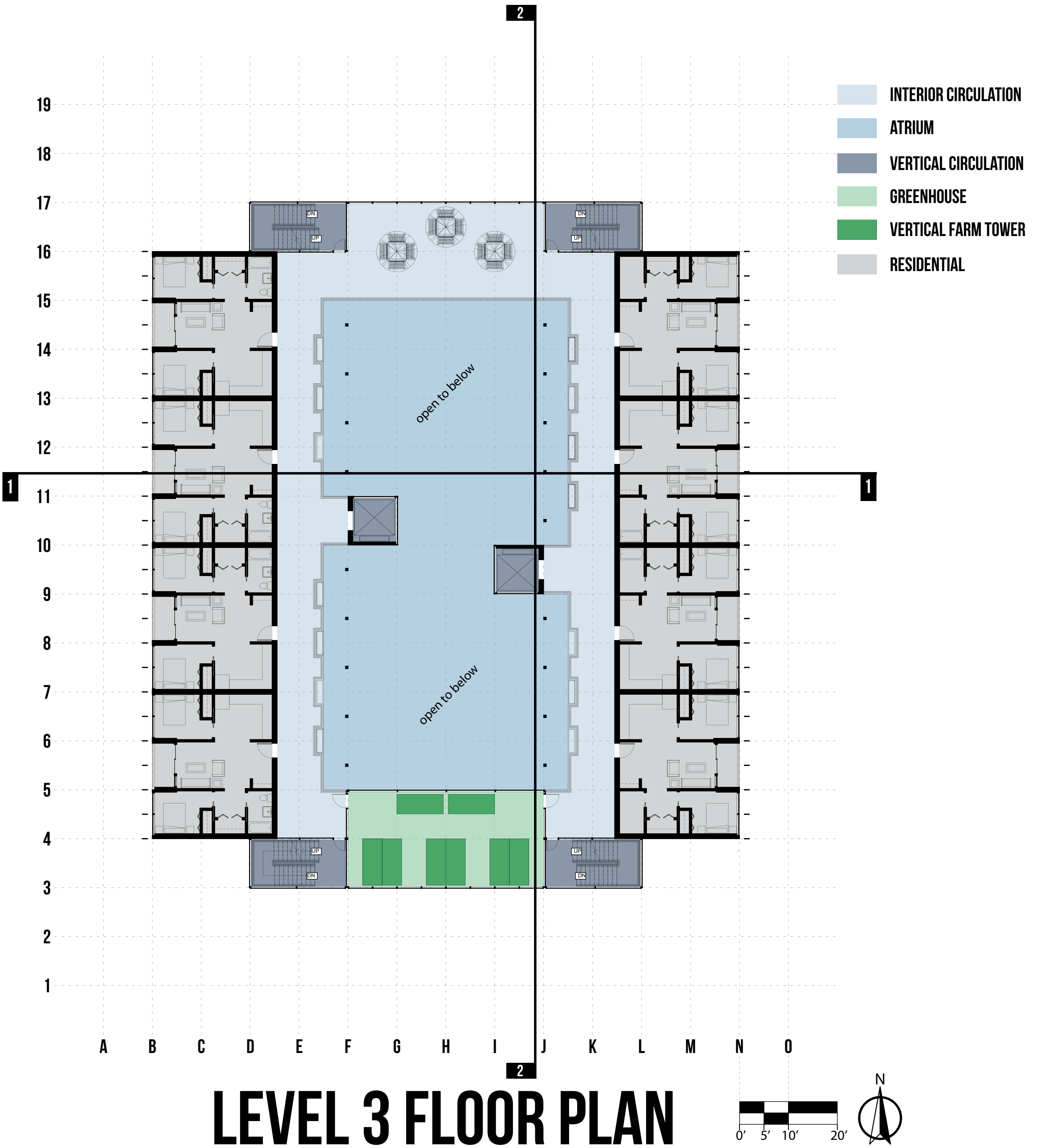
Level 0
-Concrete Floor Slab
-Concrete Columns
-Elevator Shaft Base
-Underground Parking

STRUCTURE/LAYOUT

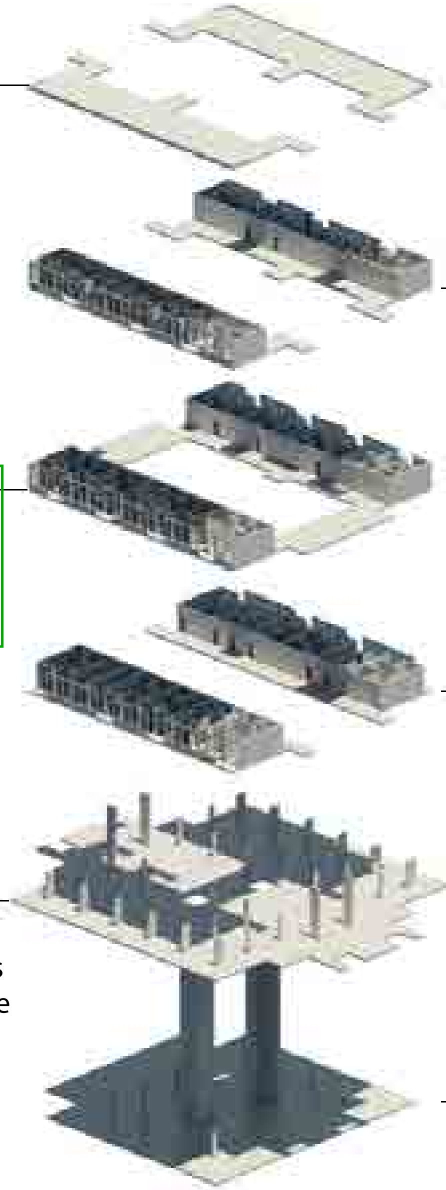


LEVEL 2 FLOOR PLAN

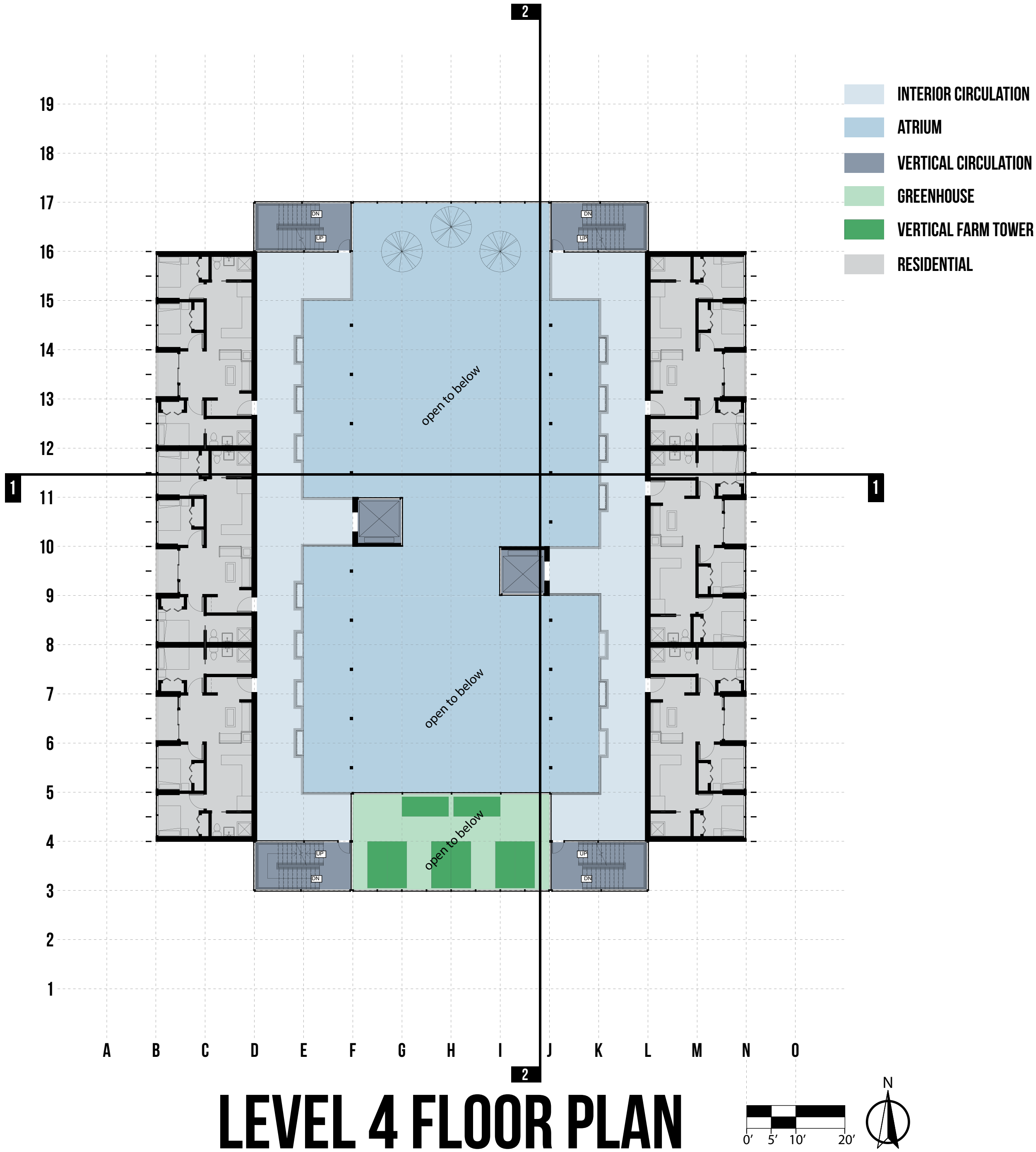
STRUCTURE/LAYOUT



LEVEL 3 FLOOR PLAN



STRUCTURE/LAYOUT



LEVEL 4 FLOOR PLAN

Level 5
- -Concrete Floor Slab
- -Vertical Farms
- -Garden Space
- -Energy Towers
- -Perimeter Water Collection

Level 4
- -Concrete Load Bearing Walls
- -Concrete Floor Slab
- -3 Bedroom Apartment Units

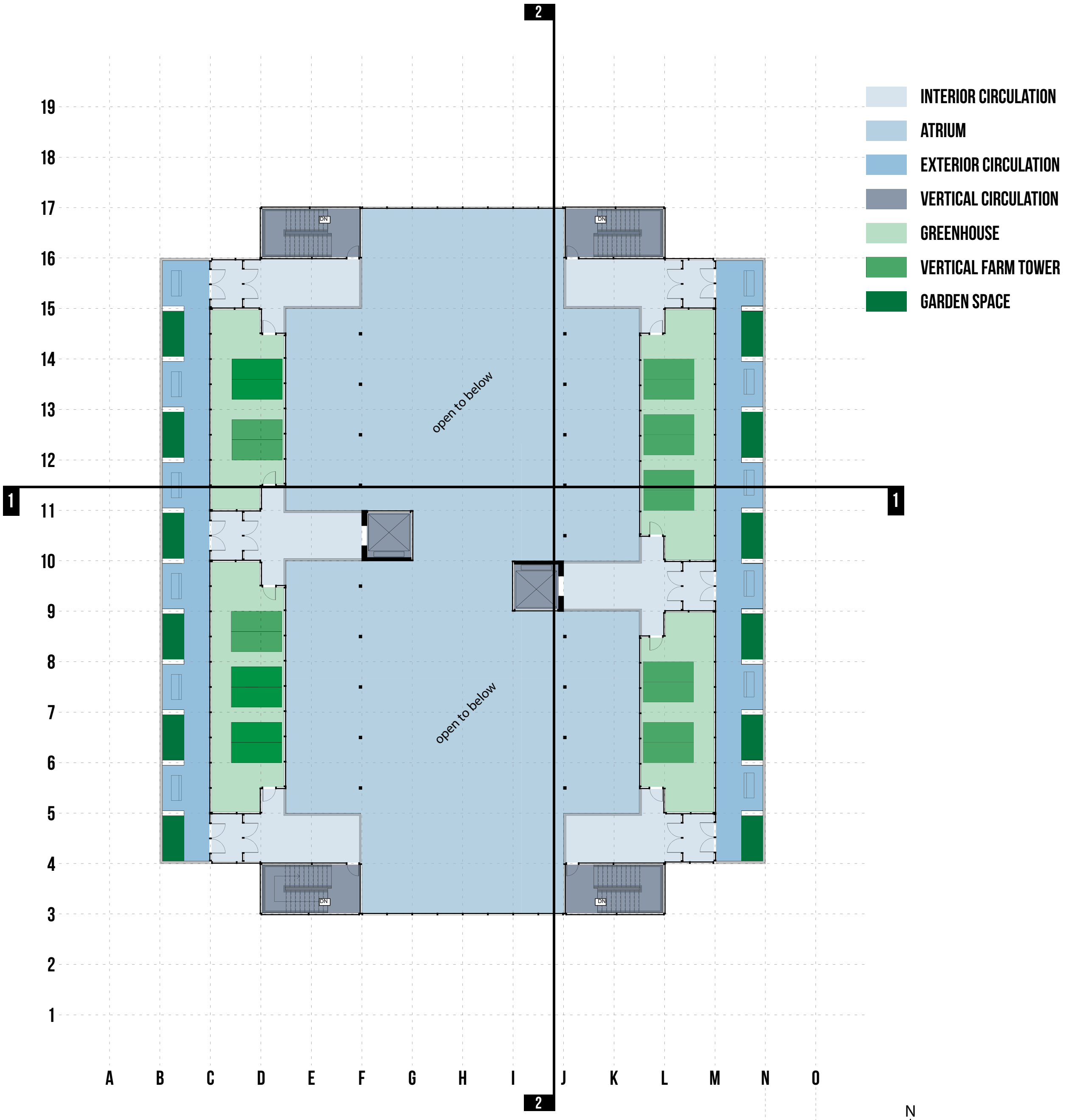
Level 3
- -Concrete Load Bearing Walls
- -Concrete Floor Slab
- -2 Bedroom Apartment Units
- -Vertical Farms

Level 2
- -Concrete Load Bearing Walls
- -Concrete Floor Slab
- -Studio Apartment Units
- -1 Bedroom Apartment Units

Level 1
- -Concrete Floor Slab
- -Rectilinear Concrete Columns
- -Ground Floor Atrium Entrance
- -Vertical Farms

