# Three Court Green

## An Exploration of Thermal Comfort and Vernacular Design Adapted to the American Condition

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Graduate Thesis Design 2018
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# INTRODUCTION

## BACKGROUND

Until the mid 20th century, cultures across the globe have relied on vernacular design to overcome adverse climatic conditions and provide themselves with spaces for living and working that offered occupants some measure of thermal comfort. With the rise of efficient indoor heating and cooling systems we have become increasingly dependant on a set of tightly defined, static indoor condtions of temperature and humidity. With this has come an increased separation from the natural world and an increase in household energy needs, both of which take a toll on the health of our natural world.

History teaches us that this resource heavy, static comfort model is no the only option. The adaptive comfort model shows that humans are able to achieve comfort through personal adjustments to seasonally dependant variation in indoor conditions. Initiating a societal shift towards adaptive comfort relies on how the message is delivered as well as how the interior environment is designed. Having society embrace interior systems designed to be highly sustainable may meet with more success if that design provides an increased quality of life and experience for the user, a system Bjarke Ingles refers to as Hedonistic Sustainability. An understanding and adaptation of vernacular design principles to contemporary needs can provide this increase in quality of life and user experience.

The goal of this project was to design a series of machines for living making use of vernacular principles to provide hedonistic sustainability in a residential setting. Through redevelpment of an exisitng urban warehouse structure these principles were put into place for small and medium sized residences to provide hedonistic sustainability at the personal, household and community level.

For a more detailed, referenced discussion see Appendix A.

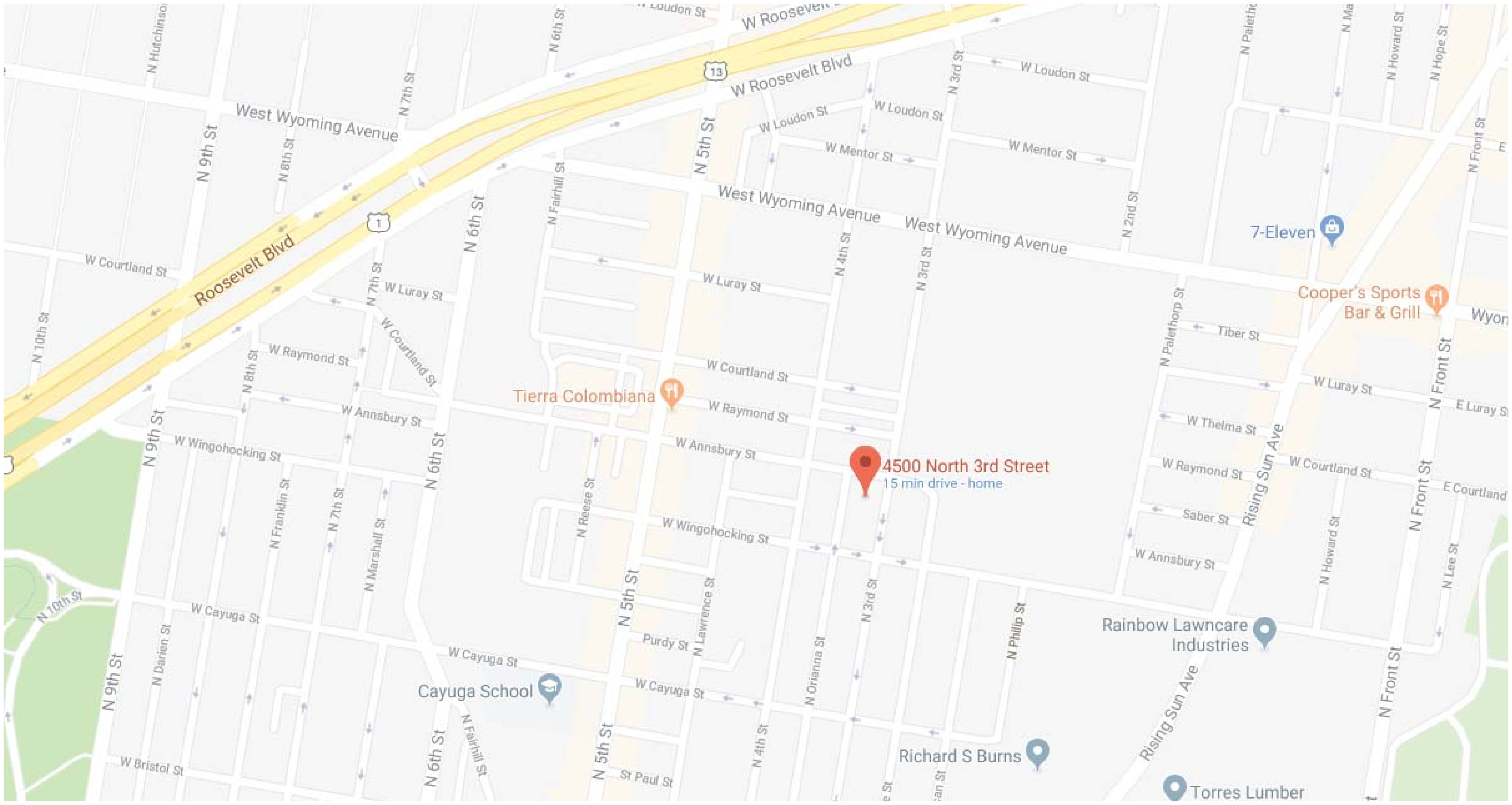
## SITE CONSIDERATIONS

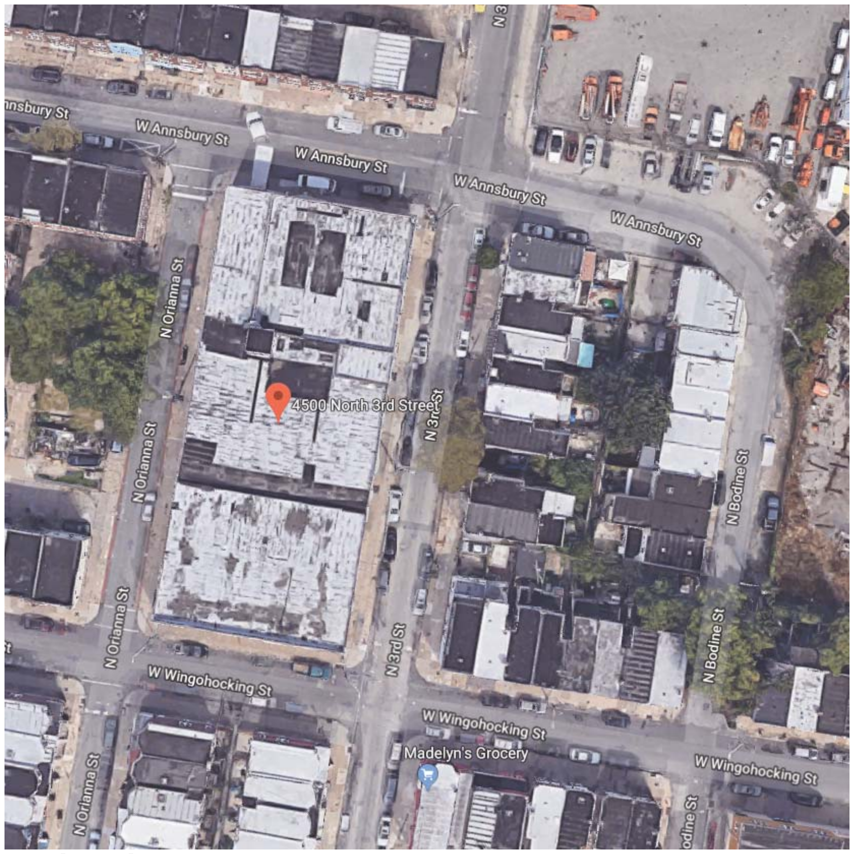
A number of ideal conditions were determined in advance of site selection in order to narrow down possible locations and to maximize successful adaptation of vernacular design elements. The ideal building was determined to be free standing in order to maximize opportunity for permeabilizing the building envelope for light and air movement. A two to three story structureof ~50,000 square feet with a wide column grid system was determined to be ideal in order to offer opportunities for the introduction of internal courtyards as well as open space planning to facilitate airflow through the interior of the units. Finally, a site location near or within a residential area made the success of the project more beleiveable.

## 4500 NORTH 3rd STREET

A review of buildings currently on the market in Philadelphia, PA was conducted and the warehouse structure at 4500 N. 3rd St. was identified as an ideal candidate location. The site is a completely free standing, two story, ~42,000 sq. ft. warehouse structure. Large windows (some currently closed in) surround the building on all sides. Based on analysis of the parapet walls at roof level and the measurements of the existing column grid the building appears to be a collection of 3 larger structures and one smaller structure. The north and central portions of the building contain a steel column grid of 12’ x 17’ and 24’ x 30’ respectively. The southern portion of the building appears to have been built last and is supported by a reinforced concrete drop column capital grid of 24’ x 23’. Ceiling heights across the entire first floor are 14’9” (including plenum). The north and central portions of the second floor are 13’7” (including plenum) while the southern portion is slightly taller at 15’2”. The smaller structure is supported by wood beams running between brick supporting walls and maintains heigh dimensions of the north and central portions of the building.

Site analysis shows that the main axis of the builidng runs southwest to north east. The building is surrounded on all sides by 2 story rowhouses while a SEPTA train yard sits diagonally across from the northeast corner of the building. A main shopping street, 5th street, is located 2.5 blocks west. An analysis of yearly wind patterns indicate a prevailing wind blowing from the southwest throughout the late spring, summer and early fall. Of importance to note is the building’s siting within a hill. The northern portion first floor is located 2’10” above grade while the souther portion is lcoated 2’8” below grade. Without the addition of ramps or lifts wheelchair accessability to the structure occurs only at one point on the east and one point on the west side of the building.



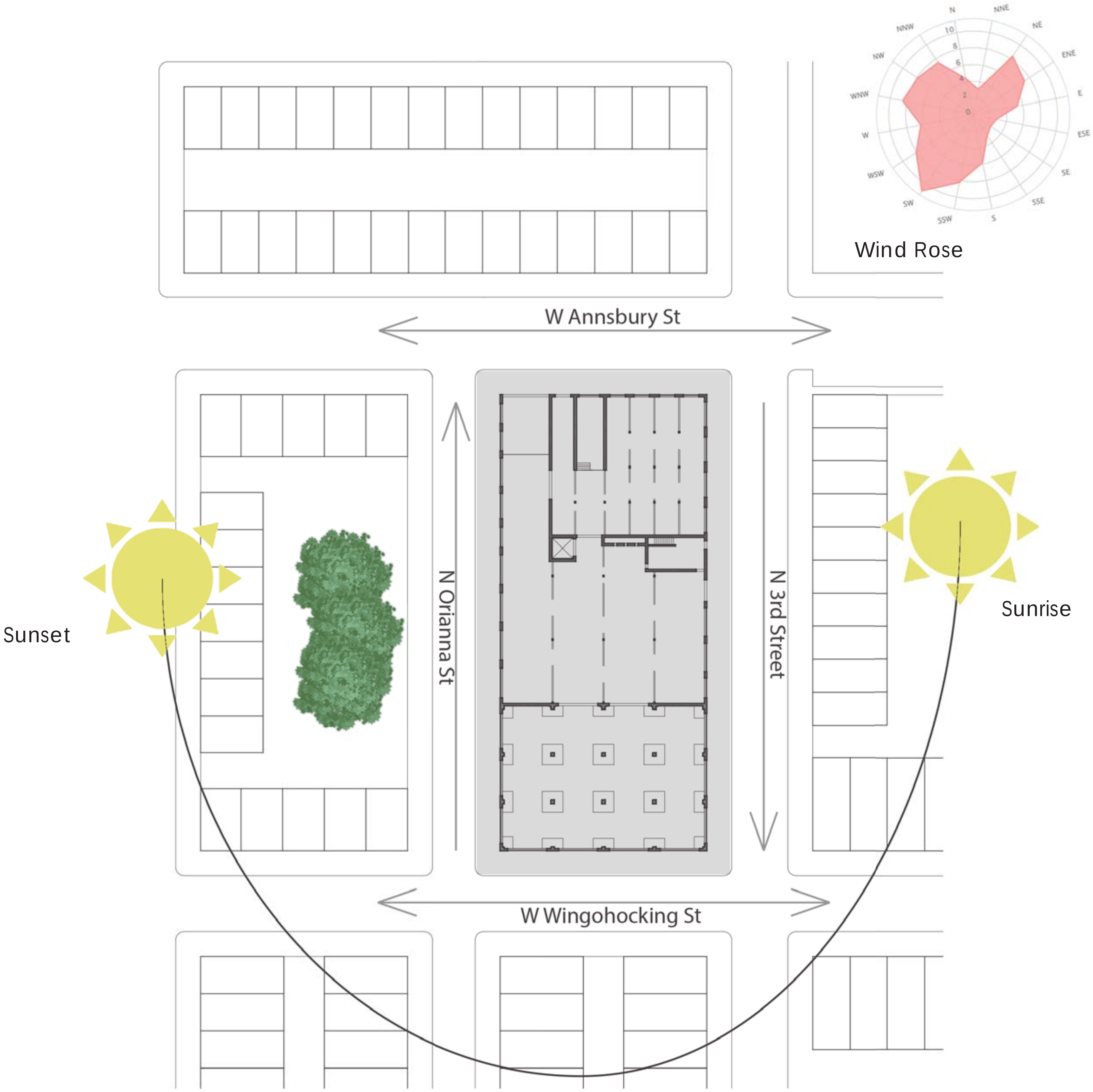




**Aerial View**

**View of South West Corner**

**View of North East Corner**

Images on this page provided by Google Maps.




**Site Analysis - Sun and Wind**

# VERNACULAR ADAPTATIONS

## VERNACULAR ADAPTATIONS

Cultures across the globe and throughout time have developed location specific building adaptations to deal with climate and provide a thermally comfortable environment. While these vernacular designs are products tailored to their specific site and cultural conditions they contribute to a set of general principles that have and can be adapted to design problems around the world.

A survey of vernacular design principles from around the world indicates that thermal comfort is in large part about control of airflow and heat gain via direct solar radiation, and the buffering qualities of thermal mass. Three vernacular design concepts were chosen as design focal points: courtyards, wind / light towers, and windows / balconies.

### Courtyards

Courtyards were chosen as a organizing feature for psychological as well as functional reasons. Within a dense urban environment private courtyards offer an element of luxury by allowing for private outdoor space safe from intrusion by the noise and bustle of the surrounding city. Courtyards allow for both direct and ambient light penetration into the deep structure of the building. Functionally courtyards also work to create a cool outdoor living space that can generate its own air movement, providing a cooling breeze within the courtyard and rooms opening on to it. By using materials with high thermal mass such as brick flooring, concrete stairs and accents and pebble dash walls the interior, especially the lower portion, of the courtyard generally remains cooler than other areas that are exposed to more direct solar radiation. Geothermally cooled fountains in each courtyard add to the cooling effect. The upper portion of the courtyard and the metal clad parapet walls surrounding it are heated by the summer sun. The resulting difference in temperature between the cool courtyard floor and the warm upper portion starts airflow via convection, with the warmer air rising and pulling the cooler air behind it. By opening rooms to both the courtyard and the exterior of the building, air is pulled through each room from the outside and vented out of the courtyard.