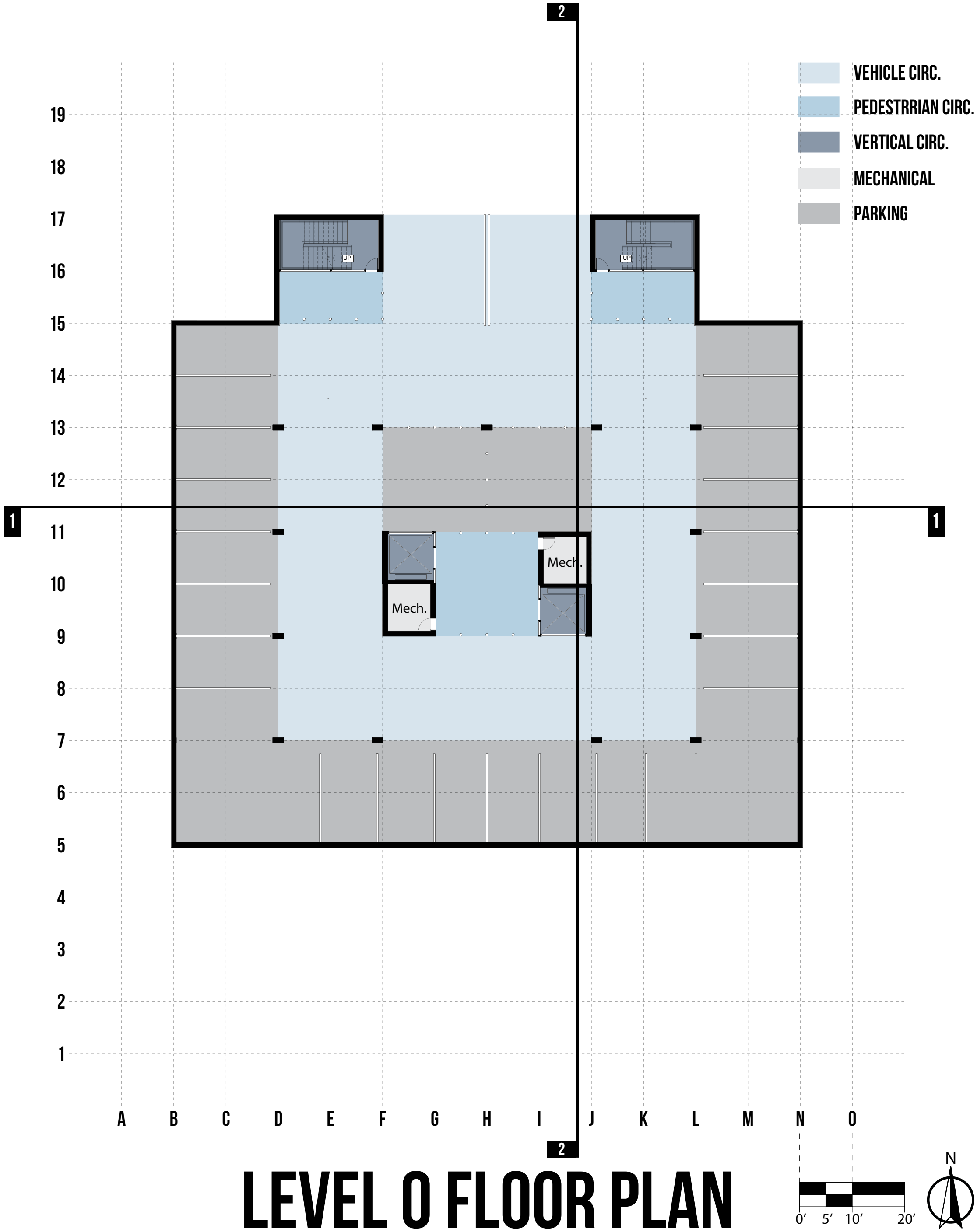
Level 0
- -Concrete Floor Slab
- -Concrete Columns
- -Elevator Shaft Base
- -Underground Parking

STRUCTURE/LAYOUT



LEVEL 5 FLOOR PLAN

STRUCTURE/LAYOUT



LEVEL 0 FLOOR PLAN

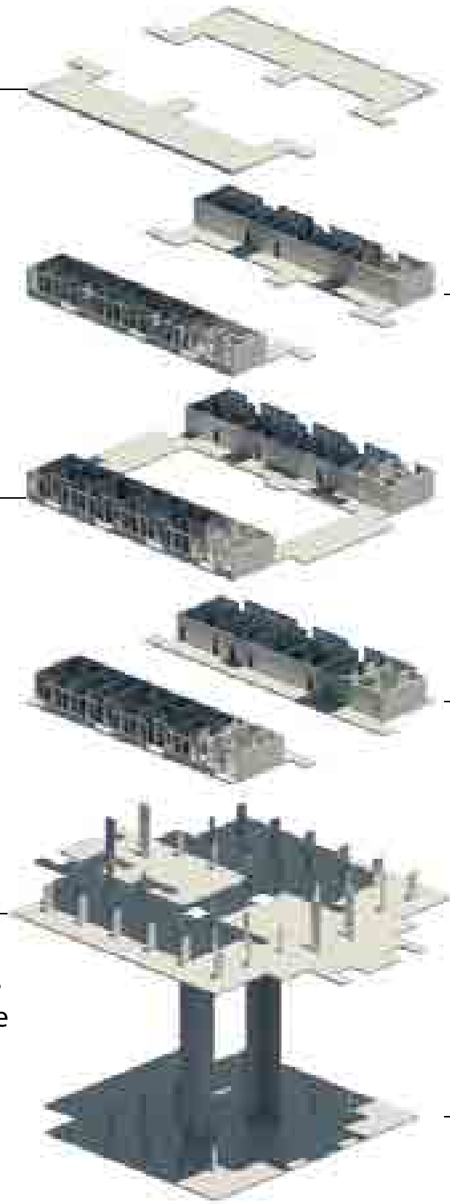
Level 5
-Concrete Floor Slab
-Vertical Farms
-Garden Space
-Energy Towers
-Perimeter Water Collection

Level 4
-Concrete Load Bearing Walls
-Concrete Floor Slab
-3 Bedroom Apartment Units

Level 3
-Concrete Load Bearing Walls
-Concrete Floor Slab
-2 Bedroom Apartment Units
-Vertical Farms

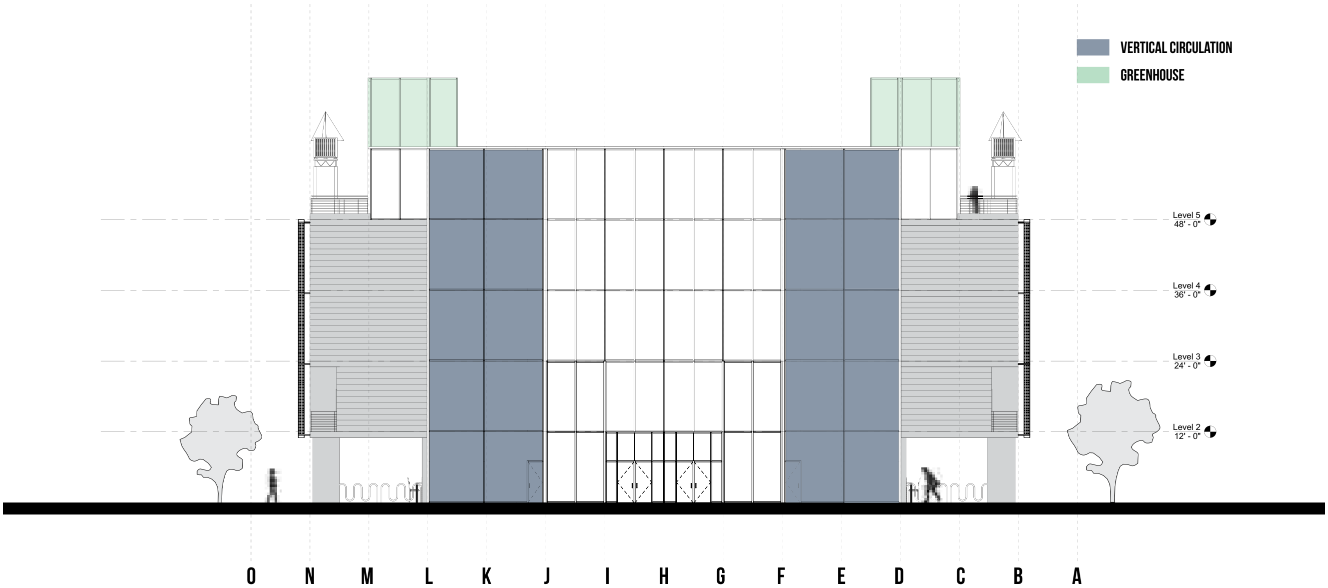
Level 2
-Concrete Load Bearing Walls
-Concrete Floor Slab
-Studio Apartment Units
-1 Bedroom Apartment Units

Level 1
-Concrete Floor Slab
-Rectilinear Concrete Columns
-Ground Floor Atrium Entrance
-Vertical Farms



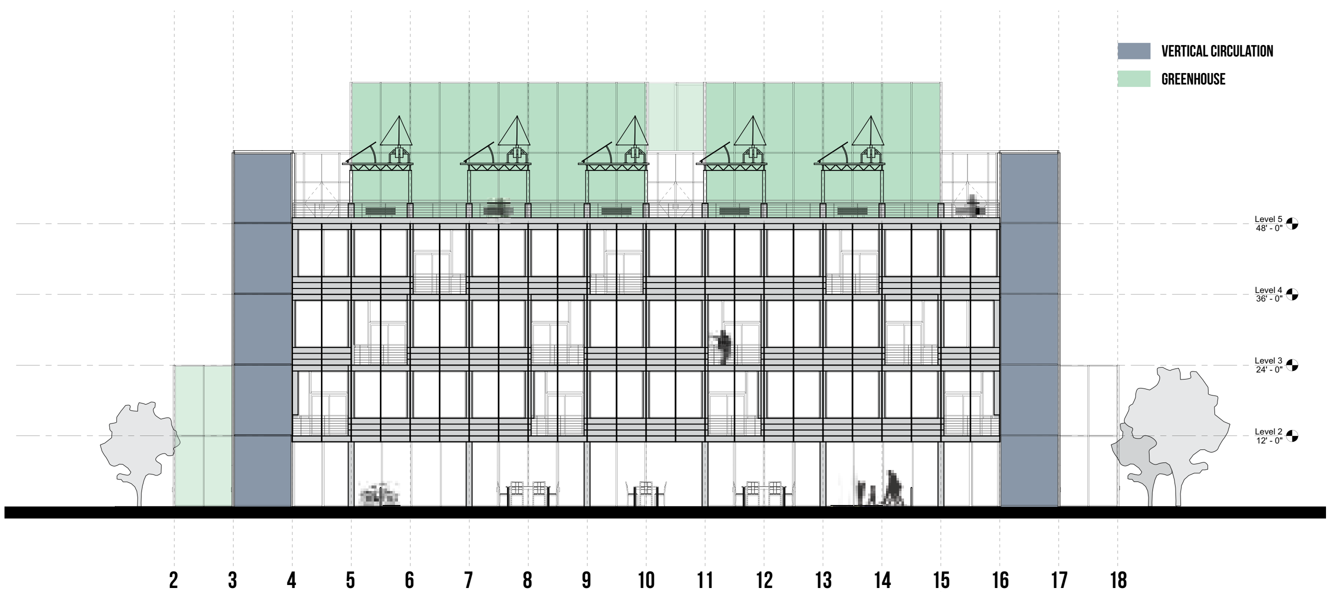
Level 0
-Concrete Floor Slab
-Concrete Columns
-Elevator Shaft Base
-Underground Parking

STRUCTURE/LAYOUT



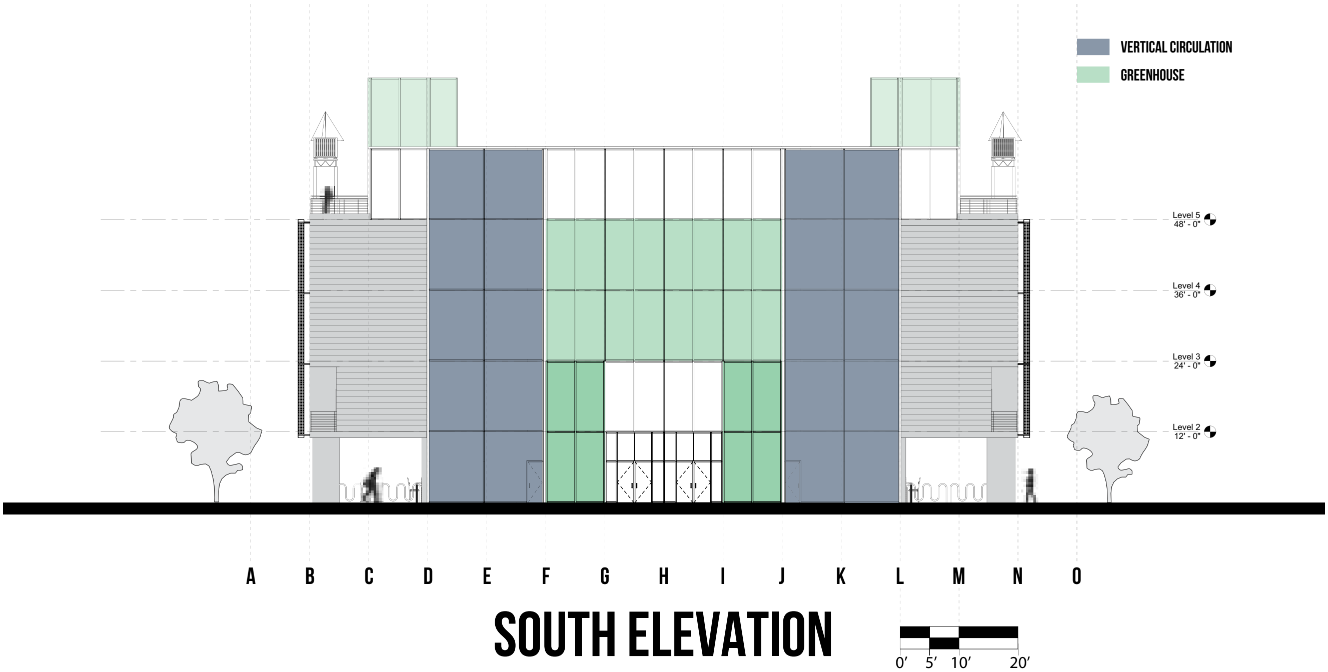
NORTH ELEVATION

0' 5' 10' 20'

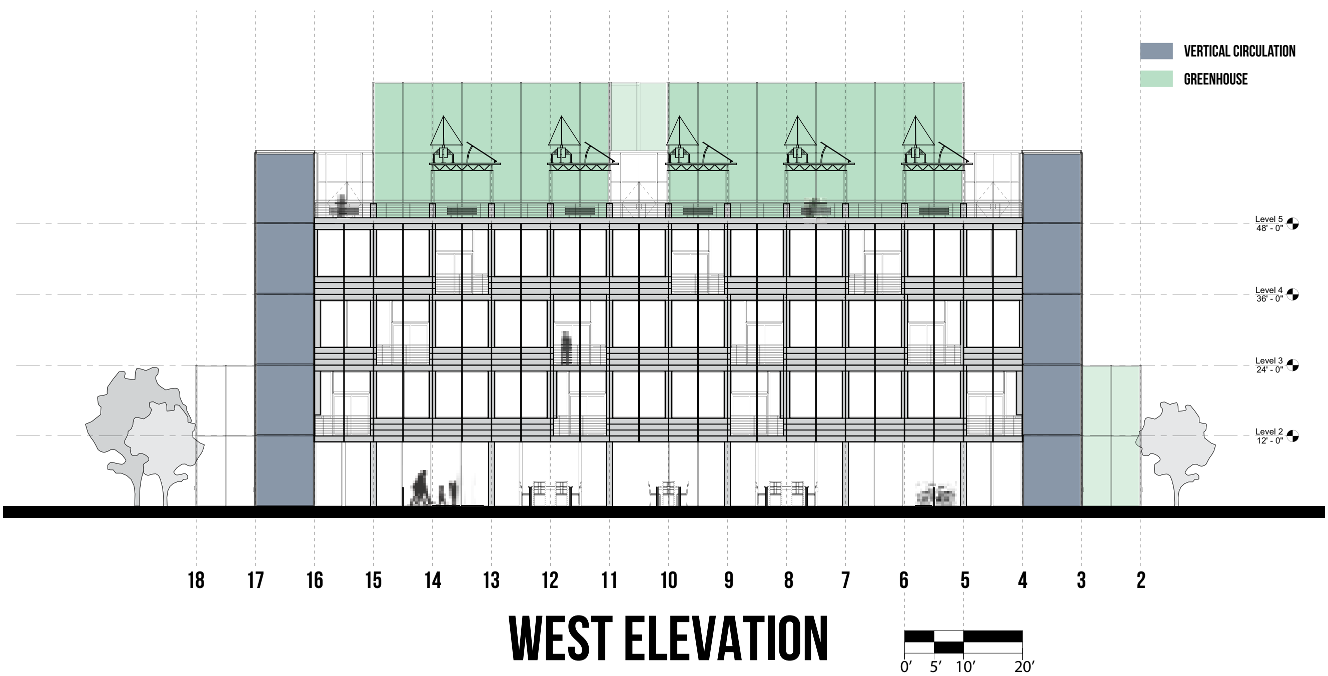


EAST ELEVATION

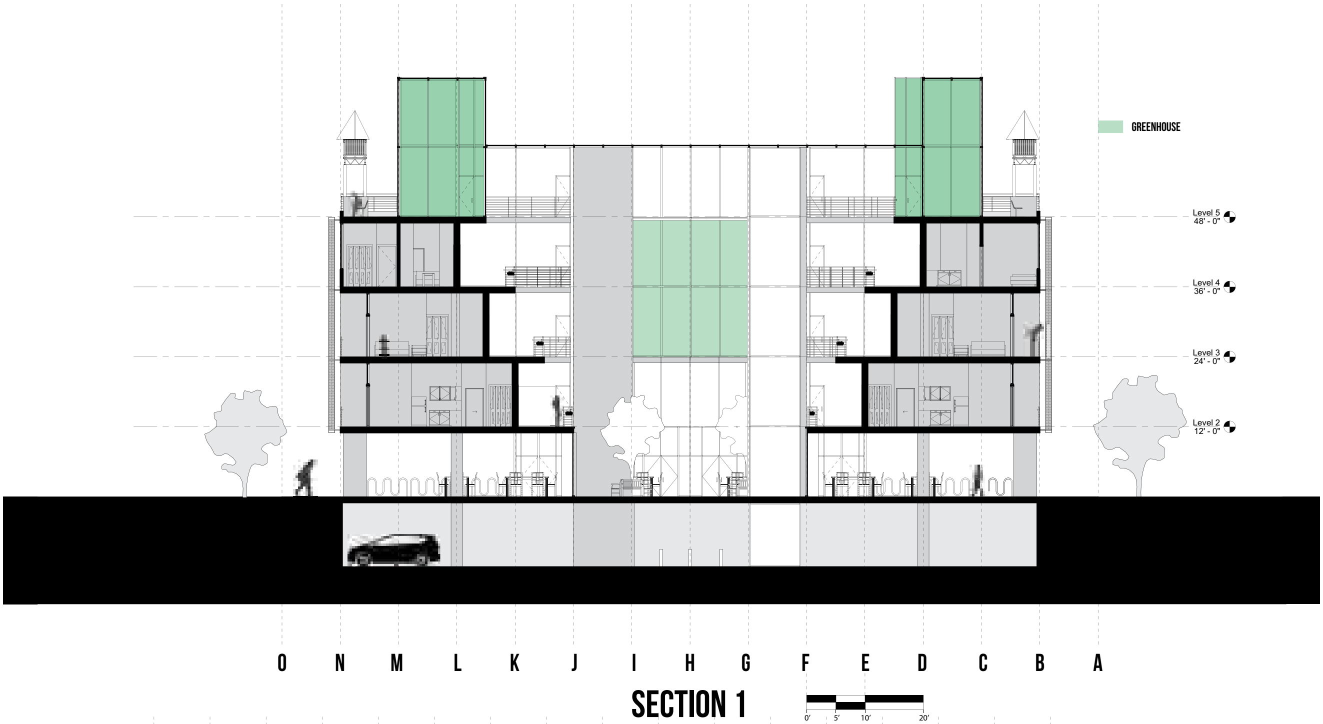
0' 5' 10' 20'