### Wind and Light Towers

Wind / light towers were incorporated into the building for their high degree of functionality. Spatially they form stair towers connecting lower and upper floors. Functionally they provide a large amount of ambient light through a series of tall, narrow casement windows, small square clerestory awning windows and a fixed glass skylight forming the tower ceiling. All openings are protected from direct solar radiation through the use of deep eaves, vertical fins and parapet walls.

The towers also have a strong functional role in the control of air movement. During the warmer months of the year the prevailing winds blow from the southwest. By opening the casement windows along the south and west sides of the tower the prevailing winds can be captured and shunted down through the tower, across the living space venting out of windows opening onto the street or into the connecting courtyard. During periods where no strong external air movement exists all of the windows in the tower can open and gain function in a similar manner to the courtyard, making use of air convection and the chimney effect to pull air through the living space and out of top of the tower. It should be noted that under these conditions the tower and the courtyard may compete with one another for airflow and so cancel one another out. A proper balance will need to be empirically determined by the user based on a general understanding of daily conditions. The number and type of windows open at any given time will regulate airflow via either method.

### Windows and Balconies

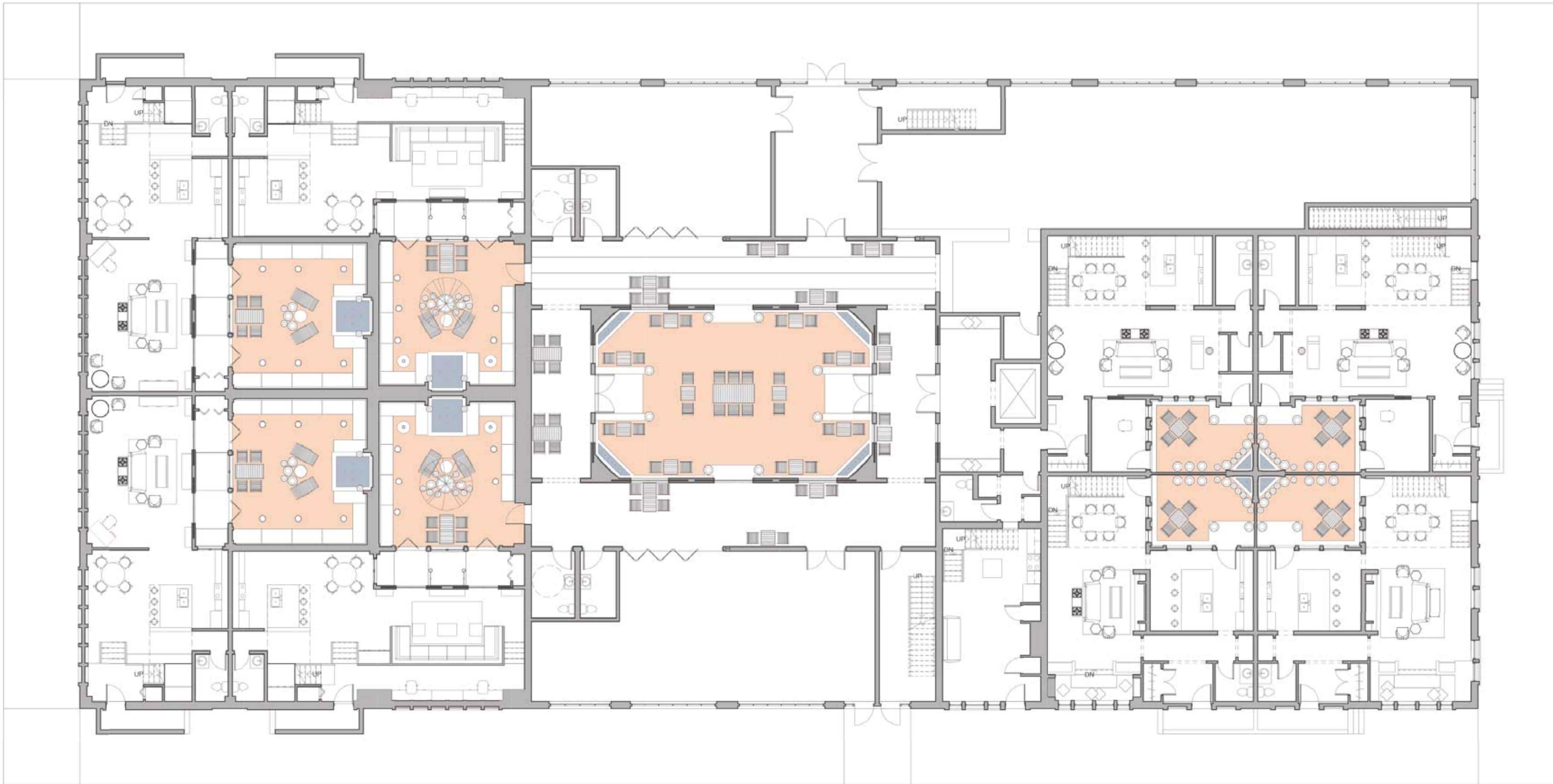
A variety of window options and balconies were incorporated into the structure to provide functional adaptability in regulating conditions in any given location. On all facades importance was placed on maximizing opportunities for incorporating operable windows while decreasing direct solar radiation during summer months that might otherwise generate a hot, uncomfortable interior environment. On the cooler north and east sides of the building windows were pulled from the facade to generate counter height surfaces for working, entertaining or just growing plants. On the warmer south and west facades windows were kept in line with the building envelope and window mullions were extruded to form deep horizontal and vertical fins. These fins block heat gain via direct solar radiation while allowing for cooler, indirect light to enter interior spaces.

On the east, south and west facades narrow balconies were designed to increase internal space, limit heat gain via direct solar radiation and to act as a buffer zone. Balconies on the exterior of the building have operable windows on the exterior and sliding glass doors seperating them from the interior. During hot summer months the balcony shades the interior space while the open windows prevent heat build up within the balcony itself. Opening and closing of the interior sliding doors allows the occupant to adjust their level of exposure as desired. During cooler months heat can be purposefully gained by keeping the windows closed, allowing for a build up within the balcony that can be kept as a buffer by closing the sliding doors or used selectively as an accessory heat source by opening the sliding doors. The balconies are also inhabitable in their own right, with each provided with a small table and chairs as well as a built-in window seat.

### Shadow Study

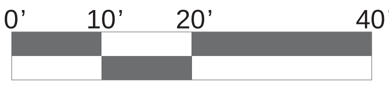
A shadow study conducted at peak sunlight hours for each facade confirmed the success of shade features on the exterior of the building. The building model was sited in Revit at its geographic location and the times of day adjusted to achieve the most accurate predictions possible.

# COURTYARDS



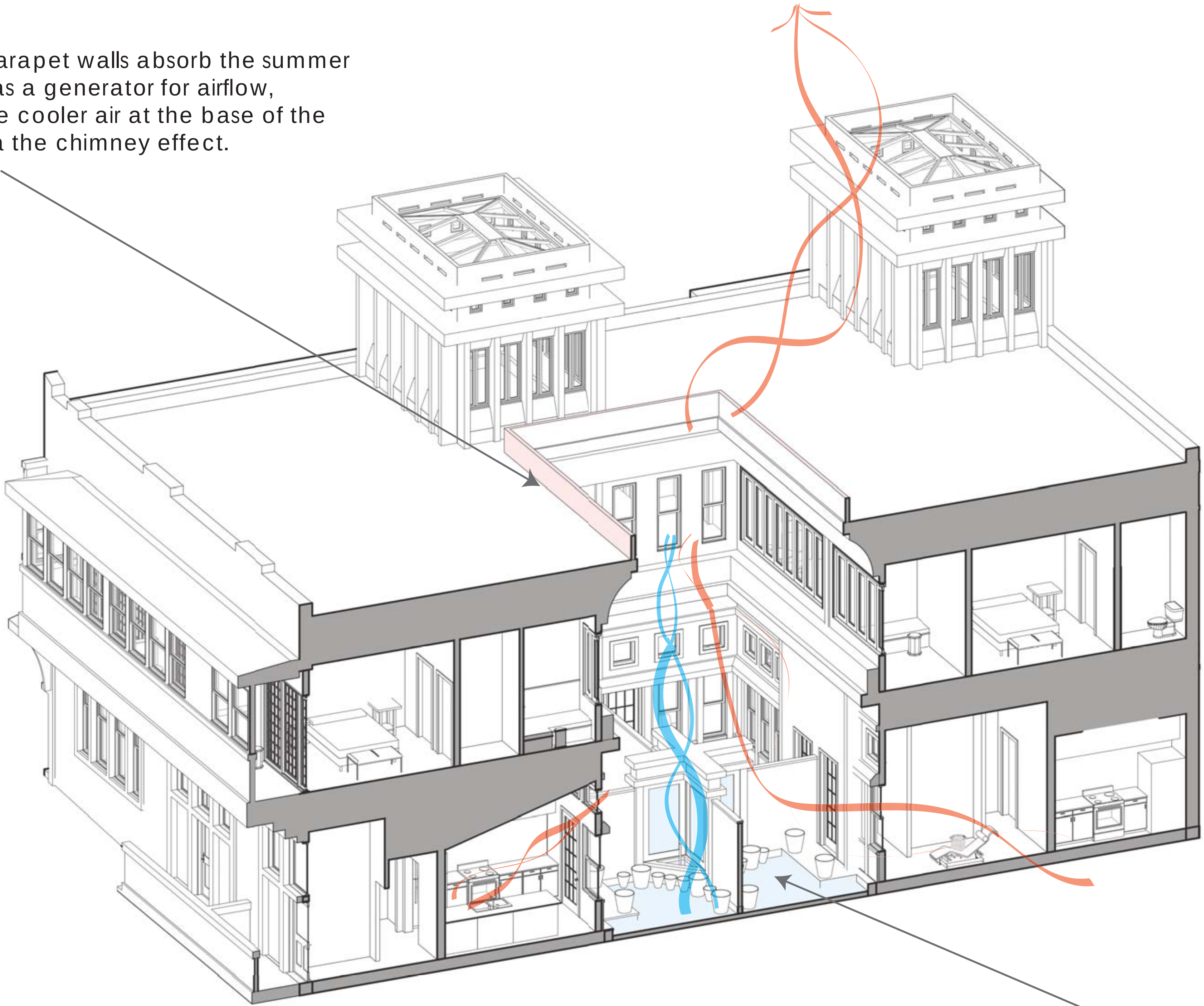
First Floor Plan

Courtyards



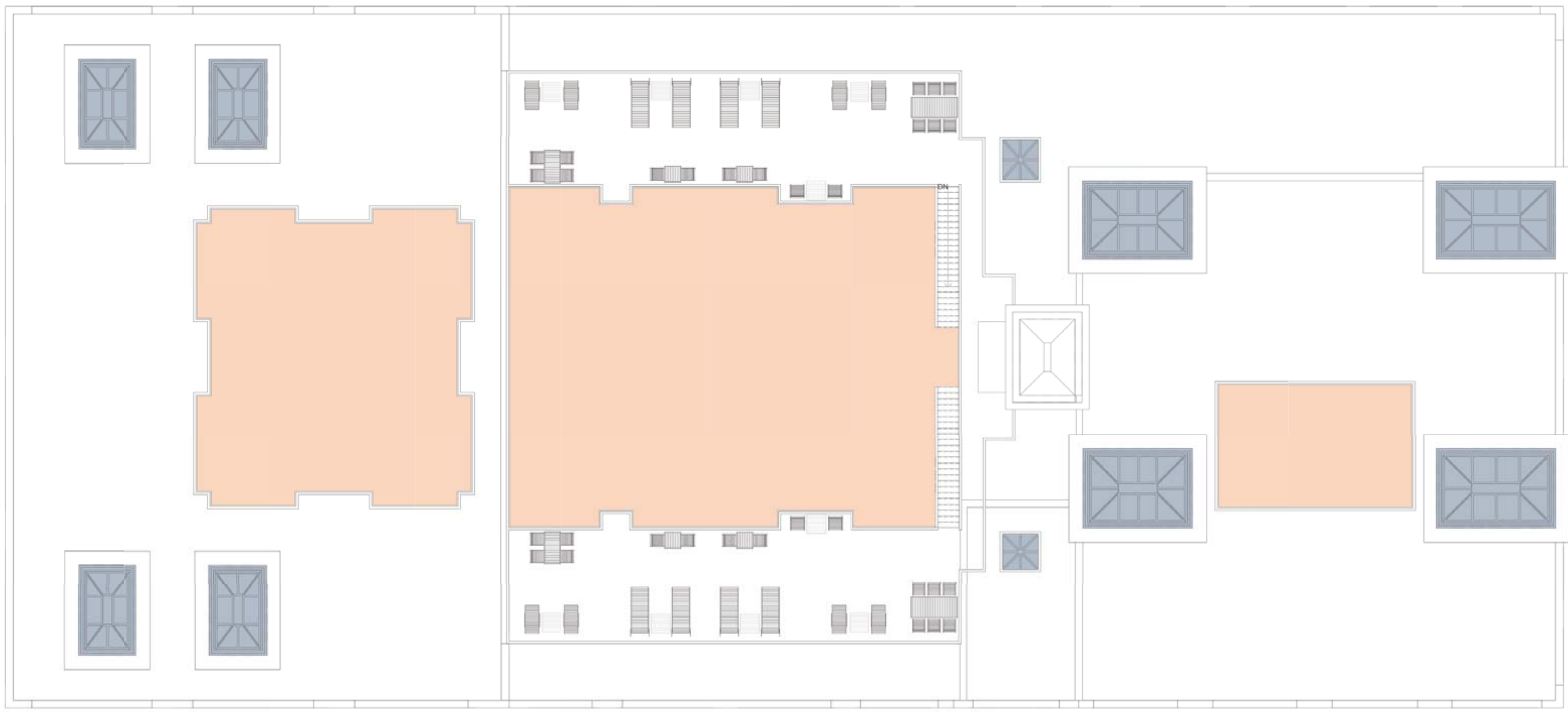
# COURTYARDS

Metal clad parapet walls absorb the summer sun and act as a generator for airflow, along with the cooler air at the base of the courtyard, via the chimney effect.



Fountains and high thermal mass surfaces (stone, brick) maintain a cool base for the generation of chimney effect in combination with the air heated at the top of the courytard by the metal clad parapet walls.

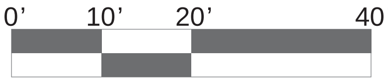
# WIND AND LIGHT TOWERS



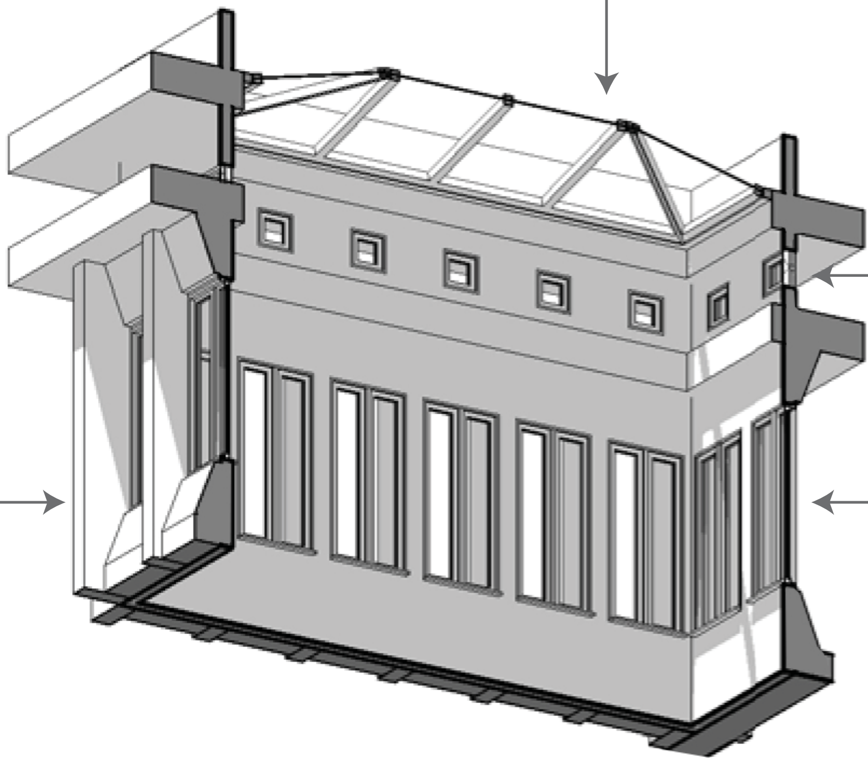
Roof Plan

Wind and Light Towers / Skylights

Courtyards

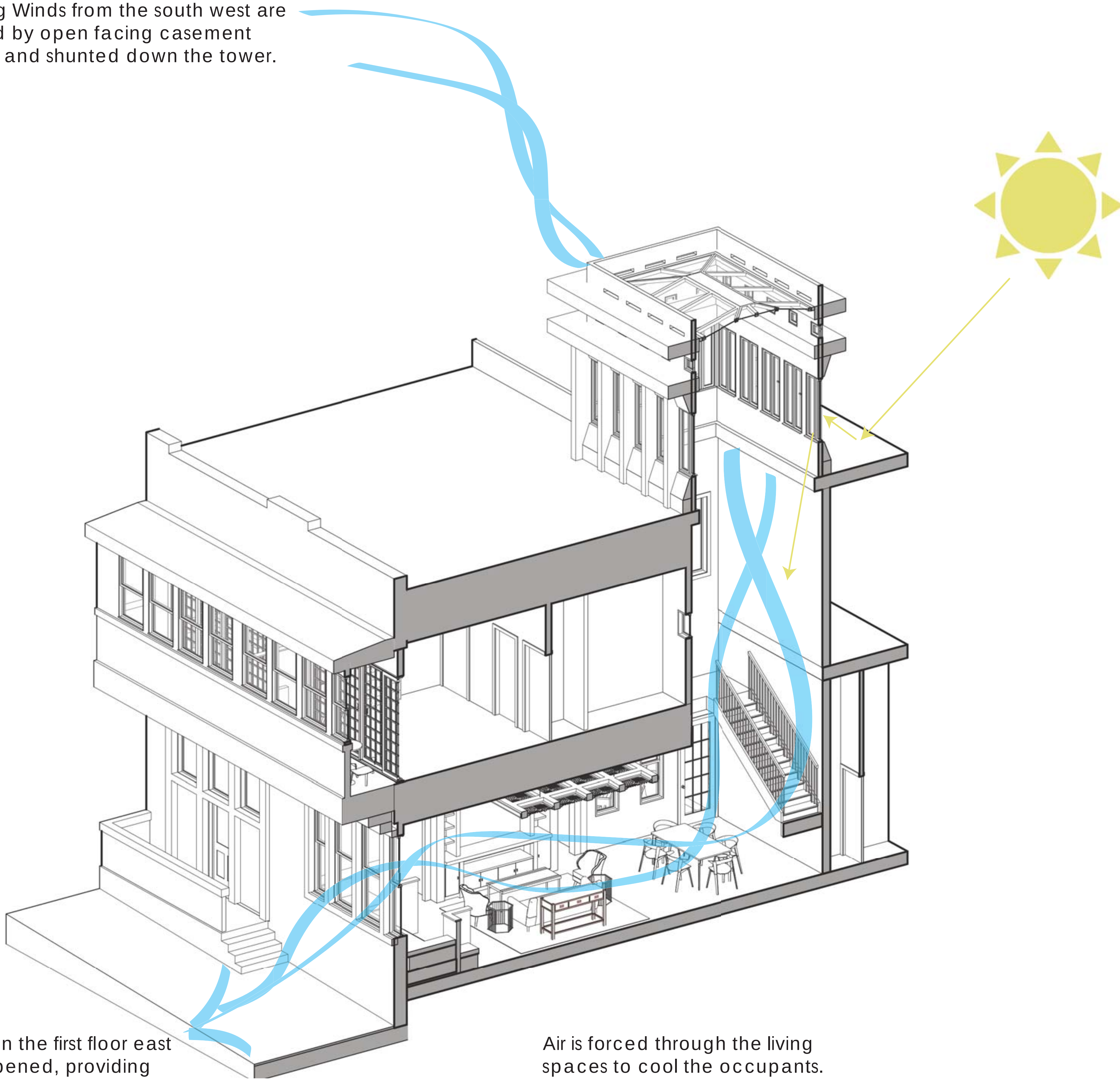


# WIND AND LIGHT TOWERS




Model Section of Tower
Not to Scale

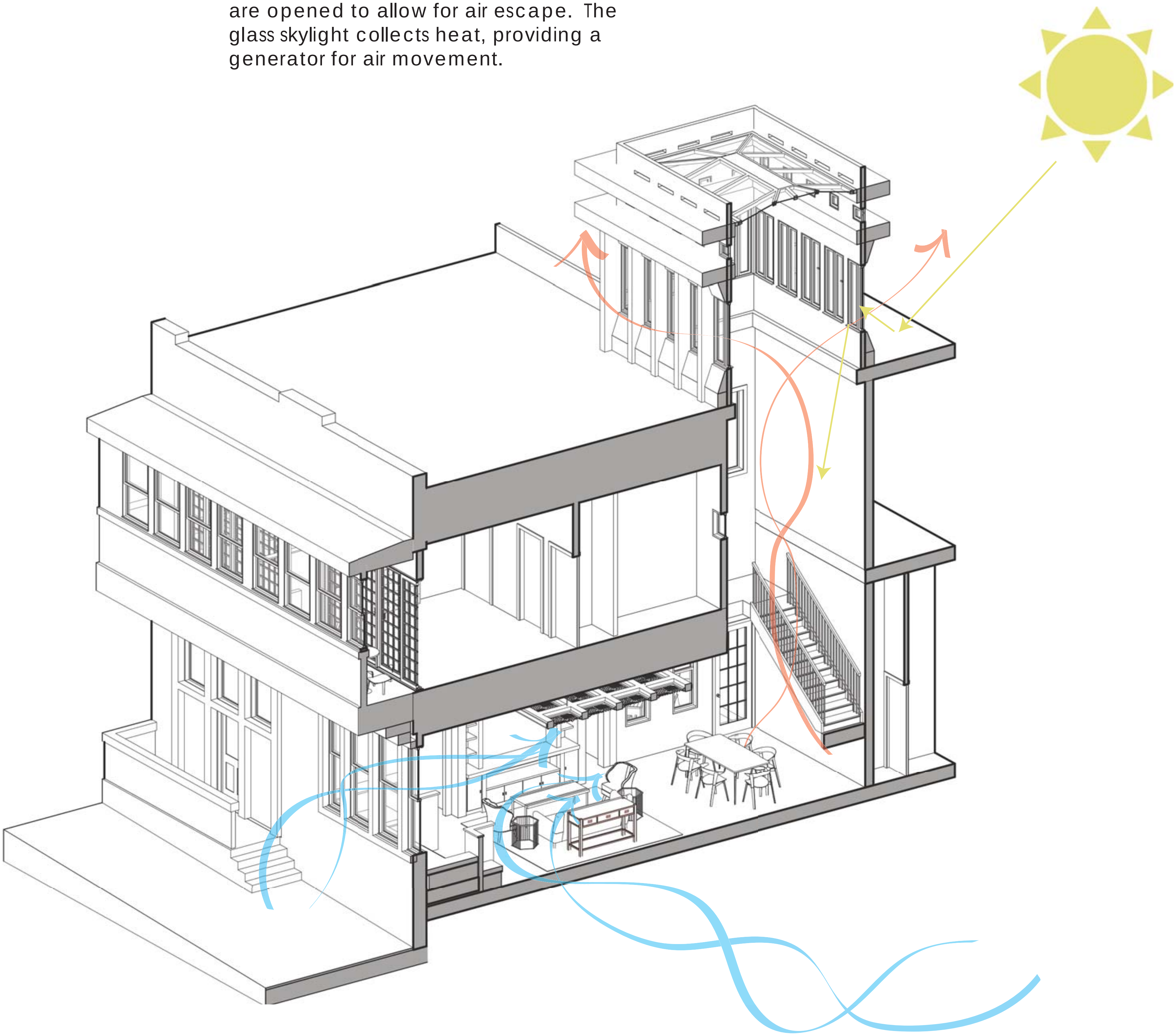
# WIND AND LIGHT TOWERS




Wind Catcher Scenario

# WIND AND LIGHT TOWERS

On windless days all of the windows in the tower, regardless of facing direction, are opened to allow for air escape. The glass skylight collects heat, providing a generator for air movement.

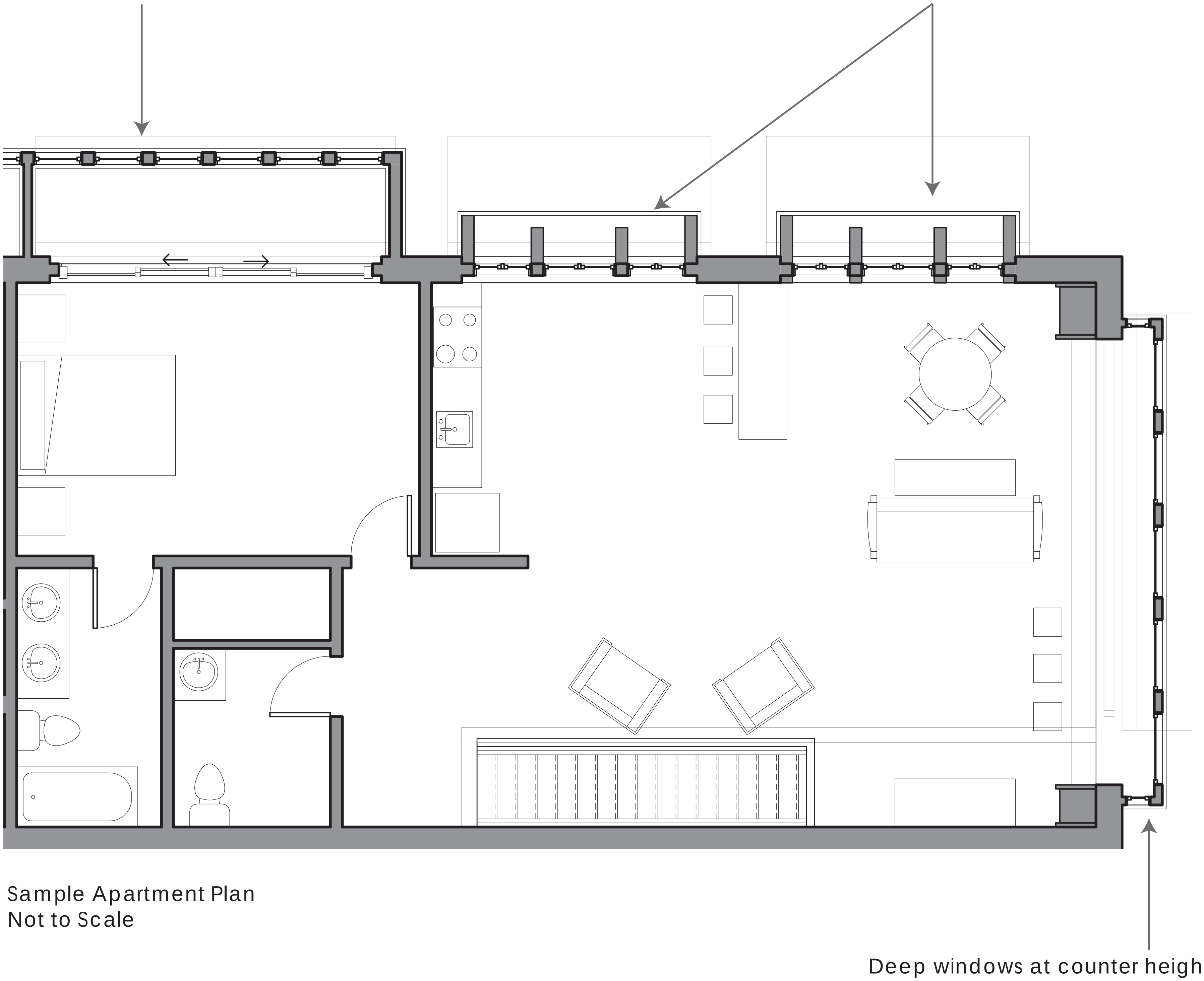


Solar Chimney Scenario

# WINDOWS AND BALCONIES

Balconies provide buffer space from direct sun during the summer when windows are open while collecting heat during winter with windows closed.

Deep projecting fins help provide shade as well as visual structure to window units.

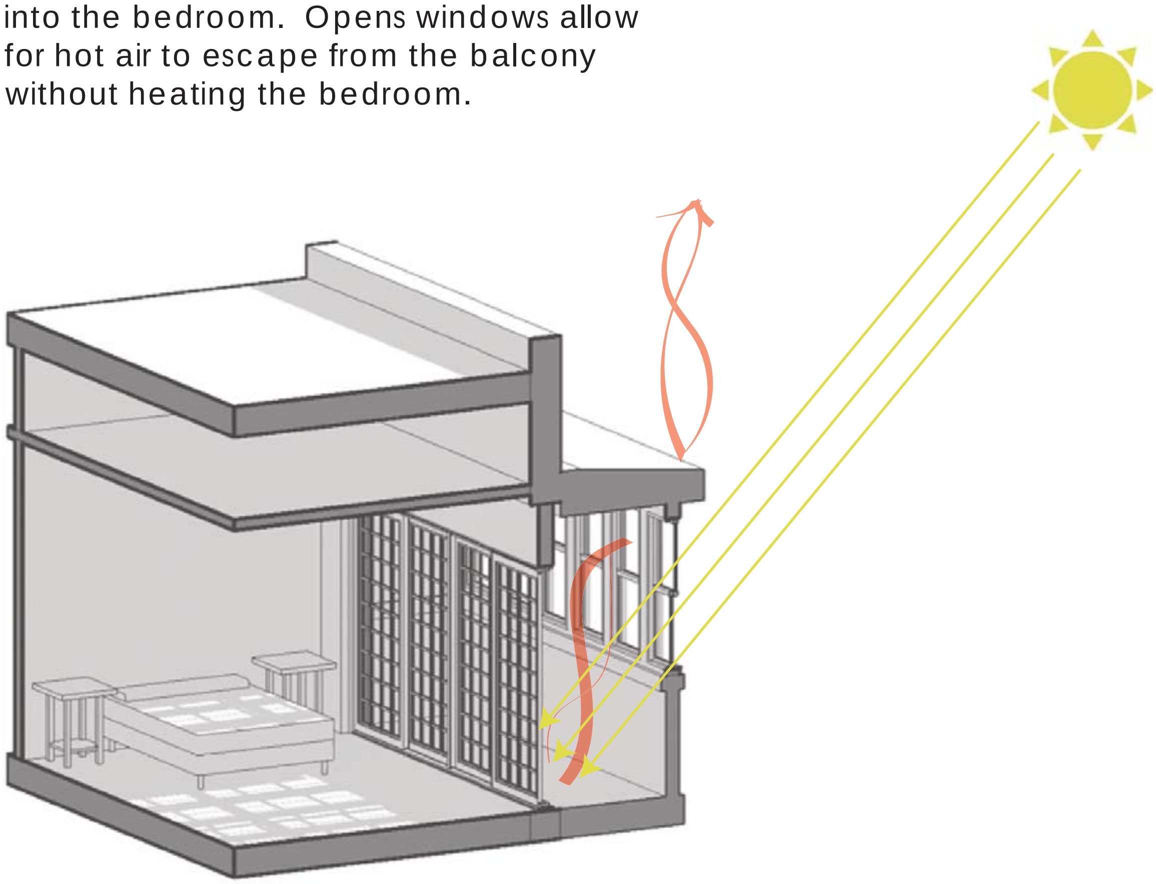


Sample Apartment Plan
Not to Scale

Deep windows at counter height provide space for reading, working, entertaining or just growing plants.