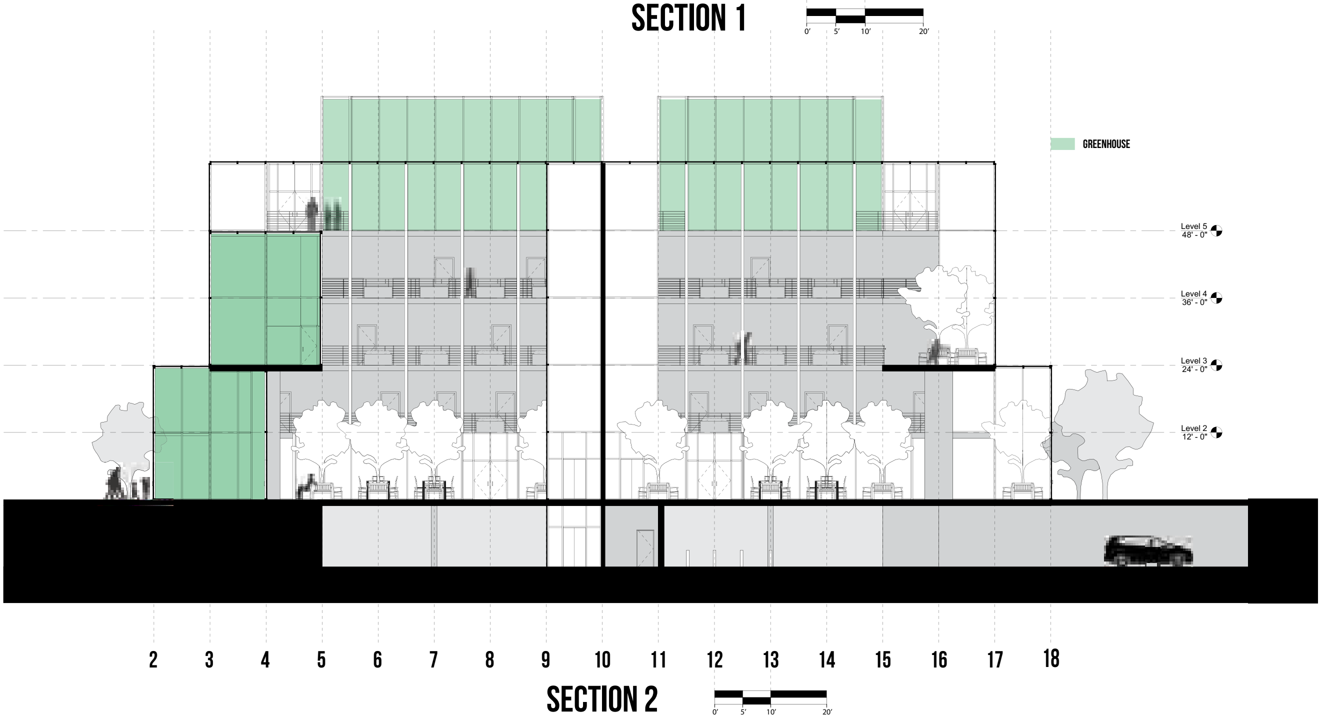
SOUTH ELEVATION



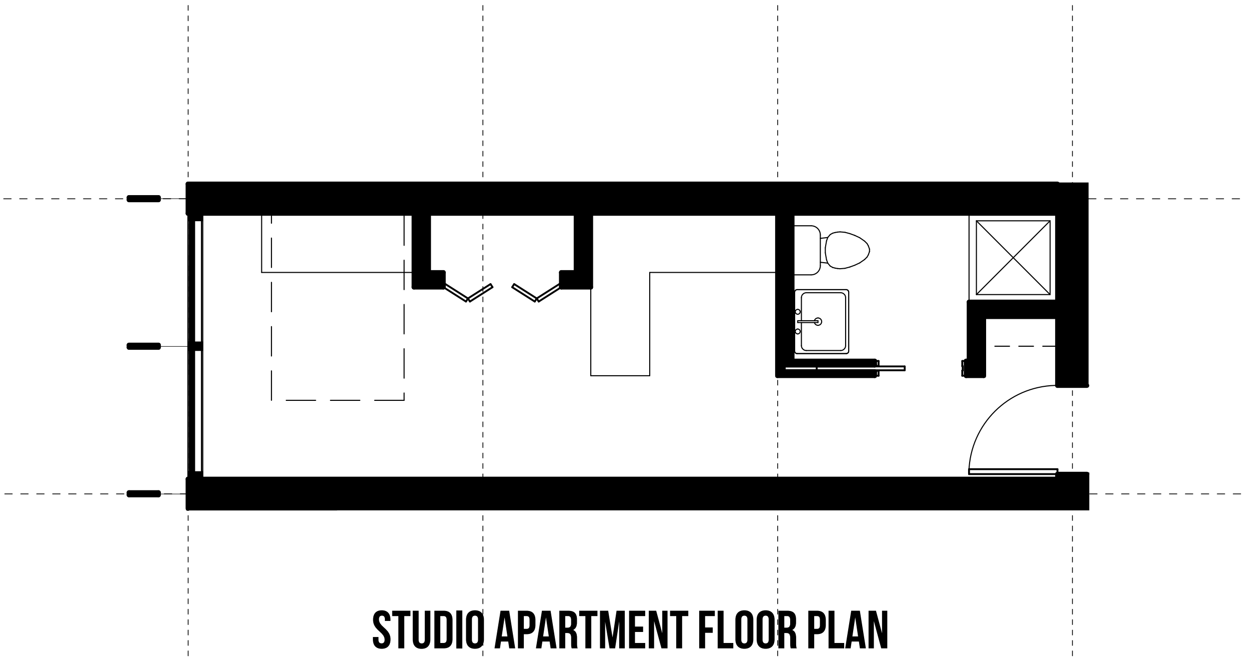
WEST ELEVATION



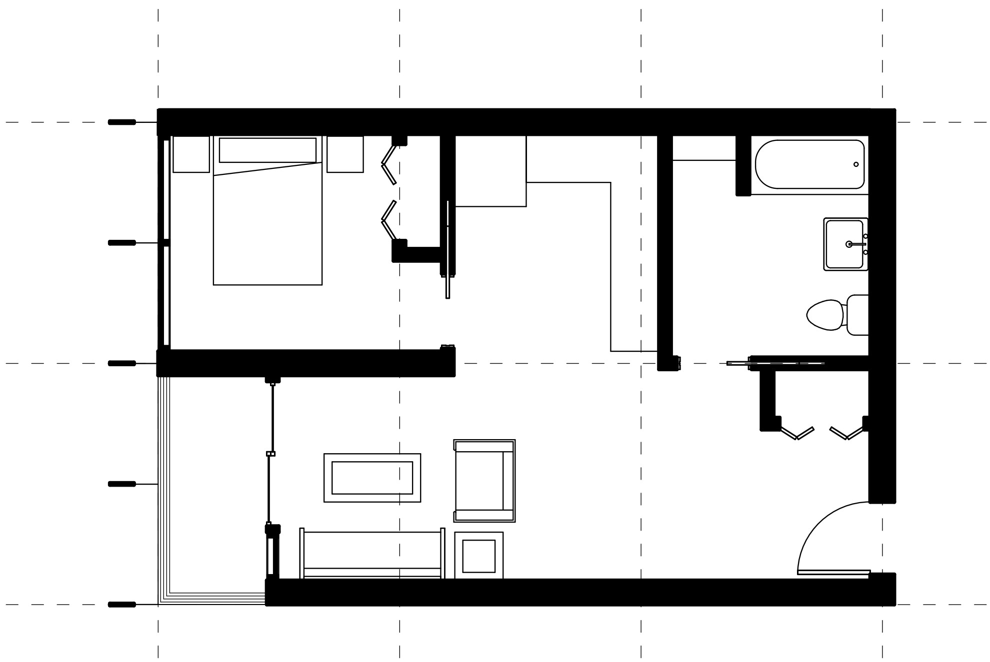
SECTION 1



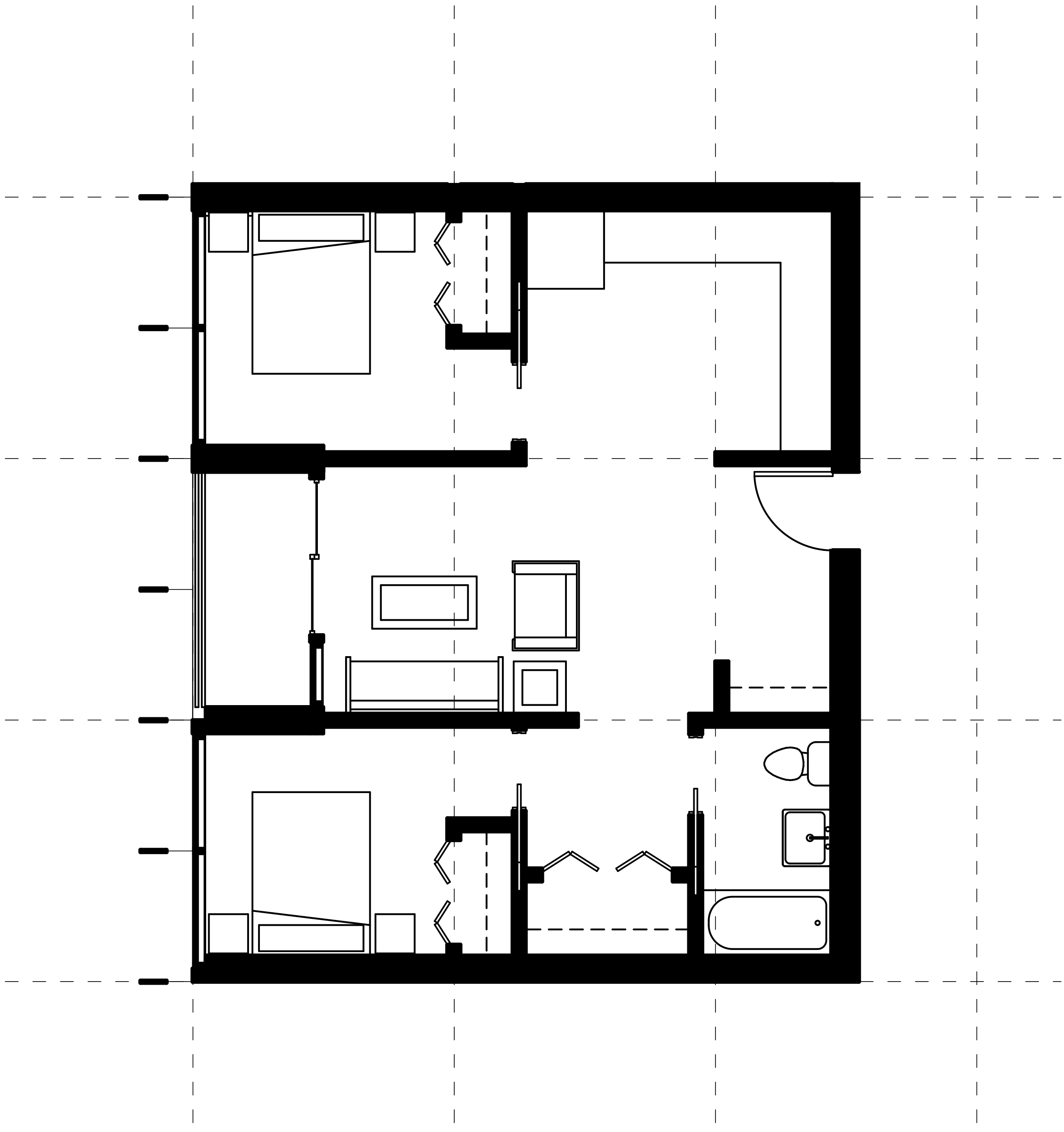
SECTION 2



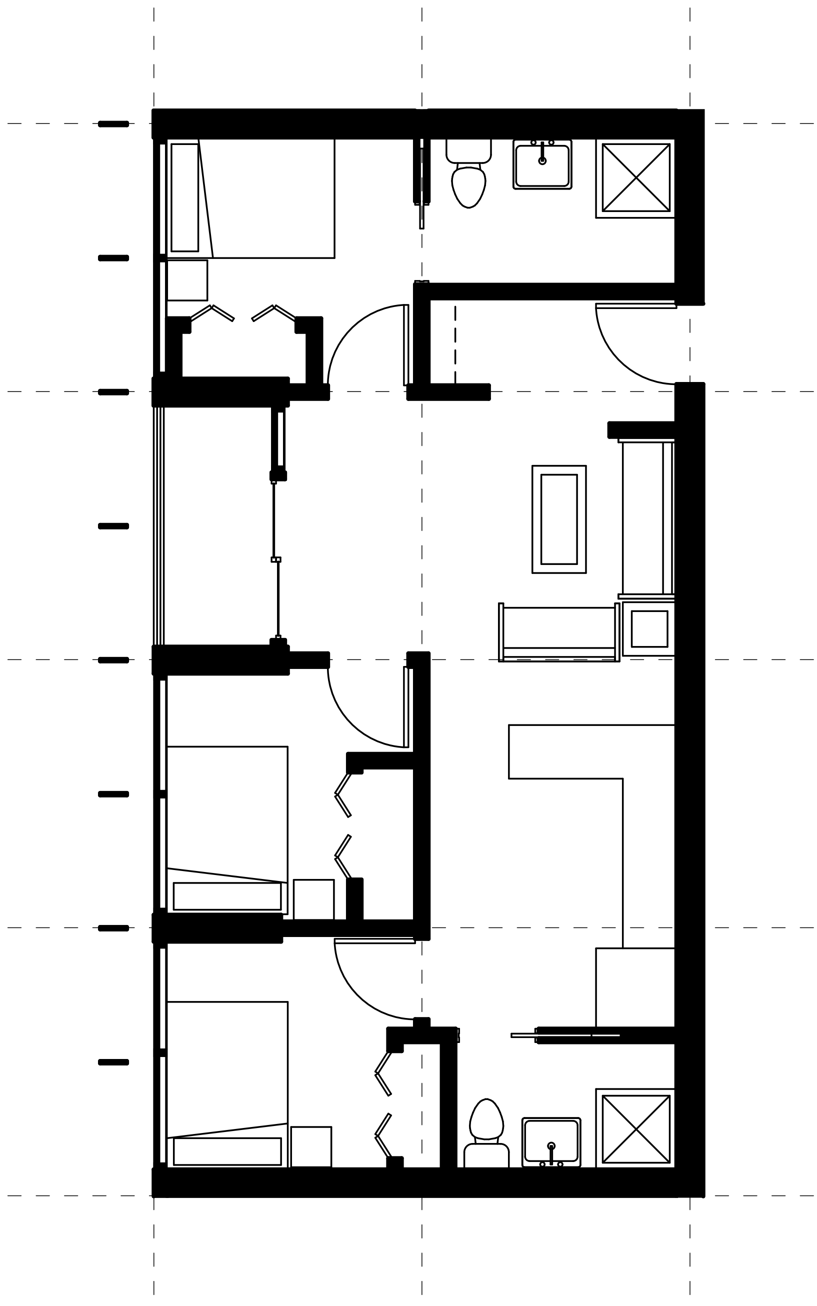
STUDIO APARTMENT FLOOR PLAN



1 BEDROOM FLOOR PLAN



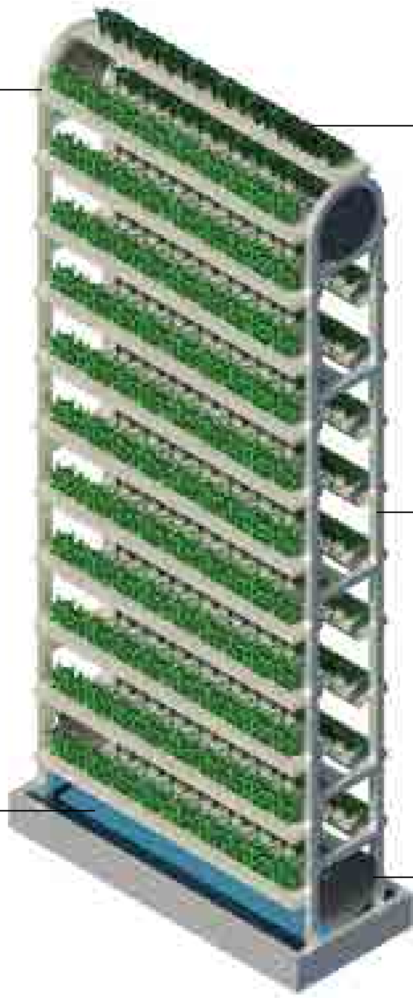
2 BEDROOM FLOOR PLAN



3 BEDROOM FLOOR PLAN

Lettuce Beds
- -Romaine lettuce
- -Beds rotate around the tower
- -Requires 6 hours of sunlight daily
- -10 lettuce plants per bed
- -22 Planter beds per tower
- -32 Towers per building

Varying Tower Heights
- -Grouped towers can vary in height to allow access to sunlight when reaching near the top of the rotation



3″ Aluminum Framing
- -Can be integrated into the greenhouse framing for additional structural support

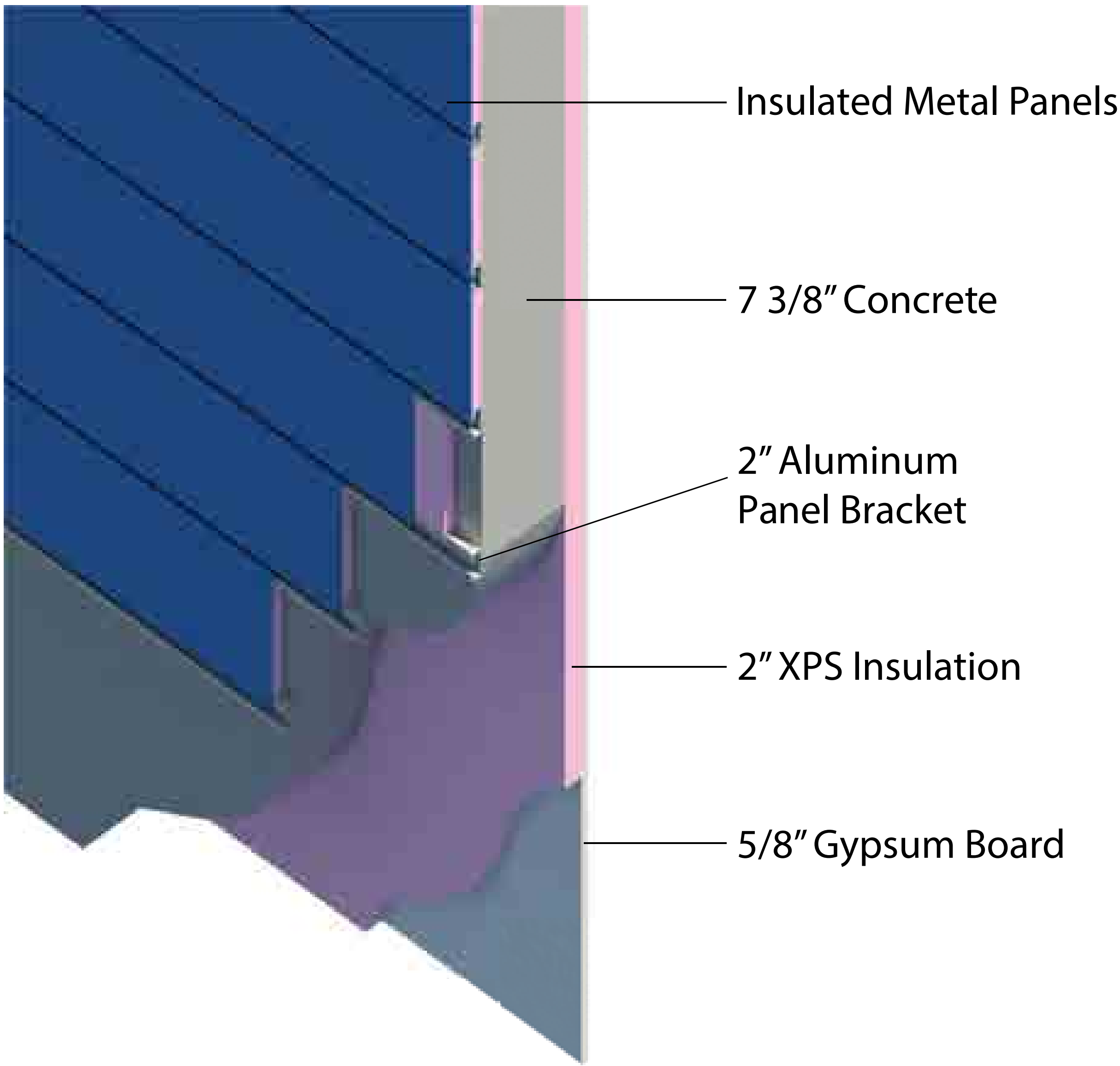
Nutrient Infused Bath
- -Lettuce beds dip into the enriched bath at the bottom of the rotation

Gravity Fed Water Wheel
- -Closed loop hydraulic system
- -About $3.00 in electricity costs per month
- -About the same energy requirements of a 60W light bulb

VERTICAL FARM TOWER

The Numbers

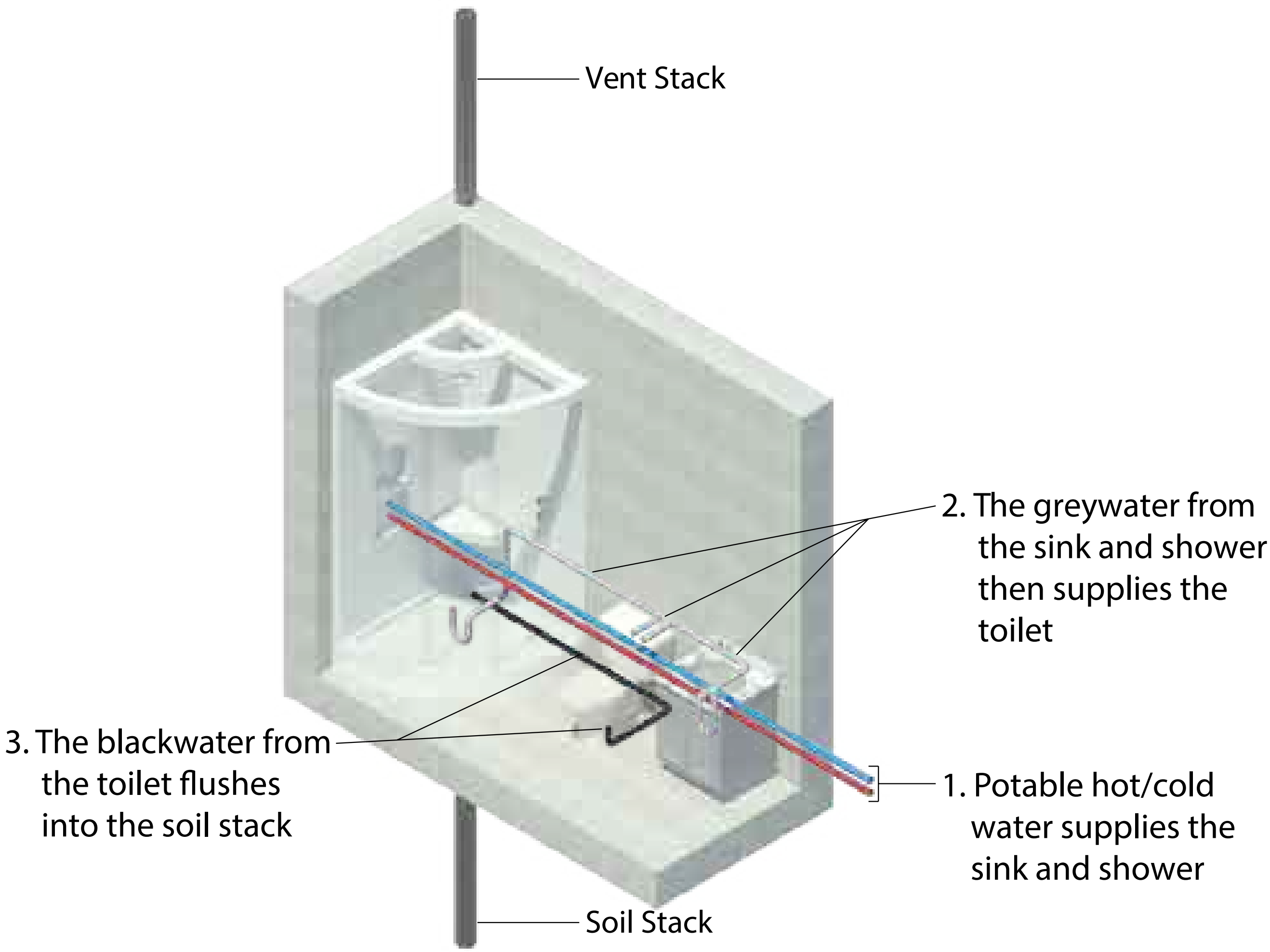
-**7,040** lettuce plants per building
-**6 week** harvest cycles
-There are **56,320** lettuce plants produced per building, per year
-With there being **4** buildings, the entire residential complex produces **225,258** lettuce plants per year
-Assuming all **223,490** of the Fargo/Moorhead area residents eat the average of **10-12** lettuce per year, this residential complex could supply about **8.4%** of Fargo/Moorhead's lettuce consumption