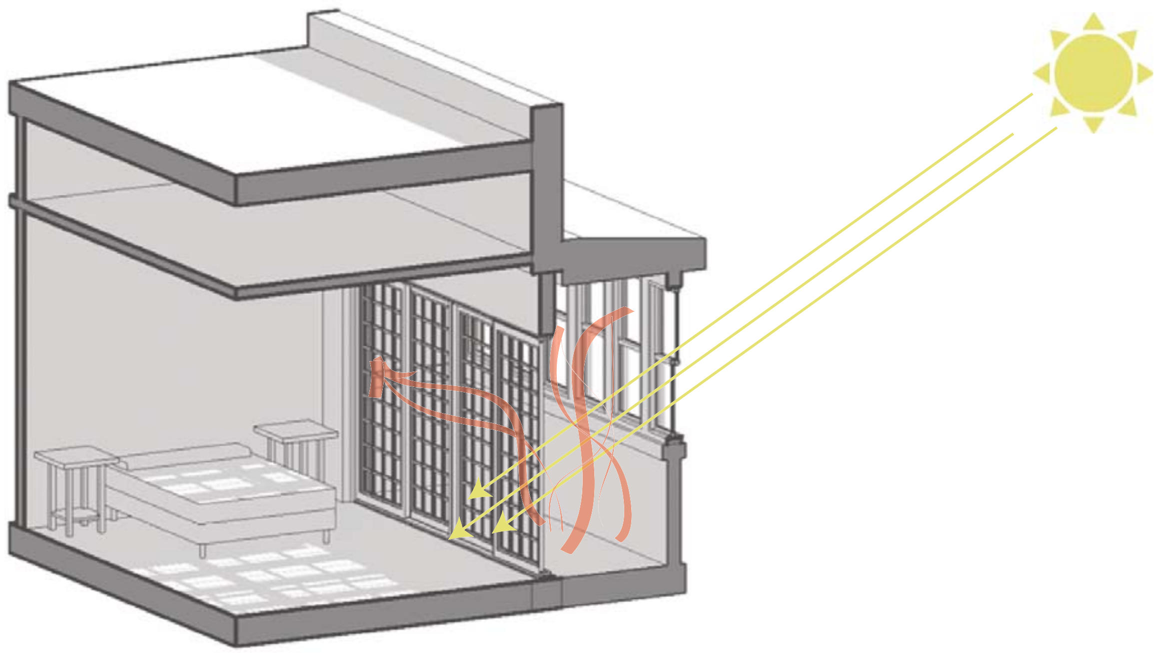
# WINDOWS AND BALCONIES

When the Sun is higher in the sky during summer light does not penetrate as far into the bedroom. Opens windows allow for hot air to escape from the balcony without heating the bedroom.



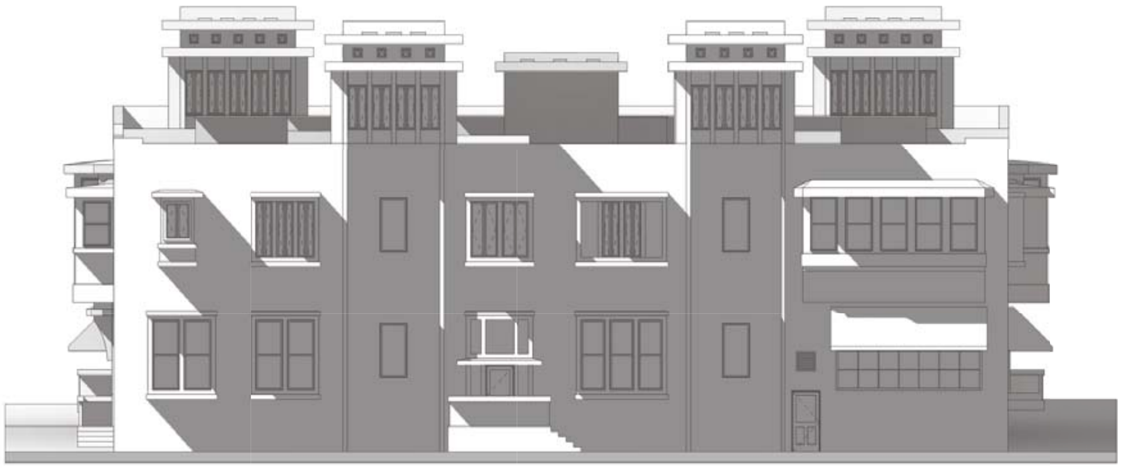
Summer

When the Sun is lower in the sky during winter light penetrates further into the bedroom. Closed windows allow for hot air to build up within the balcony providing a source of warmth for the bedroom.

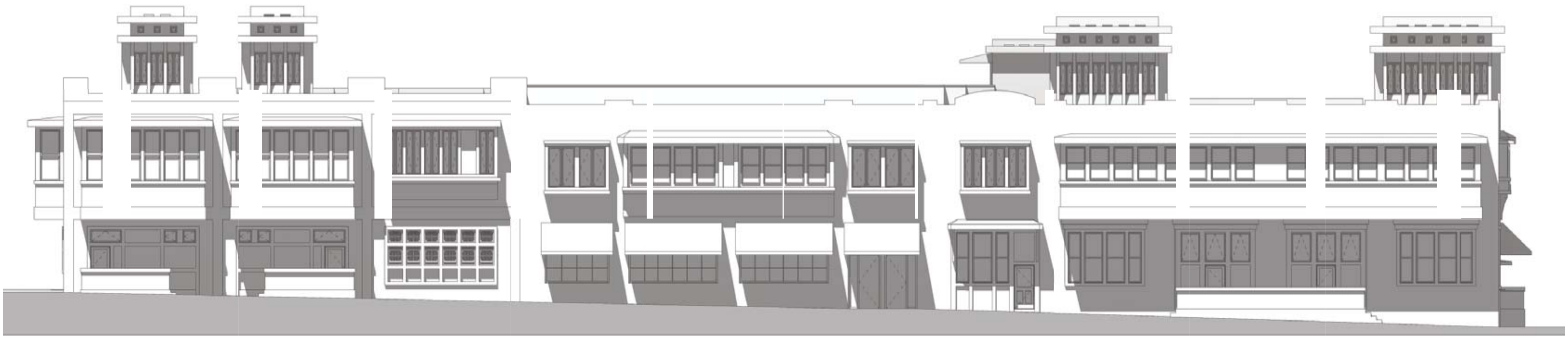


Winter

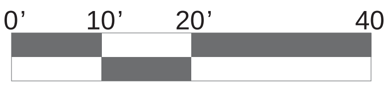
# SHADOW STUDY

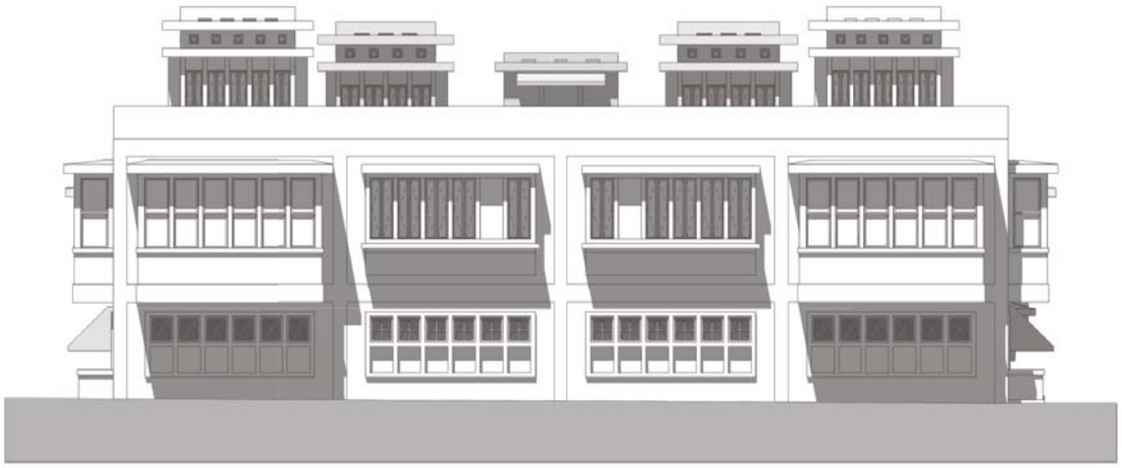


North Elevation 9 AM on June 30th

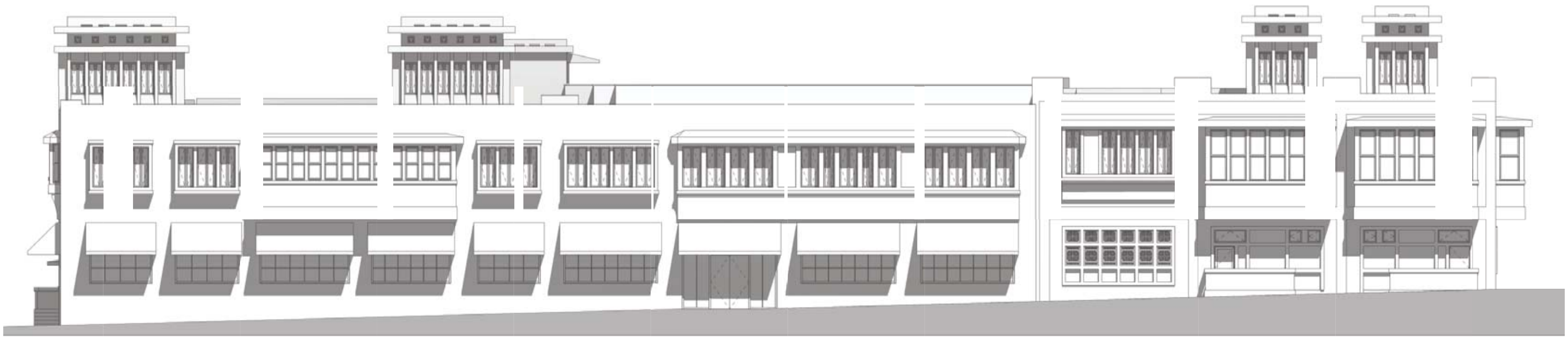


East Elevation 11 AM on June 30th





South Elevation 1 PM on June 30th



West Elevation 3 PM on June 30th

# PLANS AND SECTIONS

## THREE COURT GREEN - Courtyards

The final design resulted in a mixed use residential project offering luxurious urban living centered around three unique courtyard experiences. The column grid of each portion of the building allowed for varying sizes and shapes of courtyard intrusion into the exisitng structure, with each type able to offer a different level of access and privacy for its occupants. The variations in column grid placement and structure also dictated tower placement within each unit type, which in turn dictated room / space arrangements.

### The Central Court

This portion of the building contains the only two access points that are naturally on grade with the sidewalk, allowing wheelchair accessability without the addition of ramps or lifts. It was decided to make this portion of the building the most public, with three commercial spaces surrounding the first floor public gallery and courtyard. Maintaing accessability through the primary entrance helped equalize the experience for all users, regardless of mobility. This portion of the building also houses the secured access fire stair towers and elevator that maintain the privacy of the apartments located on the second level.

Six apartment units have direct access to the central court, one of which offers ADA accomodations. Five of the units are accessed via the uncovered walkway that encircles the courtyard on the second level while one maintains acess from the first level. A seventh apartment is located on the northern arm of the Central Court and is accessed via its own staircase due to dead end exit access requirements. A sun deck is located on the roof level and is accessible via elevator or one of two external staircases.

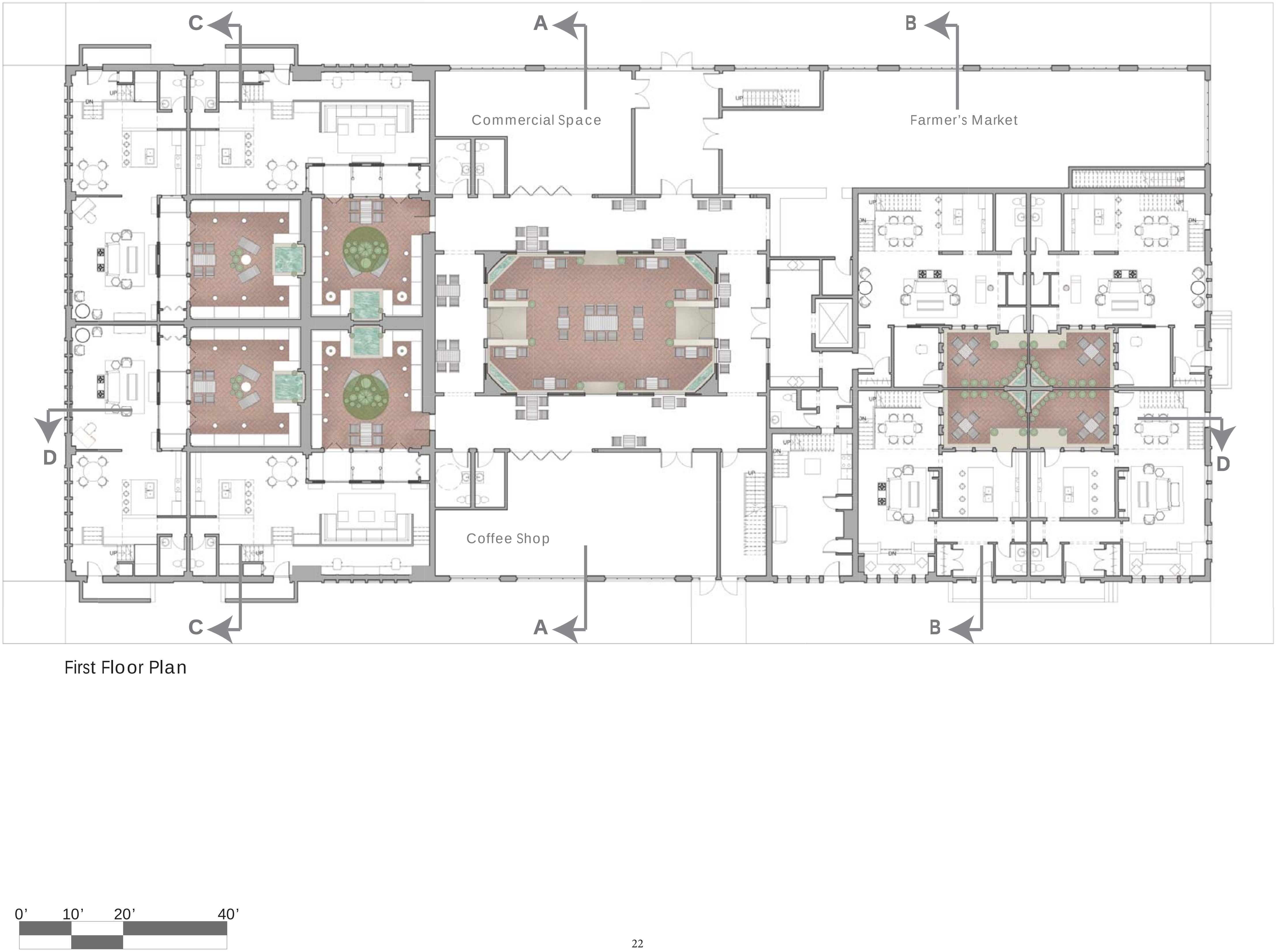
During business hours the three commercial spaces, two of which are here proposed to be a farmer's market and a coffee shop, have access via standard doors and Nana Walls to the gallery surrounding the courtyard. The gallery space contains tables and chairs and itself has large pocket doors and windows that open onto the courtyard in good weather. The courtyard is sunken down a step, with ramp access at the short ends. Four fountains, located diagonally in each corner, keep the space cool and provide gentle white noise for patrons and residents making use of the table and chairs.

### The North Court

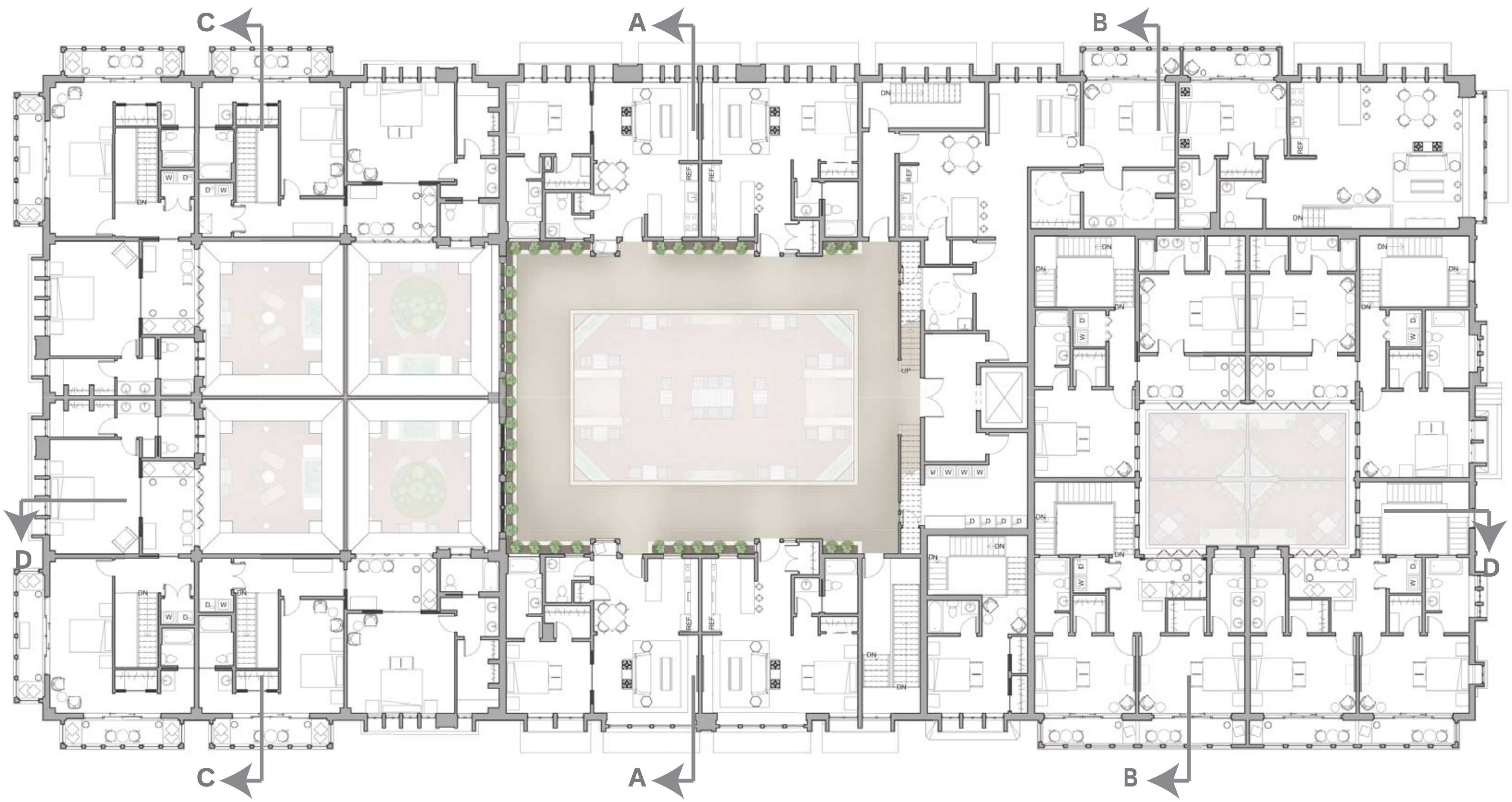
This portion of the building contains four 2 story residential units surrounding a semi private courtyard space. While the courtyard footprint is divided into four individual spaces via a 6' wall, the second story of each unit has visual access to a portion of all of the units. The decision was made to keep the wall at this height, at the cost of added privacy, in order to prevent the courtyard from feeling like a silo. The four privacy walls meet at a central fountain unit, a face of which is turned diagonal across the corner of each private court. The court itself is sunken down a step and offers space for plants and a table for four.

### The South Court

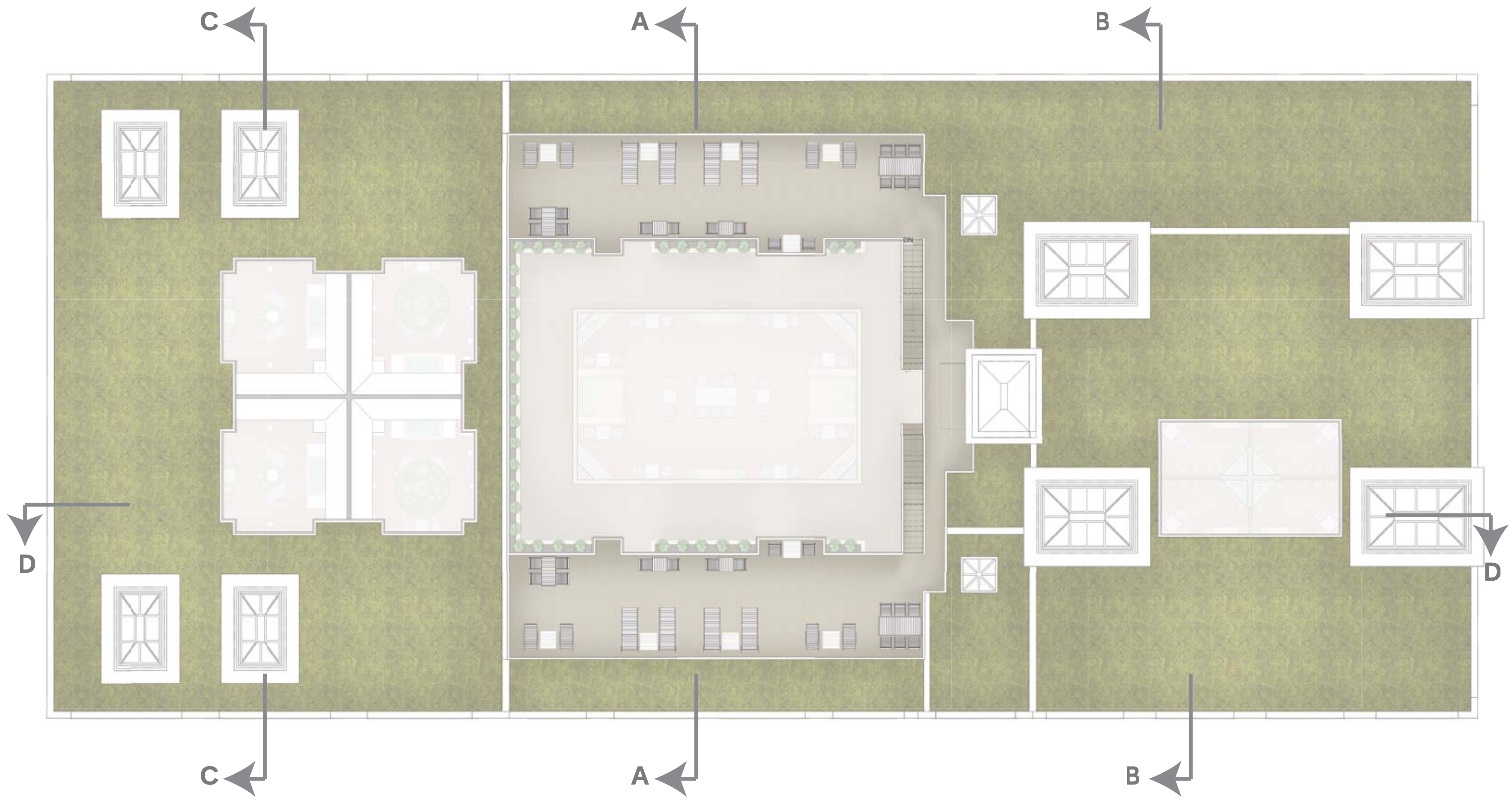
The southern portion of the builidng offers the most privacy and space within its courtyards. Due to the integrated nature of the reinforced concrete flooring and drop column capital system the courtyards here were able to be maximized. Like the North Court this portion of the building contains four 2 story residential units, though each now has access to a large, completely private courtyard. Playing off of the existing column structure, a solid wall rises to the level of the second floor before encountering a slate tile roof. This roof in turn meets a narrow dividing wall that rises to 6' above the second floor level and provides visual privacy betwen courtyards as well as between units. Each courtyard sits on axis with the residences main living space and offers an individual fountain at the end of this axis. The remaining space on this and its two flanking walls contains a cast concrete bench fitted with cushions and protected by a wide overhang from the second level. The central floor area is large enough to provide space for a table for four, two lounge chairs, an assortment of potted plants and a small potted tree for added shade and aesthetic value.



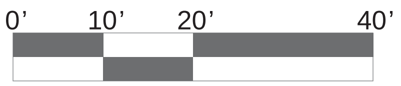

First Floor Plan

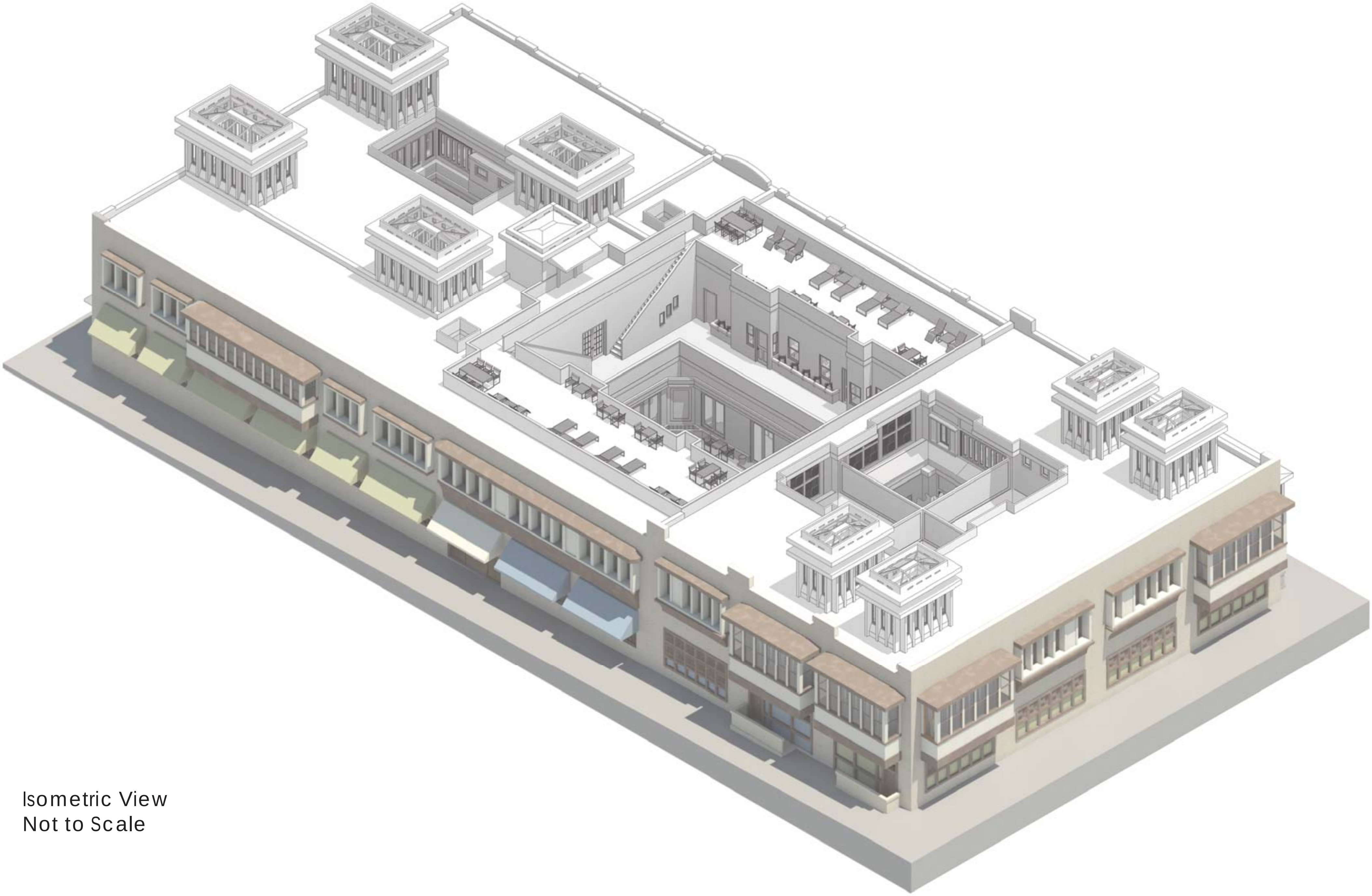



Second Floor Plan



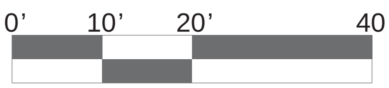

Roof Plan





Isometric View
Not to Scale

Section D - D



Section A - A

Section B - B

Section C - C

Section D - D Central Court Enlarged View

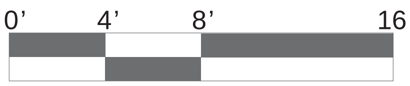
0' 4' 8' 16'

Section A - A Central Court Enlarged View

Section D - D North Court Enlarged View

Section B - B North Court Enlarged View

Section D - D      South Court Enlarged View



Section C - C     South Court Enlarged View

# INTERIOR ANALYSIS

## THREE COURT GREEN - Interiors

The goal of sectioning Three Court Green into three portions, each centered around a variation on a central courtyard, was to create a series of distinct courtyard living experiences. While each was designed first with concerns of natural ventillation and daylight, priority was next given to creating spaces that supported an occupant's ability to adapt themselves to their environment by offering a number of comfortable touch down spaces spread throughout the home. Each of these spaces was designed to offer different amounts and quality of exposure to outdoor conditions. This focusing of design from the scale of the entire building, to each unit as a whole and down to individual, personal moments for occupants therefore explored the ideas of thermal comfort, adaptive comfort and vernacular architecture that this thesis intended to make use of.