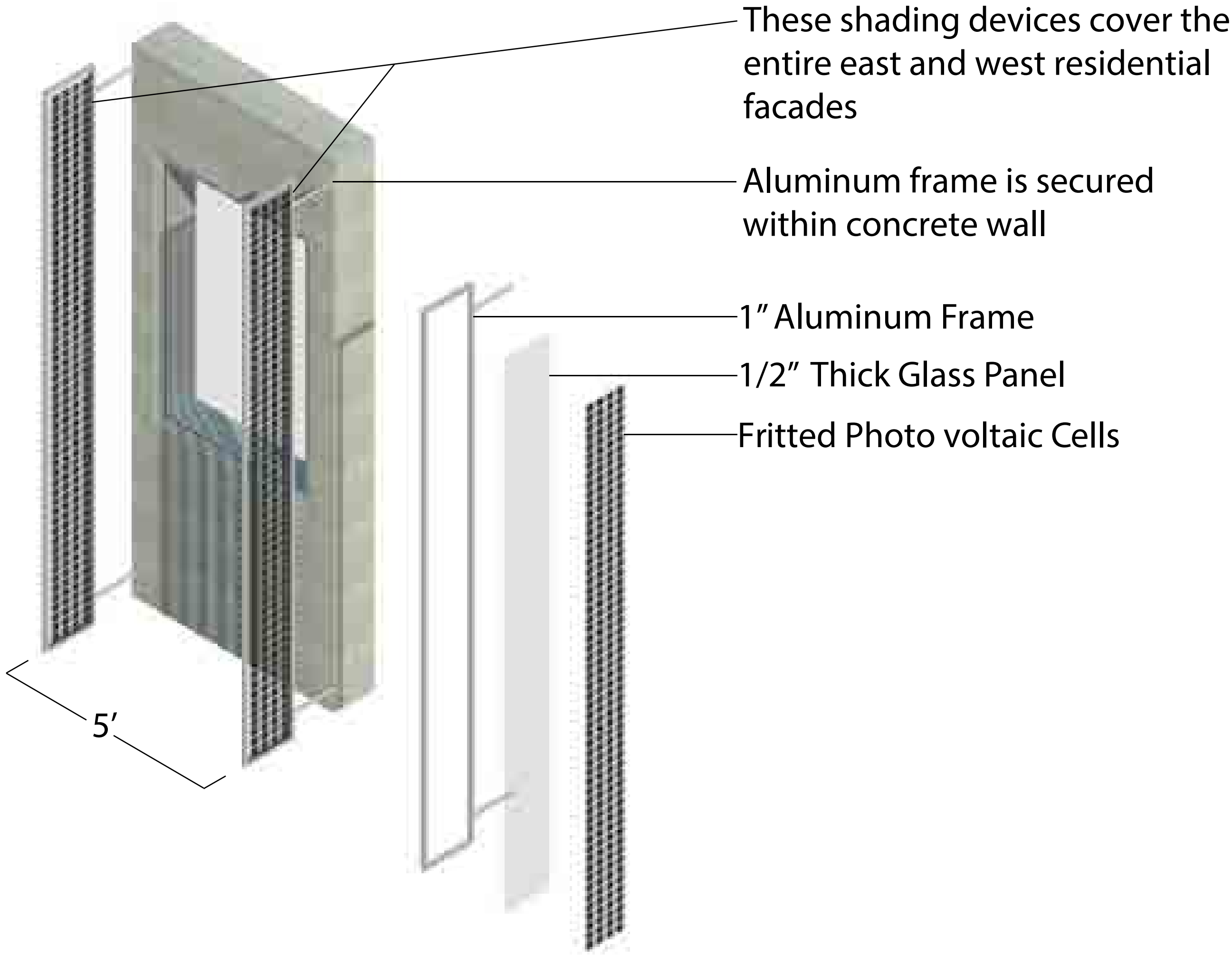
RAIN SCREEN/WALL DETAIL

Water Collection

- As rain or snow runs down the side of the building water is collected in the 2" aluminum panel brackets and consequently redirected within the building
- The collected water would supply the vertical farms as well as the residential units



EFFICIENT PLUMBING SYSTEM



EAST/WEST SHADING DEVICES

ENERGY TOWER

ATRIUM RENDERING

VERTICAL FARM RENDERING

EXTERIOR RENDERING

REVISITING RESIDENTIAL DESIGN

BY INTEGRATING VERTICAL FARMING

BY: JETSE VOLLEMA

WHY VERTICAL FARMING/RESIDENTIAL DESIGN?

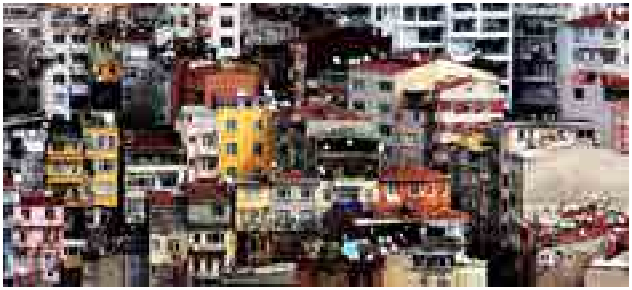
Global Population:

- In 1804 the population had reached 1 billion
- In 1923 it reached 2 billion **(119 Years)**
- In 1960 it reached 3 billion **(37 Years)**
- In 1974 it reached 4 billion **(14 Years)**
- In 1987 it reached 5 billion **(13 Years)**
- In 1999 it reached 6 billion **(12 Years)**
- In 2011 it reached 7 billion **(12 Years)**

"According to the most recent United Nations estimates, the human population of the world is expected to reach 8 billion people in the spring of 2024." ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

"The latest United Nations projections indicate that world population will nearly stabilize at just above 10 billion persons after 2062." ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

WHY VERTICAL FARMING/RESIDENTIAL DESIGN?



"But is overpopulation a bad thing?"

Definition:

- To fill with an excessive number of people, straining available resources and facilities. ("Overpopulation | Define Overpopulation at Dictionary.com", 2013)

- In other words, "overpopulation" refers to the point at which a region can no longer meet the needs of it's inhabitants.

"So does the problem of overpopulation derive from the existence of too many people, or is it caused due to inefficient/outdated methods of obtaining and providing the needs of a region's inhabitants?"

- I am not sure architecture can have an influence on the rise of population

- But I do believe that architecture can be used as a means of reconceiving how we provide the needs for a rising population

---

WHY VERTICAL FARMING/RESIDENTIAL DESIGN?

The Basic Needs of Inhabitants

- Shelter
- Food
- Water
- Energy/Electricity

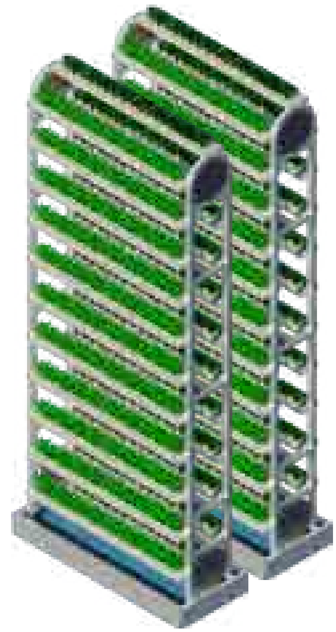
Currently the latter 3 needs are primarily provided by off-site sources

I believe that all of these needs can be provided on-site by integrating food, water, and energy generating/harvesting systems right where they will likely end up, within a residential facility.

There are many existing residential designs that assist in providing water and energy but there are not nearly as many that adequately generate food for its residents. This is why, although I incorporated systems for all the listed needs, my main focus was on integrating vertical farming within a space efficient residential facility.

WHAT IS VERTICAL FARMING?

http://www.youtube.com/watch?v=cY7O5YNxKuI



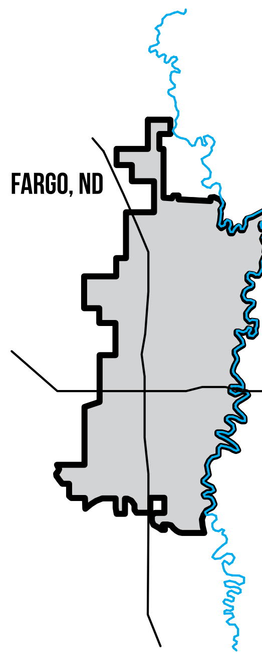
Hydroponic Farming vs Soil Farming

- Less water consumption (90%)
- Eliminates the need for toxic insecticides
- Eliminates soil borne diseases
- Crops can be grown year round
- Smaller roots
- Less land area is required (10:1 - 25:1)
- Increased shelf life (1-2 weeks longer)
- Higher nutrition and antioxidant levels
- Increased yield predictability
- Increased yield quantities
- Shorter harvest cycles
- Locally grown
- Reduced transportation costs and resulting CO_2 emissions
- Vegetables do not travel well

(http://www.greenspiritfarms.com/Comparing_Hydroponics_to_Dirt_Farming.pdf)

WHY DID I CHOOSE FARGO, ND FOR THE SITE?

- I wanted the site to be within a city experiencing rapid population growth
- Mainly due to the abundance of oil in the western regions of North Dakota and recent advancement in oil drilling/harvesting, the population of North Dakota has been on the rise
- Fargo is the most populous city in ND and it is also experiencing a population increase



- In 2000, the population of Fargo, ND was recorded to be 90,576
- In 2012, the population in Fargo, ND was recorded to be 109,779
- This mean that there was a population growth of 21.2% in Fargo in twelve recent years
- That results in an immense increase in needs for shelter and food

("Fargo, North Dakota (ND) profile: population, maps, real estate, averages, homes, statistics, relocation, travel, jobs, hospitals, schools, crime, moving, houses, news", 2013)

THE MAIN GOALS FOR MY THESIS

Conceptually
- To create a design that provokes interest in regard to reconceiving the general expectations of residential design

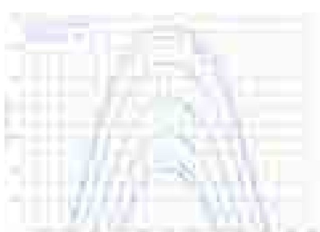
The Building
- I wanted to design a building that harmonically blends the building's needs with the needs of its inhabitants

The Future
- The most important goal for me was to create a design that assists in the future survival of our species.

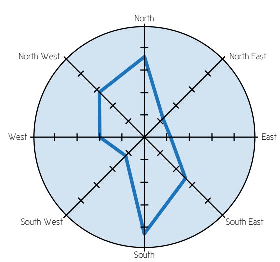
THE PROCESS PATH

Wind Study

Noise Study



Solar Study



Wind Study

Site Visits

Overpopulation

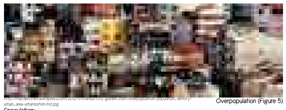
Definition:
-The condition of having a population so dense as to cause environmental deterioration, an impaired quality of life, or a population crash. ("Overpopulation - Definition and More from the Free Merriam-Webster Dictionary", 2013)

-To fill with an excessive number of people, straining available resources and facilities. ("Overpopulation | Define Overpopulation at Dictionary.com", 2013)

World Population Milestones:
In 1804 the population had reached 1 billion, in 1923 it reached 2 billion, in 1960 it reached 3 billion, in 1974 it reached 4 billion, in 1987 it reached 5 billion, in 1999 it reached 6 billion, in 2011 it reached 7 billion. ("7 Population Milestones for 7 Billion People | October 31, The Day of 7 Billion | Population Growth | LiveScience", 2013)

It took all of mankind's history up until about the 1800's for mankind to reach a world population of 1 billion. In about only 130 years after that first billion, the second billion was reached in 1923. Only 37 years later, the third billion was reached in 1974. The fourth billion was a small 15 years later, in 1974. 13 years later, in 1987, the fifth billion mark was recorded. Twelve short years later, 6 billion was achieved in 1999. The most recent recorded benchmark was in 2011, when the world population reached 7 billion. Again this billion took twelve years.


http://news.medill.northwestern.edu/chicago/news.aspx?id=213990&print=1
Overpopulation (Figure 4)


http://macders.files.wordpress.com/2012/11/istanbul-city-golden_horn-overpopulation-population_density-urban_area-urbanization-hd.jpg
Overpopulation (Figure 5)

Speculation:

> *"According to the most recent United Nations estimates, the human population of the world is expected to reach 8 billion people in the spring of 2024."* ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

If this ends up being accurate, then it will mean that the human population growth rate is declining. The world population will continue to grow, but at a slower rate. However, since the world population has increased to a relatively much larger number, even a very small percentage increase in the world's population will increase the population dramatically. (Ex: 1% of 7 billion is 7 million)

> *"The latest United Nations projections indicate that world population will nearly stabilize at just above 10 billion persons after 2062."* ("World Population Clock: 7 Billion People (2013) - Worldometers", 2013)

North Dakota Population:
In 2012, the population of North Dakota was recorded to be 699,628. In 2010, the population was 672,591. This means that in 2 recent years, North Dakota's population experienced a 4 percent growth. ("North Dakota QuickFacts from the US Census Bureau", 2013)

Fargo, ND Population:
In 2012, the population in Fargo, ND was recorded to be 109,779. In 2000, the population of Fargo was 90,576. This implies that there has been a population growth of 21.2 percent in Fargo in twelve recent years. Although the world population's growth as a whole seems to be declining, there are many places like Fargo, North Dakota where the population continues to boom. ("Fargo, North Dakota (ND) profile: population, maps, real estate, averages, homes, statistics, relocation, travel, jobs, hospitals, schools, crime, moving, houses, news", 2013)

Urban Agriculture

Definition:
-It refers to the system of cultivating, processing and distributing food in a town or city. ("Urban Agriculture Law & Legal Definition", 2013)

Average Amount of Land Required to Continuously Feed a Single Adult:
The average adult needs at least 0.07 hectares, or 7,500 square ft. to be capable of continuously growing the minimum amount and types of food required for a healthy human diet. ("Amount of land per person? (community forum at permies)", 2013)

> *"So in a more southern climate, you could theoretically support about 5 people per acre. This means about 0.2 acres per person, or roughly 8,712 square ft."* ("Urban Farming - The Future of Agriculture?", 2013)

Required Daylight (Daily):
The general consensus is that 8 hours of daylight is a "safe" amount of light for most vegetable types typically grown in the US. There are vegetables to require less, 6 Hours, and there are vegetables that require more. Strategic placement of vegetable types within a garden will allow for some leniency for vegetables growing in areas that might be lacking in light. ("Clover's Garden Centers - Resource Center - Urban Farming Resources - Sunlight & vegetables", 2013)


http://environment.nationalgeographic.com/environment/photos/urban-farming/
Raised Bed Growing (Figure 6)

Types of Urban Gardens:
Roof gardens- are a current popular global trend. They can be used to grown necessary products and/or providing spaces for inhabitants to relax and take a break. Additionally environmental and sustainable benefits are present in roof gardens as well. Biomass creates a layer of insulation for the building, improves air quality, and utilizes/retains rainwater more efficiently.

1. Backyard Gardens- are essentially just spaces on the building's property used for gardening/growing practices. Again this utilizes rainwater efficiently and also provides nice spaces for people to enjoy. It is also a great way to ensure that if adequate daylight is available, that it is used as efficiently as possible.

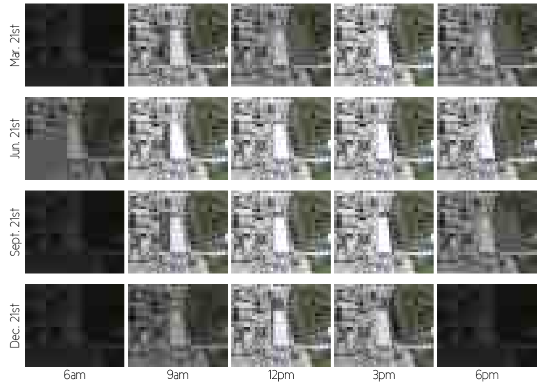
2. Allotment Gardens- are areas of public or government owned land that is given to individuals or households to access and use for gardening purposes. It can be on site or off site of where one resides/works. Typically a set up like this is creates a sense of community between the users of the gardens.

3. Community Gardens- are very similar to allotments except that the products grown are cultivated collectively rather than individually designated segments of land. ("Urban Gardens: urban gardening, guerilla gardening, community gardens", 2013)

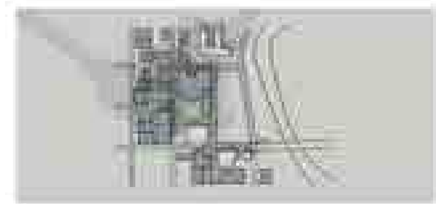
4. Vertical Gardens- are defined as hydroponic food production in cities in multi-story greenhouses. Water is recycled very efficiently and the output ratio of hydroponic growing techniques consistently surpasses soil growing techniques be a minimum ratio of 4:1. ("What is Vertical Farming? | OnEarth Magazine", 2013)


http://www.agri-tecture.com/page/70
Vertical Farming (Figure 7)