The sample units shown on the following pages indicate the overall arrangement of spaces designed to meet the goals of this project. Each space has also been minimally decorated to offer a sample of what living within the space might be like. As most units were designed as condominiums, finishes and fixtures are in large part changeable without effecting the function of the unit as designed.

**The Central Court**

The experience of the Central Court is the most public of the three courts, but also the most dynamic and energetic due to the nature of interaction with both neighbors and the commercially accessible courtyard below. Five 1 bedroom or studio apartments are located around the second level open walkway. This walkway is securely accessed through an elevator or one of two staircases located on the east or west side of the building. One two story unit located on the east side of the building offers first floor access via a secure vestibule. As private outdoor opportunity within each apartment unit is not possible, there is easy access to a sun deck located on the roof. This location allows for users to lounge in the summer sun or to sit in the shade of an umbrella and enjoy the cool feel of the prevailing winds as they blow across the rooftop.

The sample shown here is a 1 bedroom unit located on the east side of the building. The unit is designed as an open plan living space including the kitchen and living room. A soffit and lowered ceiling separate the entrance and kitchen area from the living area beyond. A window in the kitchen allows for airflow access to and from the courtyard. A deep window seat is located off of the entrance as well, with casement windows on 3 sides maximizing potential airflow and making a cozy, personal touch down space to catch a cool summer breeze or bask in a winter sunbeam. On the far end of the living room is a large window. The sill is deep enough to grow plants or use as touch down space for entertaining while still having vertical and horizontal fins on the outside to cut down on direct sun and provide ample amounts of indirect, ambient natural light. The bedroom of this unit has a large set of double doors that can be opened to the living room that, along with the large bedroom window can help maximize airflow in the unit.

Central Court Courtyard


Central Court Apartment Plan

Section G - G

Central Court Kitchen and Living Room

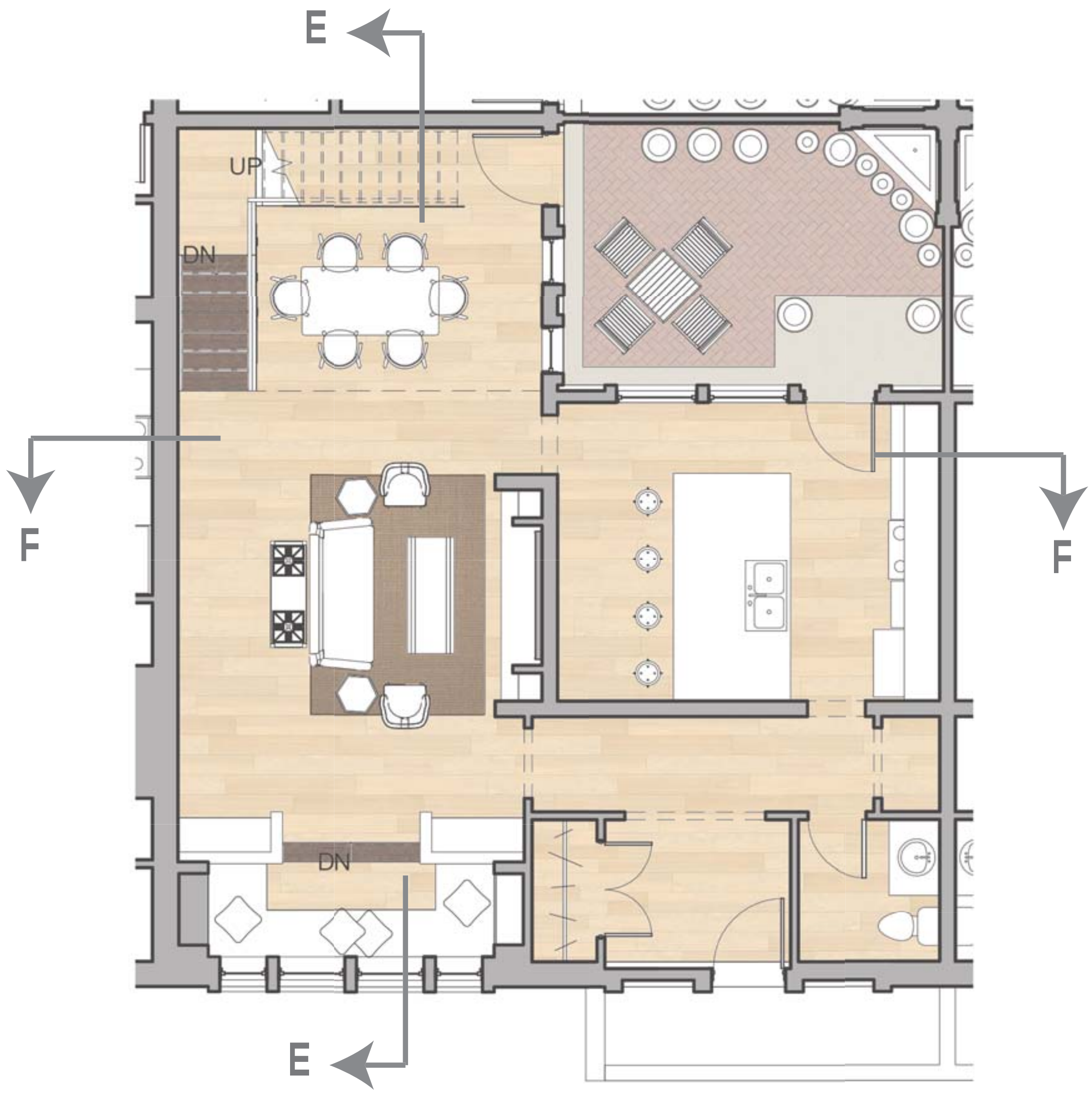
## The North Court

The experience of the North Court is one of semi-private courtyard living. Four 2-story units wrap around one large central courtyard opening. On the ground level each courtyard is given privacy through separation from its neighbors by a tall bottle dash wall. This partition does not extend past the first floor in order to prevent the courtyards from feeling like a silo. The spaces are then considered semi-private due to sight lines between units from the second floor.

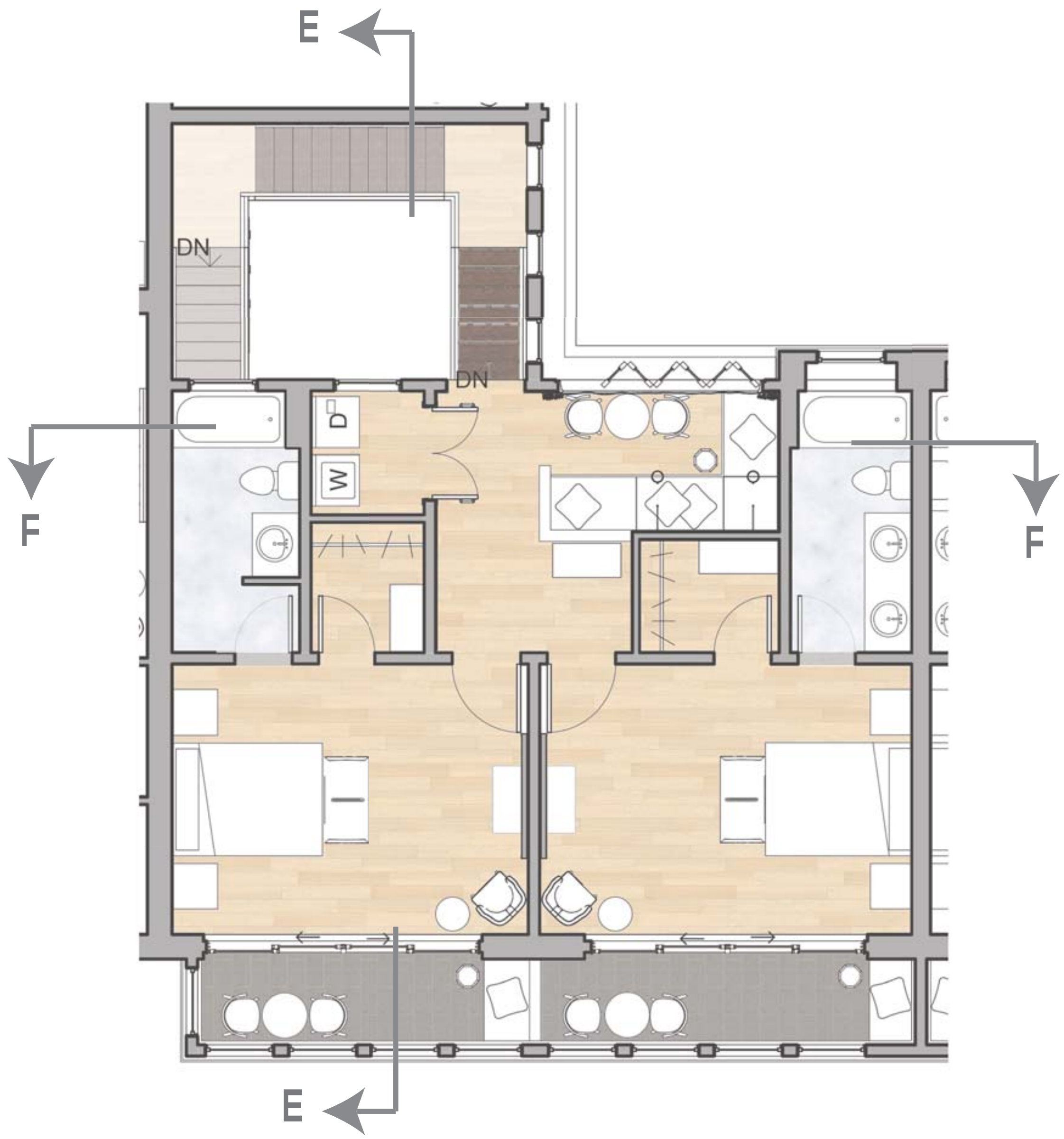
The following pages highlight the unit located in the southeast corner of the North Court. A street entrance is separated from the main living space by a short hall containing a closet and powder room. The kitchen, entered from the hall or the living area, overlooks and has direct access to the courtyard. The ceiling in the kitchen is sloped, rising towards a set of clerestory windows opening onto the courtyard to facilitate air movement while cooking. The open plan living and dining space starts at a reading nook / window seat set two steps above the main floor in front of an expansive set of windows overlooking the street. The main living room area is sited to catch air movement from the wind / light / stair tower and the street facing windows. The dining area sits at the base of the tower and provides a dramatic setting for casual or formal dining. The dining area also has its own access to the courtyard.

The second floor contains two bedrooms that are each attached to a set of enclosed baconies that provide areas for sitting and reading, working or just intimate relaxation. Both bedrooms also have direct access to a second floor loggia. This small lounge area contains a built in padded bench and can fit a small table and chair set. The wall overlooking the courtyard is fitted with a folding window system to open the entire space up to the outdoors, allowing for ventilation of connected spaces and a comfortable, protected interaction with the outdoors.

North Court Courtyard

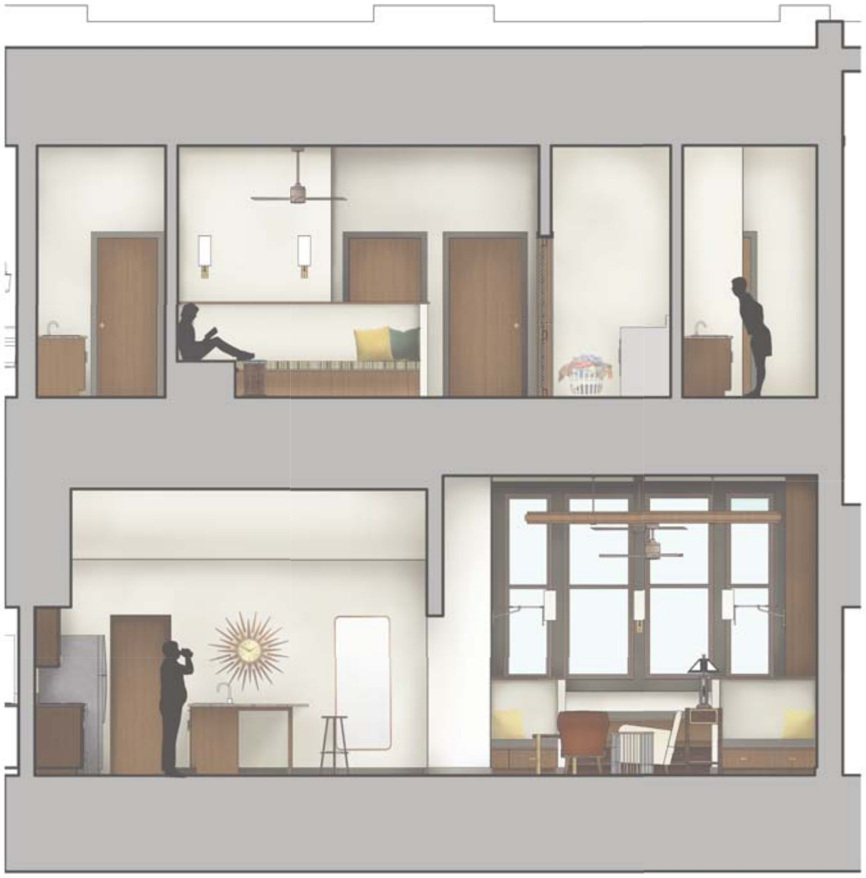



North Court First Floor Plan




North Court Second Floor Plan

Section E -E



Section F - F

North Court Living Room

North Court Second Floor Loggia

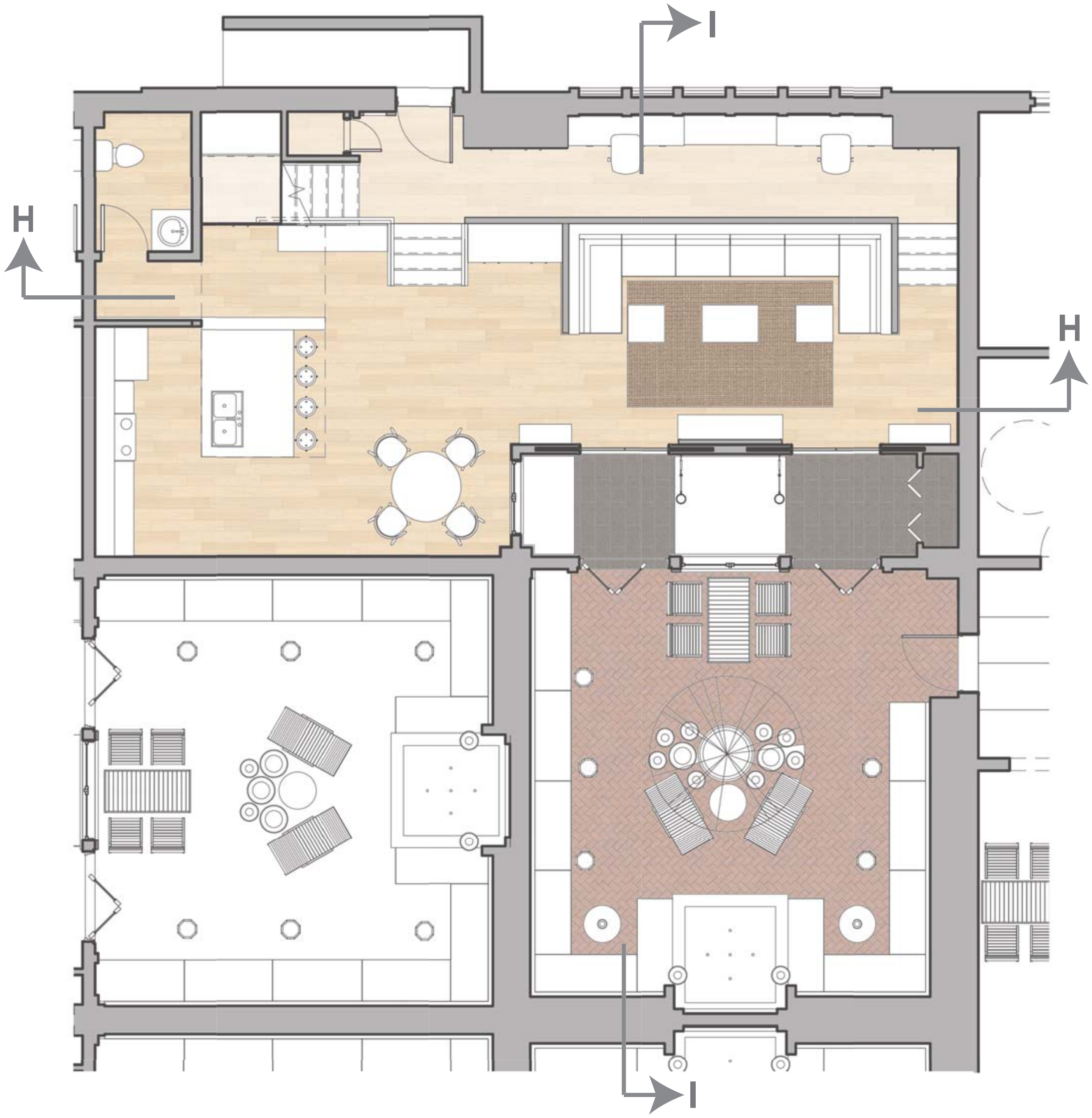
**The South Court**

The units of the South Court offer the most private living experience at Three Court Green. Four 2-story units wrap around a group of completely private courtyards. Due to the large size of these courtyards partitions were taken from ground level to 6' above the second floor, providing complete visual privacy within each courtyard and each residential unit.

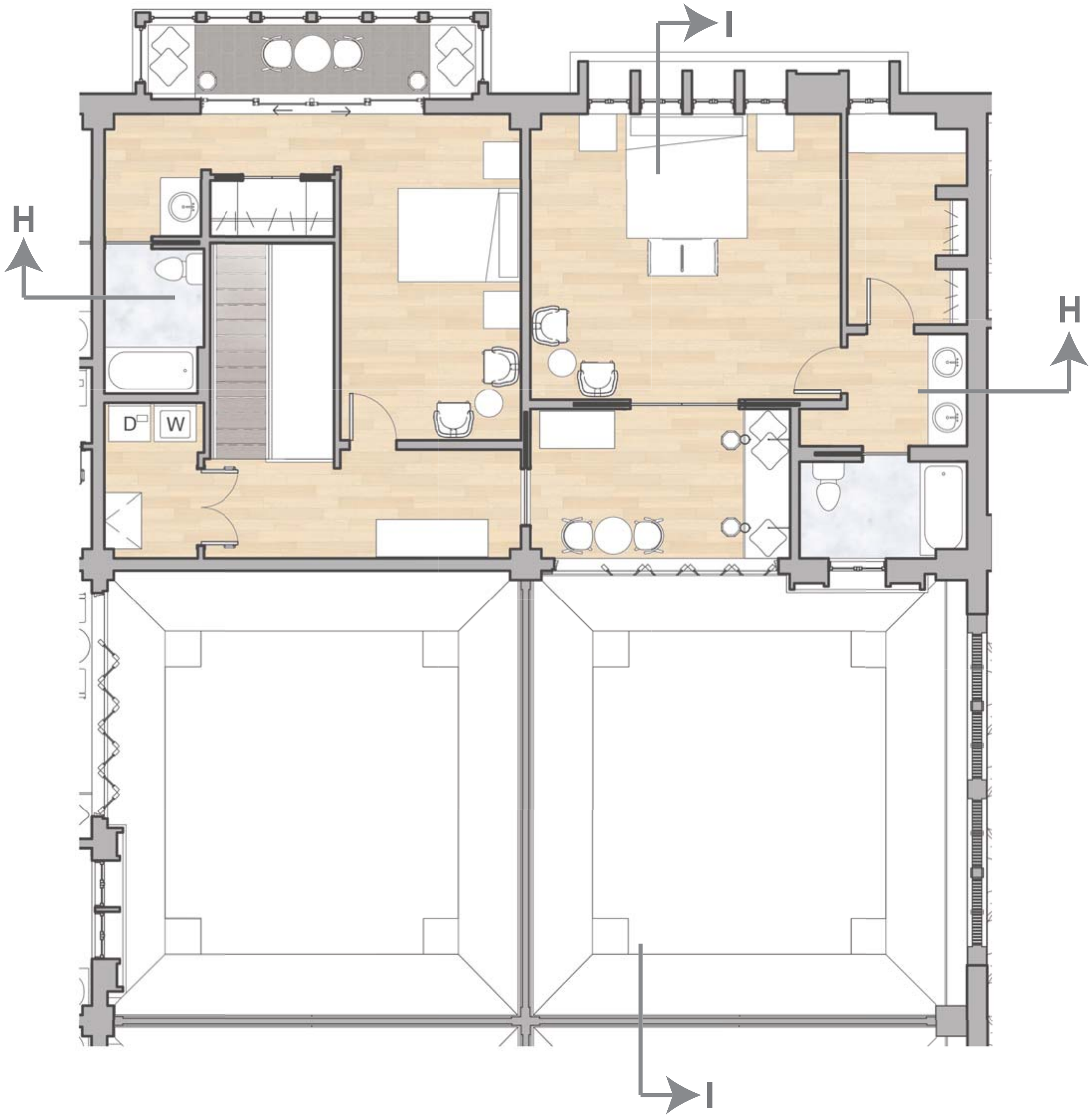
Shown here is the unit located on the north west section of the South Court. As the South Court is located partly below grade, the street entrance opens onto a mezzanine level. In this unit the mezzanine offers access to the second floor stairs as well as an area currently set up as a home office space. Two desks and a generous window seat sit in front of a two long, stacked runs of windows to catch the breeze. Stairs at either end of the office area lead down to the open plan main living floor. The kitchen is set in one corner of the floor with a wide island and seating below the wind / light / stair tower. The unit shown explores the use of a built in U shaped sofa large enough for gracious entertaining or for a family of four to comfortably stretch out. The short sides of the sofa are designed to act as lounge seating and allow views of the television as well the courtyard. On either side of the television wall a set of tall glass pocket doors allow access to a first floor loggia with a built in daybed and upholstered, built in bench for two. The loggia itself lets onto the courtyard via two folding glass doors and a double casement window. This arrangement allows for gradients of exposure to the outdoor environment through manipulation of window settings.

The second floor contains two bedrooms, one of which has a private enclosed balcony containing a built-in bench and room for a small table and chair set. The other bedroom is accessed from a second floor loggia that can be opened for use as common house space or closed off as a private anti chamber for the bedroom. A large folding window opens up nearly the entire wall to the courtyard below allowing for ventilations and a comfortable, protected interaction with the outdoors.

South Court Courtyard




South Court First Floor Plan




South Court Second Floor Plan

Section H - H

Section I - I

South Court Kitchen and Living Space

South Court First Floor Loggia

# LITERATURE REVIEW AND PRECEDENT STUDIES

## INTRODUCTION

Climate change as a man-made issue brought on by excessive use of "dirty" energy sources has become widely accepted. The human species has been on a constant quest for the increase of comfort and the ease of access to both essential and luxury goods, services and experiences. Since the industrial revolution ease of access to these things has increased dramatically for many, but it comes at an environmental cost. In a time of ever increasing globalization, climate change and its effect on humans worldwide is one of the most pressing problems we currently face as a species. Within a multi-pronged solution to curbing our negative environmental impact, an approach to our home condition that makes use of time tested design decisions to reduce energy needs should be examined. Combining a burgeoning understanding of the American attitude towards thermal comfort, sustainability and the ideal residential experience with lessons learned from a survey of vernacular design's effect on indoor thermal comfort, specifically cooling, may open up new opportunities for interior design to contribute to an American cultural shift towards a more sustainable future.

## PART I: THE PROBLEM(S)

### Thermal Comfort and the American Condition

The search for an ideal set of indoor thermal comfort conditions is not a new one. Thermal comfort itself is not even a human construct, but is a basic tenant of life as we know it. Lisa Heschong's *Thermal Delight in Architecture* seeks to capture the essence of thermal delight through a collection of examples from across time and space. She writes of the connection that all living things have for their ideal conditions of existence, noting how higher-level organisms possess increasingly sophisticated means of dealing with environmental realities, up through the modern human ability to (somewhat) easily move with the seasons, or even, in most modern situations, use mechanical means to sublimate the realities of seasonality to a steady state, narrow range of interior conditions. This fact is in ways at odds with cultural trends around the world which seek to offer variation and contrasts in thermal experience (American beach culture, Northern European outdoor spas in winter). These sought out experiences, in which thermal extremes combine to form a desirable experience, provide continued evidence for the need and value of varied thermal conditions in our human experience.[1]

Since Heschong's writing in 1979 the American love affair with a tightly conditioned indoor environment has only increased. In 2013 Jack Barkenbus published a review of thirty years of indoor thermal conditions in the American home. Analysis of data collected by the Energy Information Administration since the early 1980's has shown a distinct increase in the use of both heating and cooling in the American home, pointing towards an increasing narrowing of the acceptable indoor thermal comfort range. Data also indicates that American winters and summers have become increasingly warmer. Combining this with an observed shift of the American population from cooler to warmer climates indicates that the American household's requirement for cooling is a distinct and significant target for energy reduction possibilities. In 2009 83% of American homes contained some form of air conditioning system, a dramatic increase from the mere 22% with a system in 1981. Air conditioning has now become a standard feature of new built homes. Since 2005 data collected by the Residential Energy Consumption Survey indicates that over three quarters of Americans prefer an ever narrowing range of temperature with cooling season values not set to exceed 76 F while the home is occupied, with approximately half of Americans preferring temperature settings at or below 73 F.[2]

In 2015 Rupp et al. published an exhaustive review of journal literature published between 2004 and 2014 on human thermal comfort across the world in order to examine findings on thermal comfort models and their relative success at predicting comfort across the diversity of the human condition. The modelling of thermal comfort generally falls into two large categories. The Predicted Mean Vote – Predicted Percentage Dissatisfied model (PDM-PDV or PDM) for discussing thermal comfort takes the approach that users are passive in respect to their environment. This describes the approach to comfort in which people require a restricted range of indoor thermal conditions and that these conditions are predictable and applicable across the board. It treats all occupants as having similar comfort needs and states those needs be met through a constant indoor condition regardless of location or climate. This model was based on the work of P.O. Fanger in the 1970's and is often the standard for mechanically controlled buildings,

[1] Heschong, *Thermal Delight in Architecture*.

[2] Barkenbus, "Indoor Thermal Comfort."

requiring that indoor conditions provide adequate thermal comfort for 80% of occupants.

In contrast, the Adaptive Comfort Model (ACM) counts on the individual and their response to changes in indoor thermal comfort as perceived on a personal basis. This model, instead of requiring mechanical generation of a constant indoor state, operates through the opening / closing of windows, the use of shading from direct sun exposure, evaporative cooling, natural and low energy movement of air, as well as changes of clothing, etc. This model, while offering greater possibilities for discomfort under extreme conditions, offers the widest range of possibilities for individualized comfort along with greater savings in energy usage. This is often the model used in naturally ventilated and hybrid buildings.[3]

The literature review by Rupp et al. found that, in studies conducted across the world, feelings of thermal comfort vary greatly among individuals as influenced by age, sex, cultural norms, short term temperature range exposure, long term temperature range exposure, as well as just having the ability to control temperature conditions. This list is not exhaustive, nor is a detailed investigation necessary to make the point that thermal comfort is a complex phenomenon and cannot / should not be subjected to one governing model. It is also worth noting that a uniform, tight range approach to indoor thermal conditions (that is, a tight temperature and humidity range within a well-sealed shell) is something of a self-fulfilling prophecy. As occupants become used to a tight range of indoor conditions, their perceived tolerance for situations falling outside of this range becomes less, leading them to seek out an ever increasing artificial, monotonous set of indoor thermal conditions.[4]

**Perceptions and Values on Thermal Comfort and Sustainability**

It is worth noting, again, that while a trend for globalization continues, and along with it a “western” led cultural hegemony of the built environment, there still exists moments of cultural distinction with respect to feelings of indoor thermal comfort and its relation to sustainability. A study published by Zhao et al. examined occupants’ perceptions and values in two climatically similar but culturally different locations (Phoenix, Arizona and Doha, Qatar). The study found that health, thermal comfort, indoor air quality, personal productivity, visual comfort, environmental protection and energy cost savings were all of moderate importance or higher to the majority both groups. While residents of Doha ranked health and environmental protection equal in importance, Phoenix residents ranked environmental protection as the least important factor.[5] This difference of opinion is of interest to note in that American ideas of sustainability are likely subject to the desire for physical comfort, but that these American ideas are not inevitable and are, potentially, adaptable to the current cultural norms. In fact, a recent paper by Wolsko et al. examined the cultural split on sustainability and related conservation behaviours from the context of political ideology within the United States. They note that liberals are more likely to be aware of and act on environmental concerns as they are most often presented in terms of an injustice. The authors state that by reframing sustainable concerns within a context of importance to conservatives (obeying authority, defending the purity of nature, and patriotism) they were much more receptive to conservation behaviours.[6] These findings again point to a malleability of thought in regards to sustainability as it relates to intent, even if that intent does not always lead to action.