THE PROCESS PATH



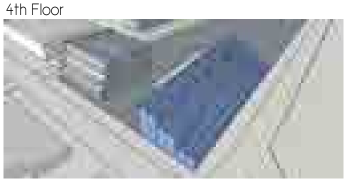
Shadow Studies



THE PROCESS PATH

1st Floor

4th Floor

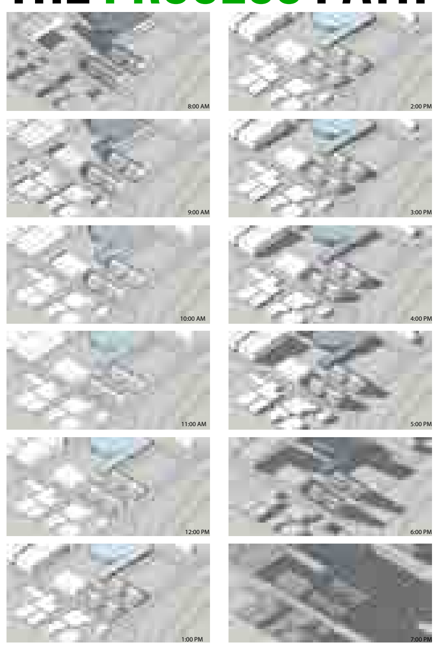


2nd Floor

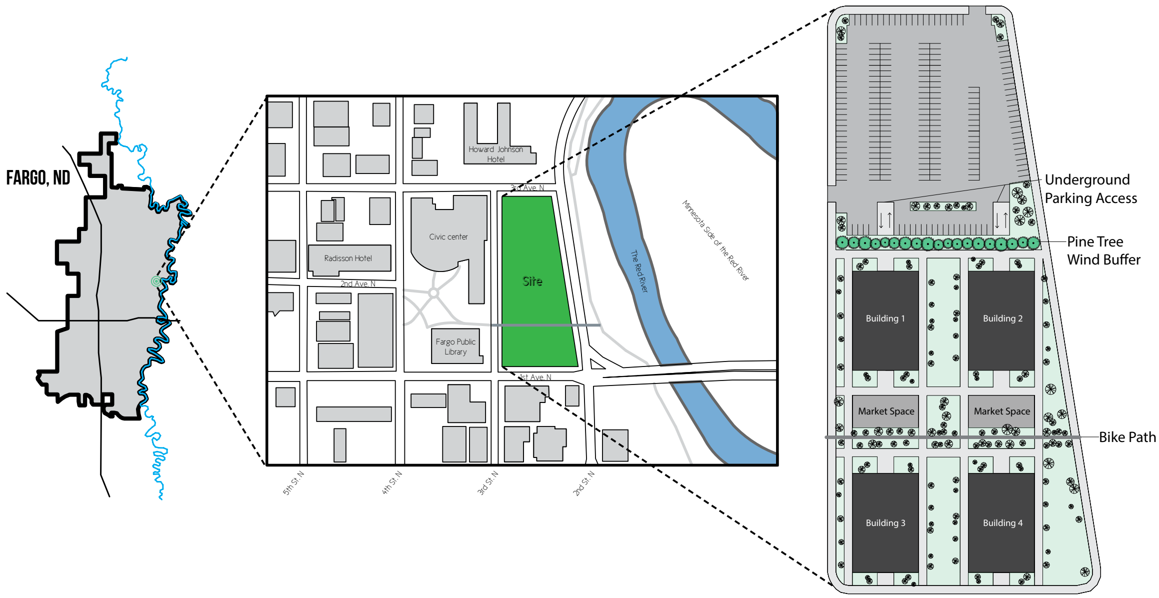
5th Floor

3rd Floor

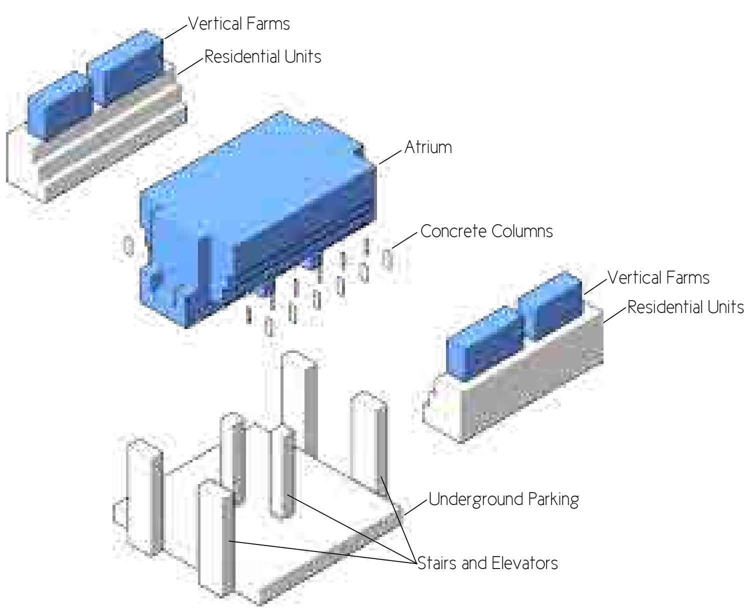
Added More Concrete Walls



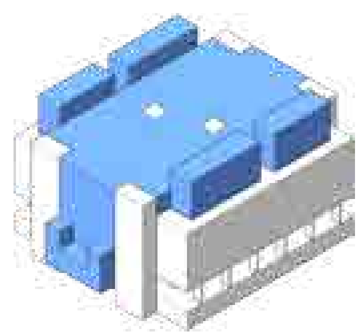
THE FINAL DESIGN



THE FINAL DESIGN

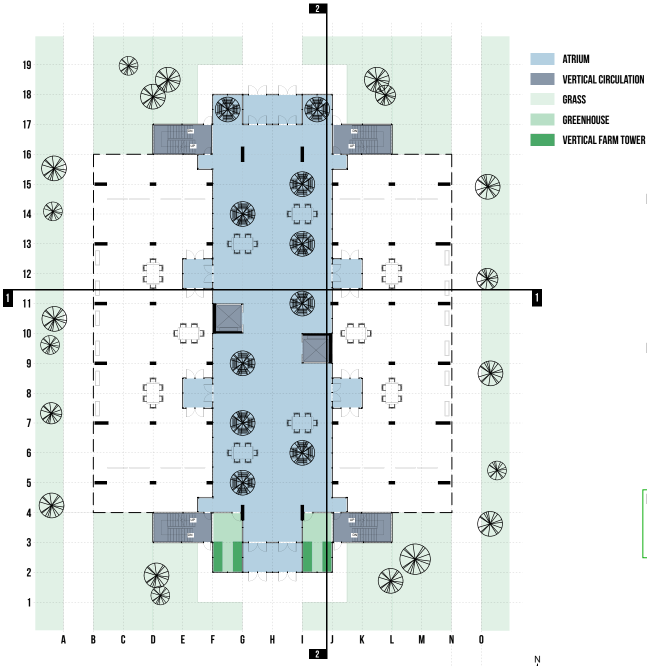


Exploded Axonometric

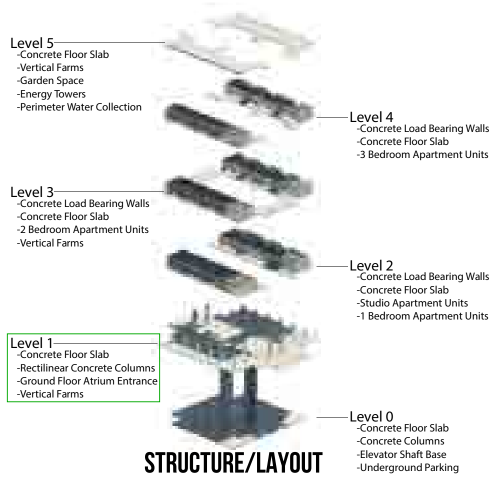


Axonometric

THE FINAL DESIGN

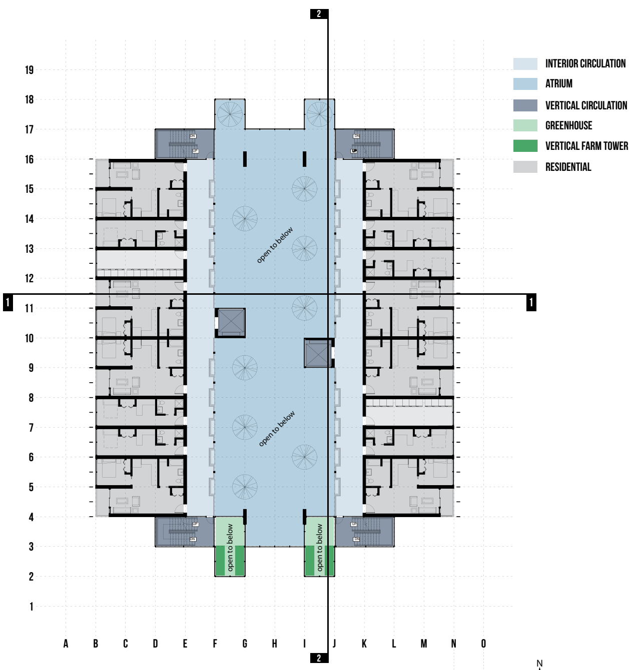


LEVEL 1 FLOOR PLAN

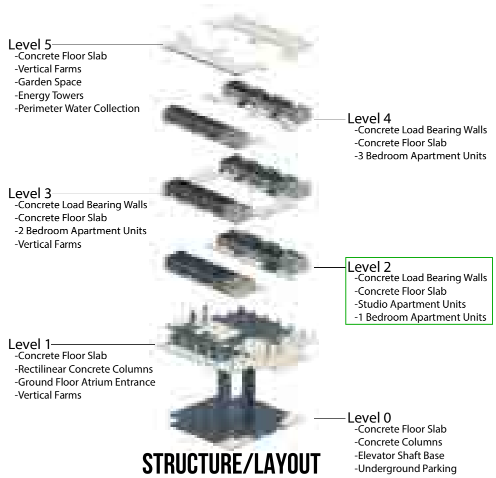


STRUCTURE/LAYOUT

THE FINAL DESIGN

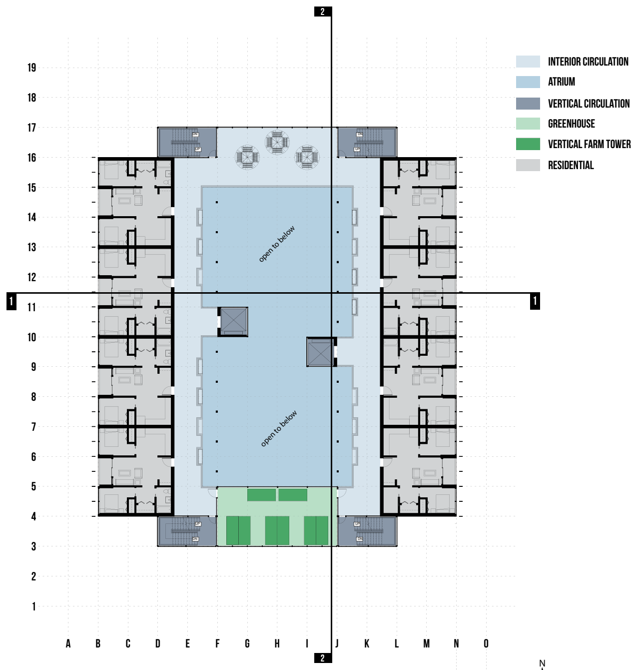


LEVEL 2 FLOOR PLAN

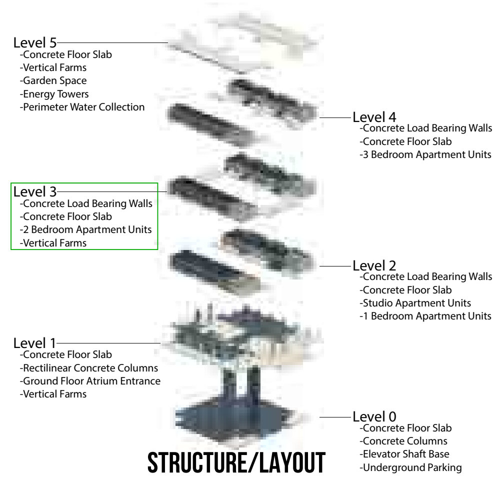


STRUCTURE/LAYOUT

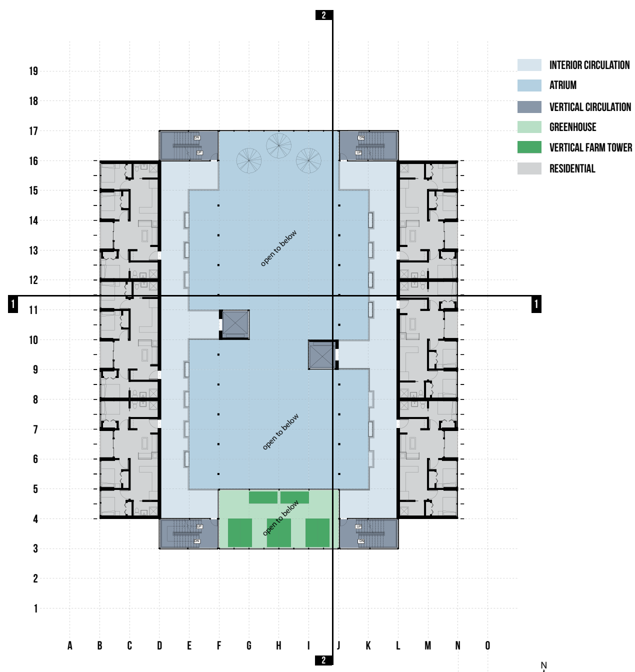
THE FINAL DESIGN



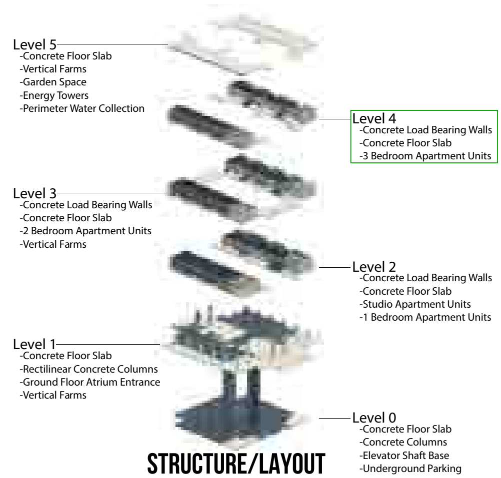
LEVEL 3 FLOOR PLAN



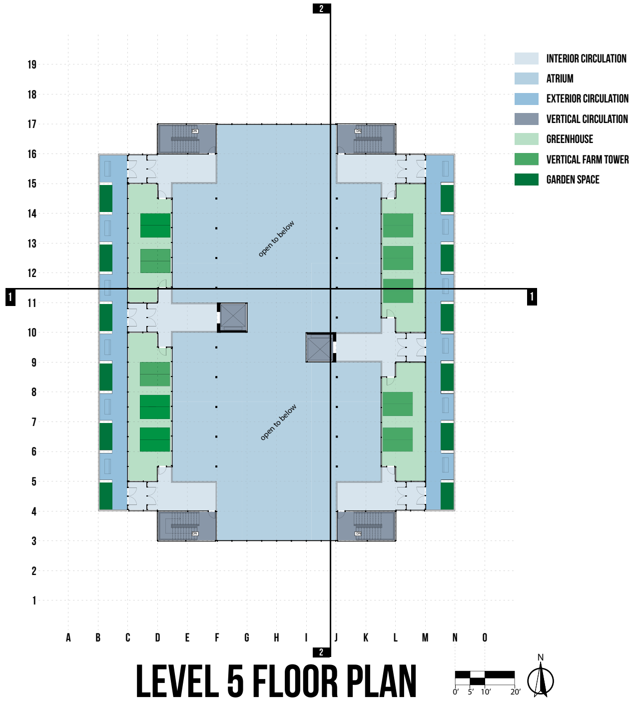
THE FINAL DESIGN



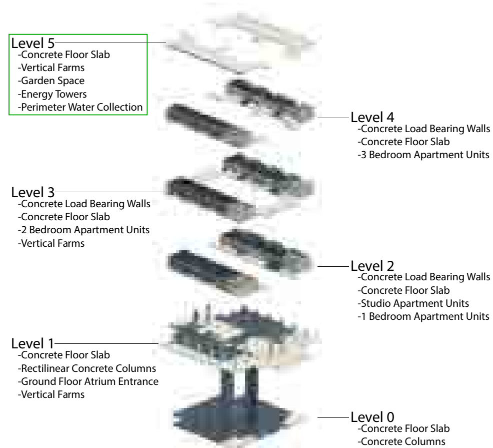
LEVEL 4 FLOOR PLAN



THE FINAL DESIGN

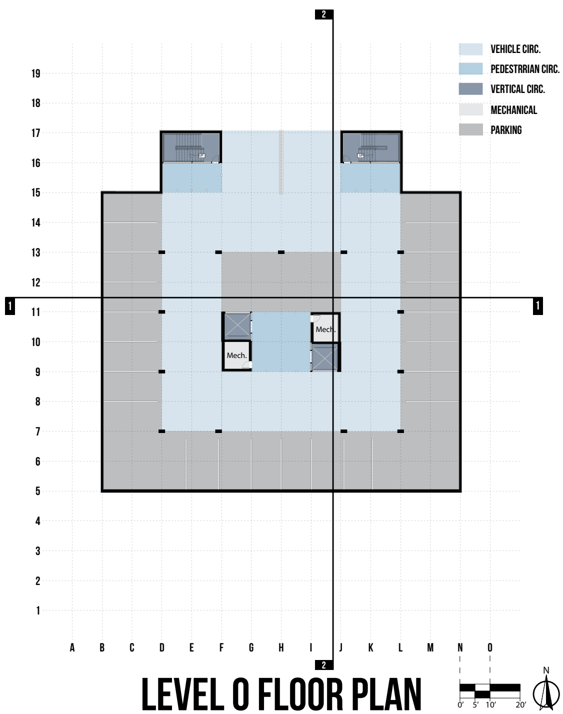


LEVEL 5 FLOOR PLAN

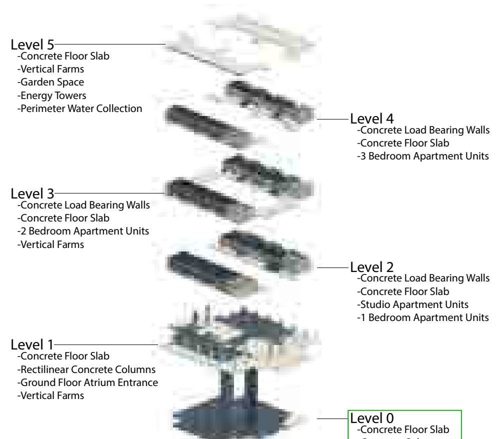


STRUCTURE/LAYOUT

THE FINAL DESIGN

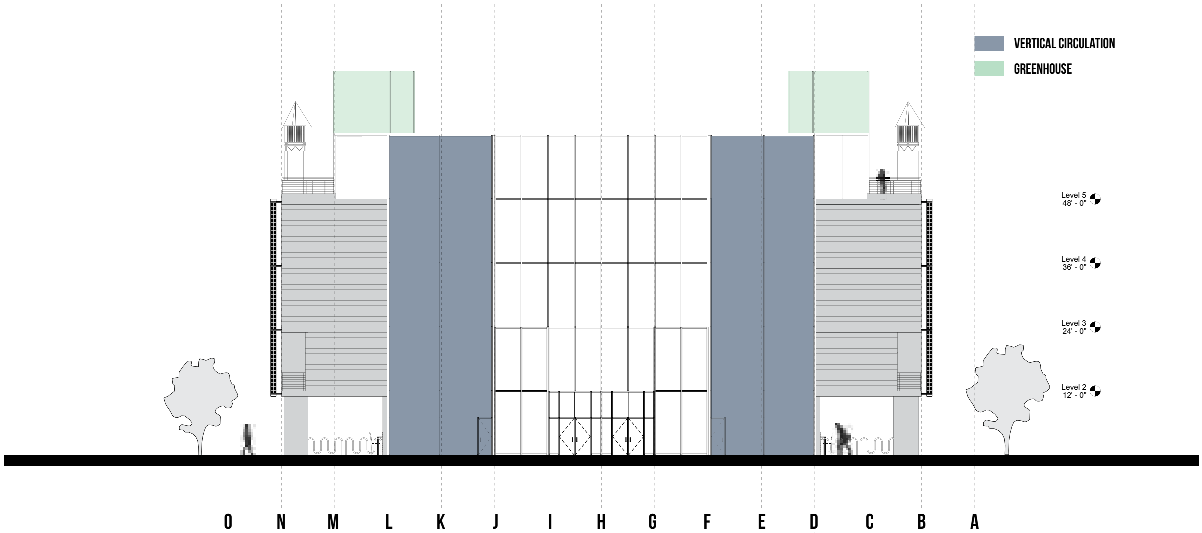


LEVEL 0 FLOOR PLAN



STRUCTURE/LAYOUT

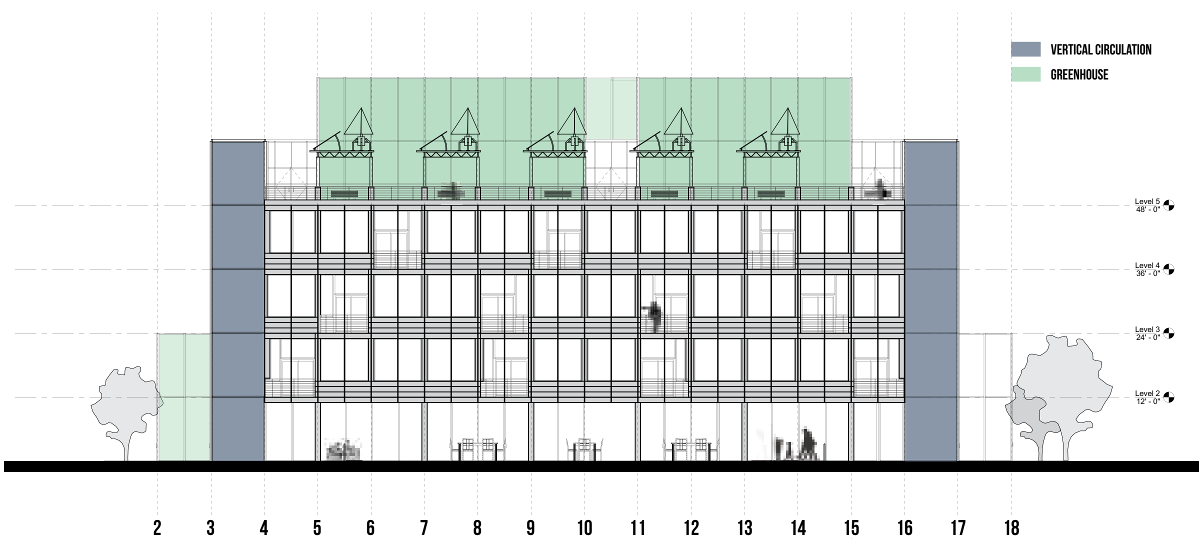
THE FINAL DESIGN



NORTH ELEVATION

0' 5' 10' 20'

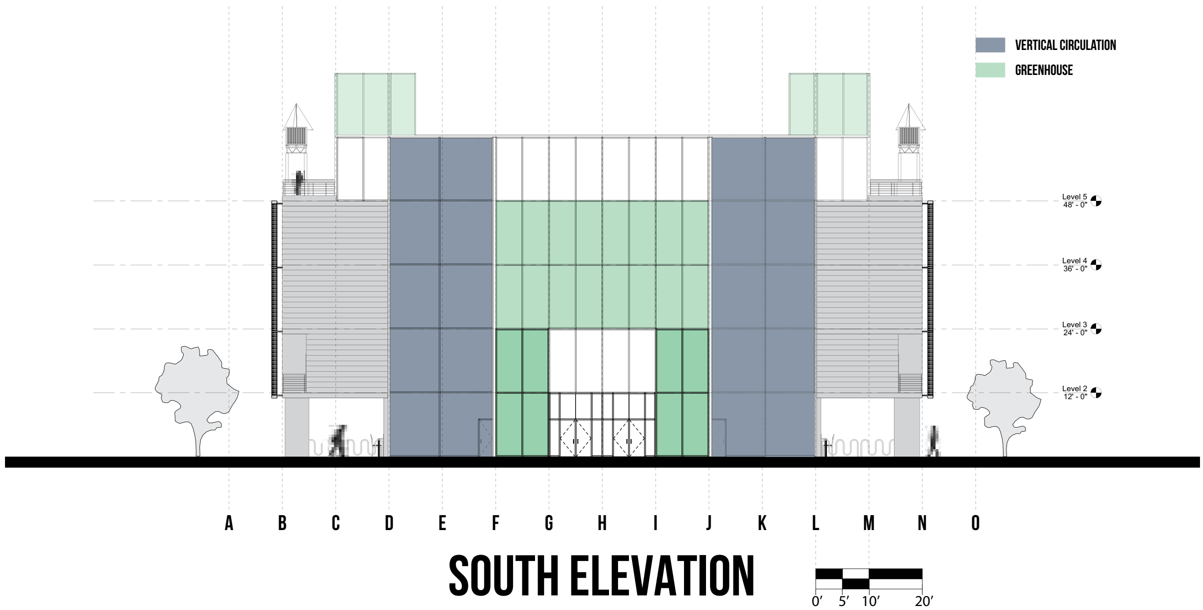
THE FINAL DESIGN



EAST ELEVATION

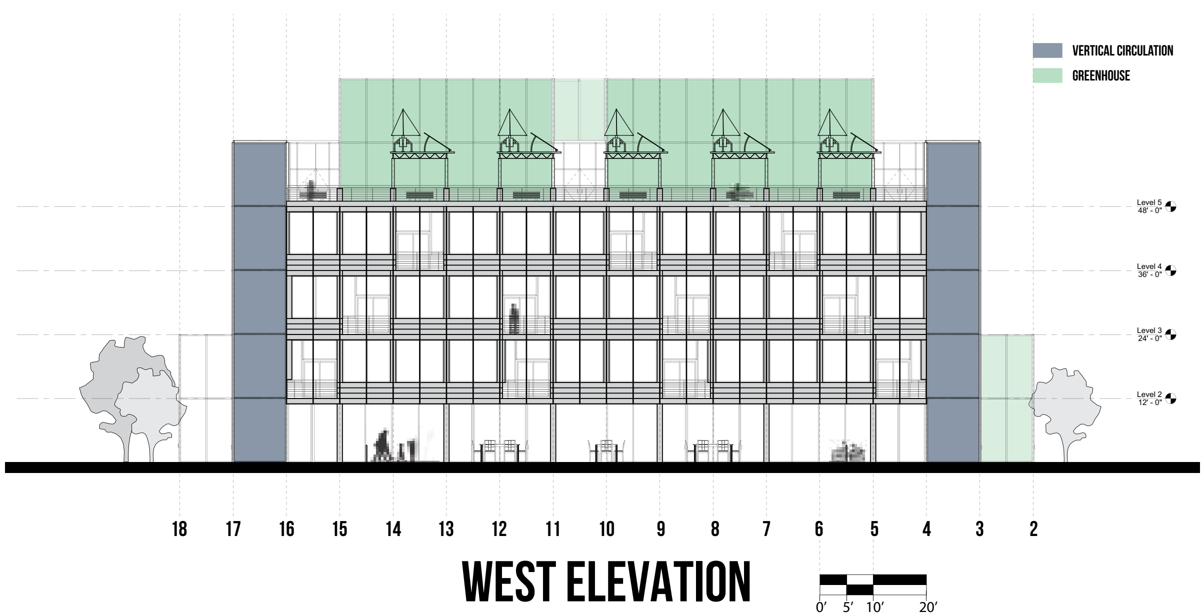
0' 5' 10' 20'

THE FINAL DESIGN



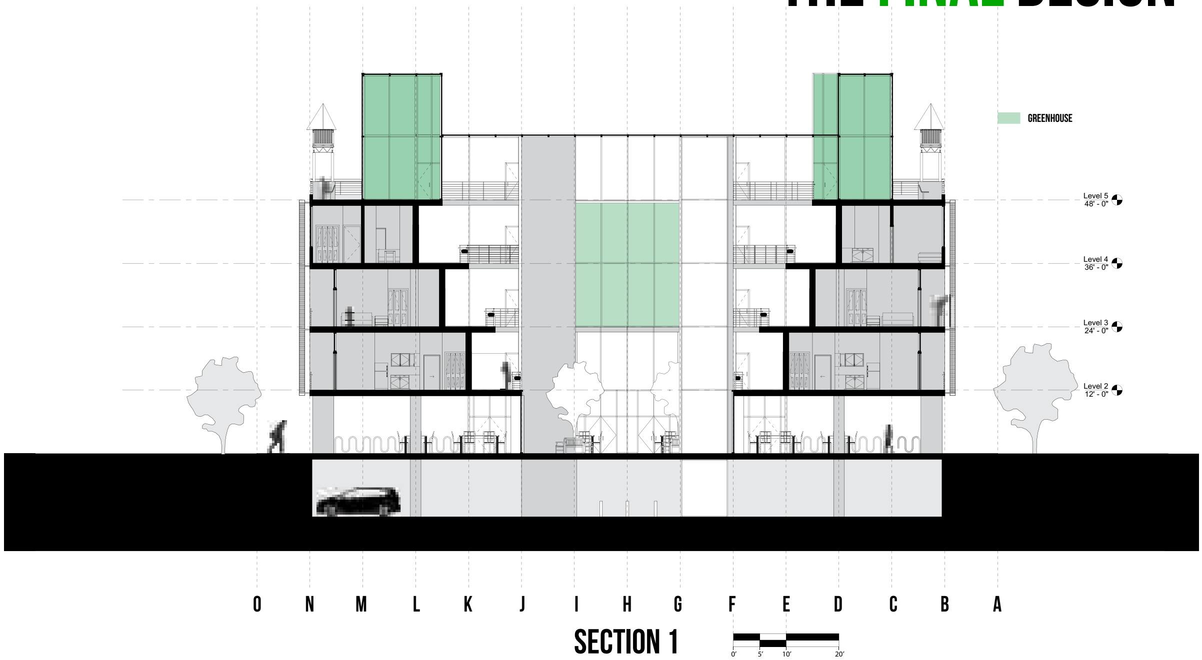
SOUTH ELEVATION

THE FINAL DESIGN



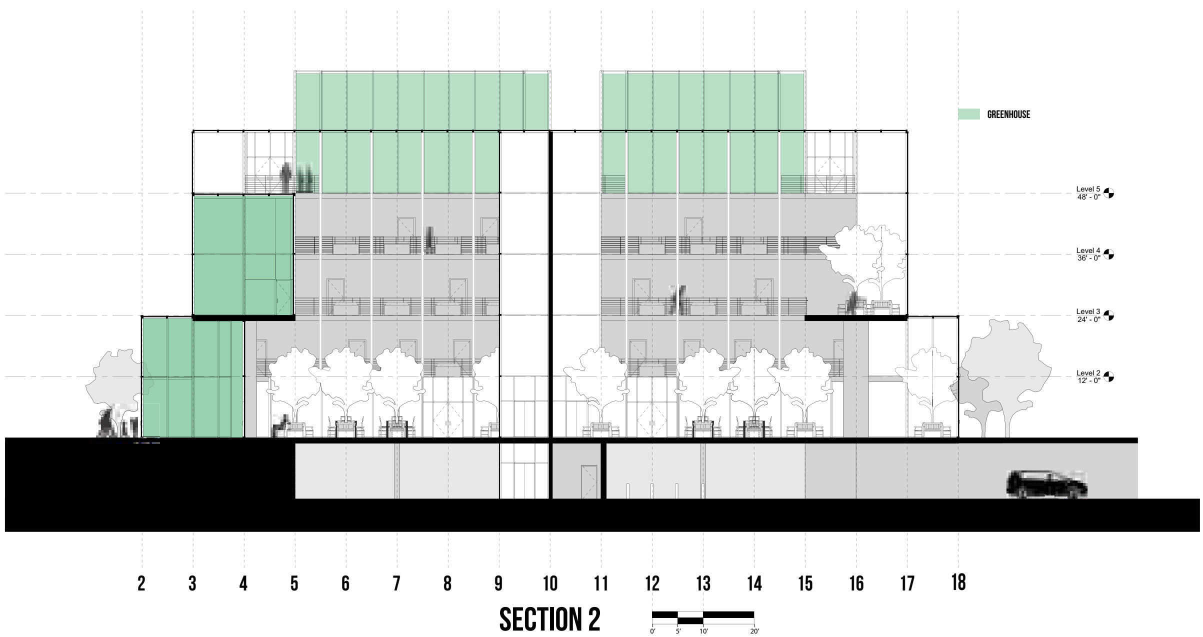
WEST ELEVATION

THE FINAL DESIGN



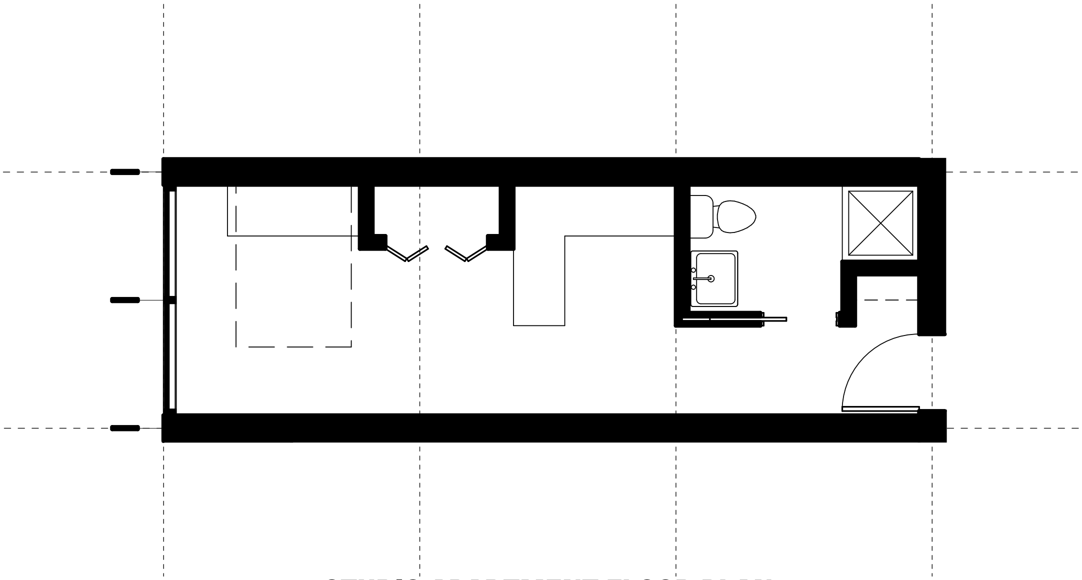
SECTION 1

THE FINAL DESIGN



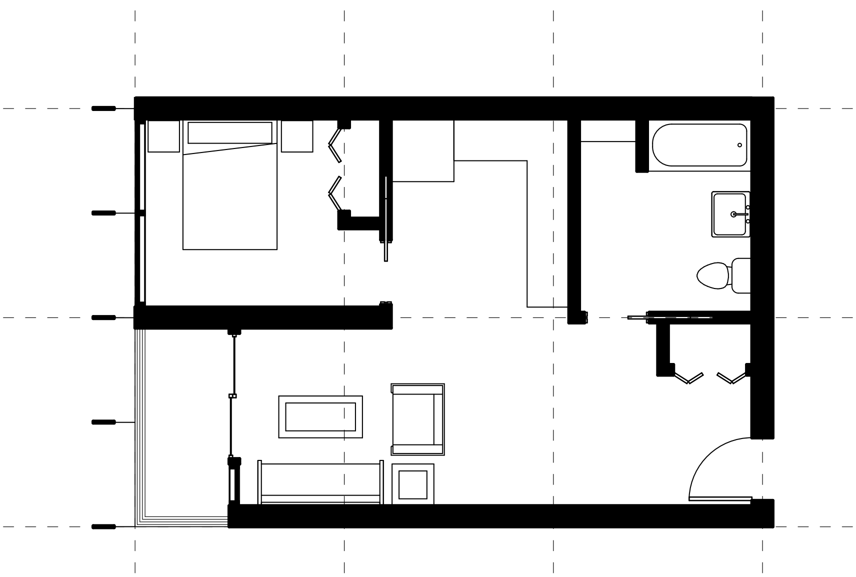
SECTION 2

THE FINAL DESIGN



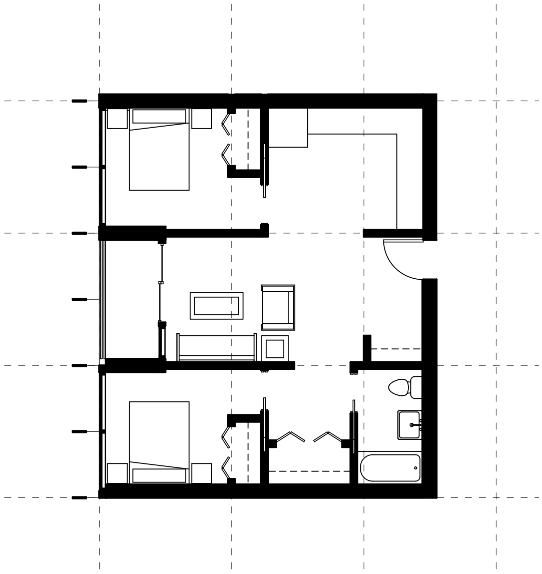
STUDIO APARTMENT FLOOR PLAN

THE FINAL DESIGN



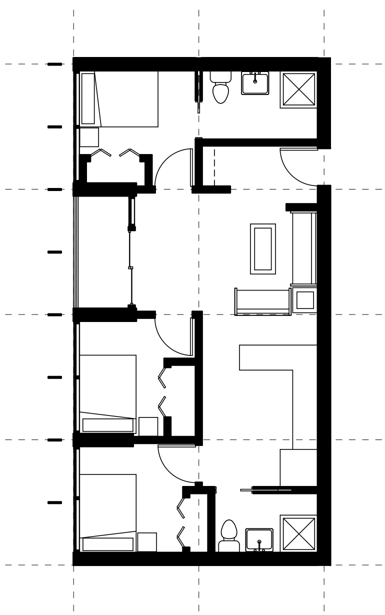
1 BEDROOM FLOOR PLAN

THE FINAL DESIGN



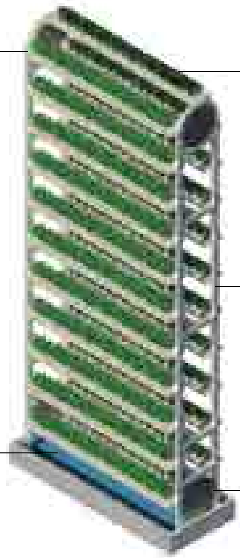
2 BEDROOM FLOOR PLAN

THE FINAL DESIGN



3 BEDROOM FLOOR PLAN

THE FINAL DESIGN



Lettuce Beds
-Romaine lettuce
-Beds rotate around the tower
-Requires 6 hours of sunlight daily
-10 lettuce plants per bed
-22 Planter beds per tower
-32 Towers per building

Varying Tower Heights
-Grouped towers can vary in height to allow access to sunlight when reaching near the top of the rotation

3" Aluminum Framing
-Can be integrated into the greenhouse framing for additional structural support

Nutrient Infused Bath
-Lettuce beds dip into the enriched bath at the bottom of the rotation

Gravity Fed Water Wheel
-Closed loop hydraulic system
-About $3.00 in electricity costs per month
-About the same energy requirements of a 60W light bulb

VERTICAL FARM TOWER

The Numbers

-7,040 lettuce plants per building
-6 week harvest cycles
-There are 56,320 lettuce plants produced per building, per year
-With there being 4 buildings, the entire residential complex produces 225,258 lettuce plants per year
-Assuming all 223,490 of the Fargo/Moorhead area residents eat the average of 10-12 lettuce per year, this residential complex could supply about 8.4% of Fargo/Moorhead's lettuce consumption

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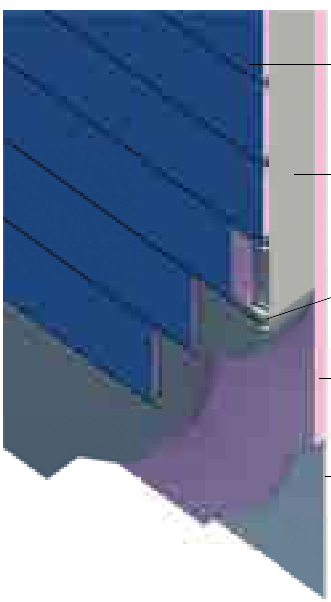
THE FINAL DESIGN



Insulated Metal Panels

7 3/8" Concrete

2" Aluminum Panel Bracket

2" XPS Insulation

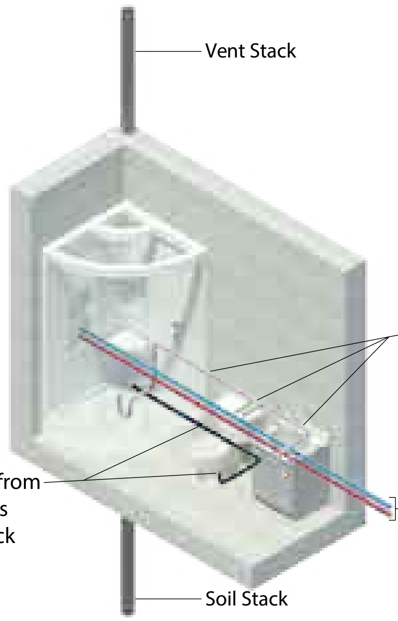
5/8" Gypsum Board

RAIN SCREEN/WALL DETAIL

Water Collection

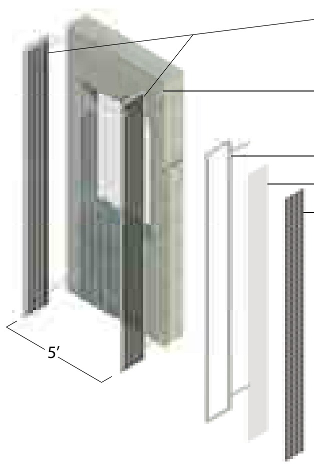
– As rain or snow runs down the side of the building water is collected in the 2" aluminum panel brackets and consequently redirected within the building
– The collected water would supply the vertical farms as well as the residential units

THE FINAL DESIGN



EFFICIENT PLUMBING SYSTEM

THE FINAL DESIGN



EAST/WEST SHADING DEVICES

ENERGY TOWER

FINAL THESIS DISPLAY


REVISITING RESIDENTIAL DESIGN

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All photographs and images were taken and created by the author of this book, Jetse Vollema (2013) unless otherwise noted.

PERSONAL INFORMATION

Jetse Vollema

502 8th Street S. (Unit 2)
Fargo, ND 58103
(952)-687-1935
Jetse.Vollema@my.ndsu.edu

Hometown: Amsterdam, The Netherlands

"A thought, idea, or design is only as effective as the conceiver's ability to communicate it."


Personal Identification (Figure 25)