Having found indications that the idea of comfort is in large part a social construct and that feelings towards thermal comfort and sustainability are malleable when presented under optimized conditions to a given social group, what are some of the forces at work shaping these thoughts? Work by Heather Chappells and Elizabeth Shove in the United Kingdom began to address the issue from the perspectives of a number of invested professions. They note that those who subscribe to the PDM model see comfort as a set of predictable, optimal conditions and so responding to climate change while meeting these conditions requires an increase in efficiency of environmental conditioning systems. As an alternative, Chappells and Shove point towards the adaptive comfort model, whereby comfort is a personal / cultural choice providing a variety of options for self-regulation. Regarding the choice of what model to follow, some designers and professionals noted that client’s descriptions of needed comfort were often “fuzzy” and difficult to quantify and so basing decisions on a set of predetermined numbers was a more realistic

[3] Rupp, Vásquez, and Lamberts, “A Review of Human Thermal Comfort in the Built Environment.”
[4] Rupp, Vásquez, and Lamberts.

[5] Zhao et al., “Occupants’ Perceptions about Indoor Environment Comfort and Energy Related Values in Commercial and Residential Buildings.”
[6] Wolsko, Ariceaga, and Seiden, “Red, White, and Blue Enough to Be Green.”

approach. Others noted that client's fear of future conditions and the necessity of adaptability required installation of greatly oversized systems. Still others noted that clients seemed to go along with an adaptable model if it meant cost savings.[7]

Later work by Shove has explored the potential of social sciences to effectively contribute to the conversation about and outcomes of sustainable behavior in the United Kingdom, and around the world, by helping to measure the success / failure or current models and to suggests changes / alternatives. She described the current dominant model as the ABC model: Attitude, Behaviour, Choice. This model works under the assumption that attitude (A) drives a set of behaviours (B) that persons chose to adopt (C). In other words, well informed individuals who know what to do, how to do it and who are given the opportunity to act more sustainably will do so. The ABC model is one which puts the decision making onto consumers and casts governments and policy makers as those who work to induce the "correct" choice. Shove argues that this model is flawed in its assumption that the attitude and knowledge will translate into action (the value-action gap). Shove feels that adoption of a transition management based model may meet (and has met) with more success. A transition management model, while not as neat to define, works with a wide range of players and resources to erode and eventually replace unsustainable behavior, allowing for / instilling / demanding change from a full spectrum of activities (technology, routine, governance, social convention and expectation, as well as the market place).[8]

## PART II: POSSIBLE SOLUTION(S)

### Vernacular Design as a Time-Tested Solution

Throughout history humans have designed their built environment to achieve, among other goals, their cultural idea of ideal indoor thermal comfort. These solutions have been tested in varied locations around the globe and honed over centuries in order to provide the most viable solution given the climate, economy and resources conditions present. In 2013 Vellinga published a review of the study of vernacular architecture, examining the field from its academic, descriptionist roots along with the field's somewhat independent examination of the vernacular as it relates to sustainability. While the piecemeal study of vernacular architecture in a purely academic sense goes back at least to the mid-19th century, more collected works encompassing a wider world view did not begin to be published until the 1960's.[9] Until the beginning of the 21st century most work still focused on vernacular in general. Since then work has been done to examine, in a more scientific manner, the way in which these vernacular traditions effect the thermal conditions of a given built environment. Publications such as *Natural Energy and Vernacular Architecture* were among the first well known works to focus on the environmental performance aspect of vernacular design.[10]

A survey of these performance tested vernacular designs starts to resolve a set of standard approaches. The resulting wide geographic, cultural and climatic range for a common set of approaches brings a strong sense of validity of form and function that is now being backed by scientific examination. Designed to work alongside one another, these solutions can be broken down to include: prevention / capture of heat through structural orientation and materiality, harvesting of moving air and evaporative cooling.

Prevention of or capture of heat gain is achieved in a number of ways. Strategies incorporating simple blocking of direct solar exposure by overhanging eves, well chosen trees and bushes, or directionality and location of a building and its openings along with use of materials with high thermal mass to resist heat gain (or store it for cooler evenings) are used in warmer climates while adaptations of these strategies to increase heat gain are used in areas requiring more heat. Harvesting of moving air thru strategically placed openings to catch prevailing winds, the use of solar chimneys and overall designs to induce a stack effect are also used as cooling techniques as well as methods of battling humidity. In drier, warmer climates cooling by evaporation is often achieved thru the use of fountains and other bodies of water, or thru materials (terra cotta roof tiles, clay jugs) who become damp with dew or are filled with water and then slowly dry off (or out), cooling and moistening the air at the same time. Precedent studies, both historic and contemporary, provide built instances of these principles at work and provide a real world laboratory to test and observe the effects of these design principles.

### Historic Precedent

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[7] Chappells † and Shove ‡, "Debating the Future of Comfort."

[8] Shove, "Beyond the ABC."

[9] Oliver, *Shelter and Society*; Rudofsky, *Architecture without Architects*.

[10] Fathy, *Natural Energy and Vernacular Architecture*.

Built in the 17th centruy as a country house and restored in 1907 for use as a residence for European artists, the Villa Abd-el-as in Algeria serves as an example of many of the prominent features found across the globe that are used to modulate indoor climate in order to generate a thermally comfortable experience. The Villa makes use of a number of features including thick walls to promote thermal lag and keep the interior cool from the heat of the day, louvered exterior windows to allow ventilation while protecting from direct solar heat gain, a varied roofline with high openings to promote air flow, a central courtyard with cool fountain to promote the cimney effect and provide for evaporative cooling and a gallery surrounding the courtyard to protect interior rooms from direct solar heating. In addition to these items (shown in figure 1), the Villa also makes use of siting to catch prevailing winds from the Mediterranean Sea, a system of adjustable doors to modulate airflow, rain pipes to bring rainwater down through the building to aide in cooling interior walls and a protected ground floor with a few small high openinings to provide a cool based upon which the main rooms of the piano nobile sit.[11]

### Contemporary Precedents

Remaining on a smaller, residential scale, the Greenstein Residence by Rob Wellington Quigly makes use of a number of worldly vernacular traditions in an American setting. Built towards the beginning of the passive house movement in America [12], the Greenstein house was designed to function without the air conditioning systems of today, instead relying on shading, thermal mass and air movement through the chimney effect in an attempt to maintain a pleasant indoor thermal environment. The open floor plan, despite being nearly 40 years old, feels contemporary in many ways. Low vents on the north side of the structure bring in air over a cooled, protected rock bed, before it is blown into the main living areas. In this way it provides a source of cool air to replace the warmer air escaping from the roof turbine exhaust system high above. A water wall on the south side is protected by insulative doors to provide a longer lag time for the summer sun to affect the interior. During the winter the extra protection of the doors is opened, allowing the water wall to warm and radiate heat into the building during the day and into the evening (figure 2).[13]

On a larger scale, the (non-residential) Pearl Academy of Fashion in Jaipur, India makes use of many vernacular traditions to provide a hybrid building intended to deliver comfort and usability while maintaining a tight budget for building and operations. The building consists of three stories, each increasing in size and so providing a deep overhanging eave (and so cooling shade) for the story below. The second and third floors are wrapped in a contemporary system of pierced screens held a distance away from the building. These screens provide a generous amount of dappled sunlight while still protecting the interior from the intensity of the direct sun. The ground floor is dug into the earth to provide space and the cooling benefits of the ground itself, along with plants and a water source, all of which combine to provide a cool, shady respite from the sun and a source of cool air to feed a chimney effect through the three openings that pierce the building to create galleried courtyards. The openings themselves are designed to provide a balance between natural light and a shielding from direct solar radiation (figure 3).[14]

Vernacular features can even be found in large scale projects by well-known architects. Renzo Piano has been known to incorporate vernacular features, or features based on vernacular tradition, into his projects. The California Academy of Sciences building incorporates a number of features inspired by vernacular design in a contemporary manner. The green roof provides a layer of natural insulation reminiscent of turf houses. Deep overhanging sunshades provide shade to help cool exterior walls made of thick concrete, which helps increase thermal lag time. The domed structures within the roof contain functional vents and so act as wind catchers as well as aide in a chimney effect to help syphon hot air from the rest of the building. The basement is used to house aquarium exhibits, helping to provide a naturally cooled and stabilized thermal mass that in turn helps buffer thermal conditions in the remainder of the museum (figure 4).[15]

### Hedonistic Sustainability and the Future

Now knowing that Americans are, in general, conditioned to a static, tight ranged thermal environment and that they are not given to choosing

[11] Adli-Chebaiki and Chabbi-Chemrouk, "Vernacular Housing In Algiers."
[12] Torres Moskovitz, *The Greenest Home*.
[13] Wright and Andrejko, *Passive Solar Architecture*.
[14] Shah, "Academy of Fashion, Jaipur."
[15] "California Academy of Sciences / Renzo Piano Building Workshop."

the sustainable option despite education efforts but that their attitudes are, under the right conditions, able to be altered, how then can design work to provide acceptable sustainable options? Heschong pointed out that thermal variation provides delight, siting instances of hedonistic relaxation such as swimming in cool ocean water on a hot summer day, or experiencing a hot thermal spa on a cold winter's day. Bjark Ingles has produced examples of contemporary design based on what he refers to as hedonistic sustainability, which he defines as a sustainable design option made desirable by pairing it with / wrapping it in a hedonistic "by-product," such as the Amager Bakke waste-to-energy plant that Ingles wrapped in an urban ski slope. [16]

As Shove has indicated, successfully redirecting society towards a sustainable future likely requires a transition management approach in which multiple factors of our current social condition (technology, government, etc.) that negatively impact our environment are eroded away and replaced by new options that promote sustainability. Finding a design solution might start by examining current trends in the American housing market and looking for ways to meet consumer desire in an exciting, even (seemingly) luxurious manner that are, at the same time, primarily designed to lower household energy needs. Data on the American market is primarily provided by companies with a financial interest in that market. Groups like the American Homebuilder's Association or companies like Zillow have a large stake in understanding the American mindset so that they can meet it profitably. Innovative and interesting ways to incorporate consumer desires (higher quality materials, decks, private outdoor space) [17] into housing stock via vernacular precedents while providing for options both thermal comfort (sustained) and delight (variation) may prove a valuable step towards a sustainable future.

## CONCLUSION

By considering these many factors of society and the built environment, interior architecture and design can continue to advance the cause of sustainability and its acceptance by the American public. Many have worked to define thermal comfort in both cultural and biological terms and many have come to understand that thermal comfort is a social construct, defined by accidents of geography and climate, and perpetuated by given cultural norms. Research has also provided evidence that these notions of thermal comfort are not set in stone. Neither are notions of sustainability. The question of how to change notions of thermal comfort, linked with behaviours and related ideas of sustainability, is complex. Evidence indicates that informed options do not in themselves lead to sustainable choices and that a more integrated transition management approach, such as incorporating vernacular and hedonistic strategies, may provide greater success. Under this integrated approach, research, design, policy and the marketplace must come together to provide offerings that are exciting to the consumer and that also work to erode unsustainable practices and lifestyles.

[16] Ingles, *Hedonistic Sustainability*.

[17] "The Zillow Group Report on Consumer Housing Trends - Zillow Research"; Hepp and Economist, "American Dream Home."

# Villa Abd-el-tif, Algeria

Architect: Unknown

17th century, Restored 1907

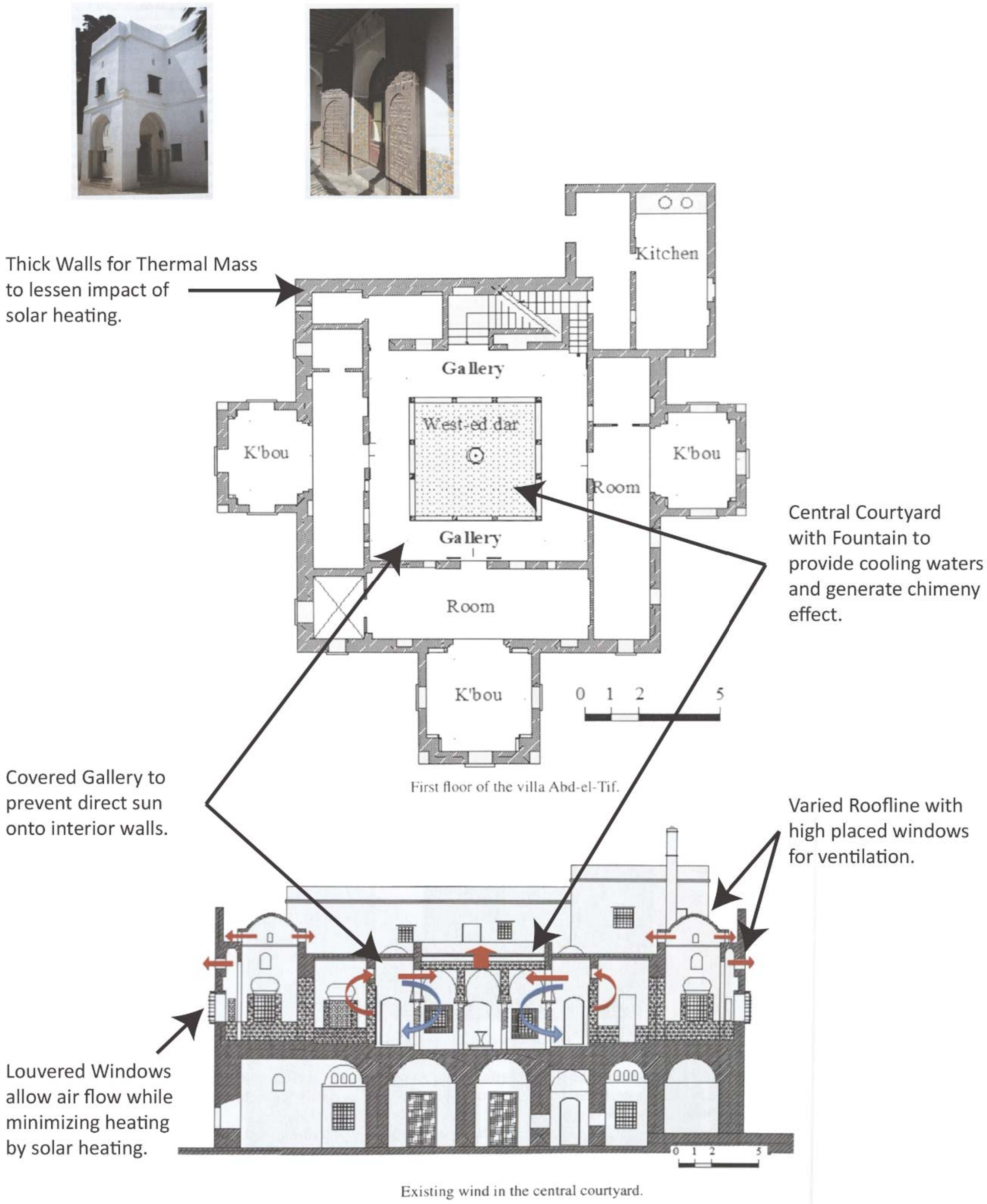



Figure 1

# Greenstein Residence, Woodland Hills, California

Architect: Rob Wellington Quigley

before 1982

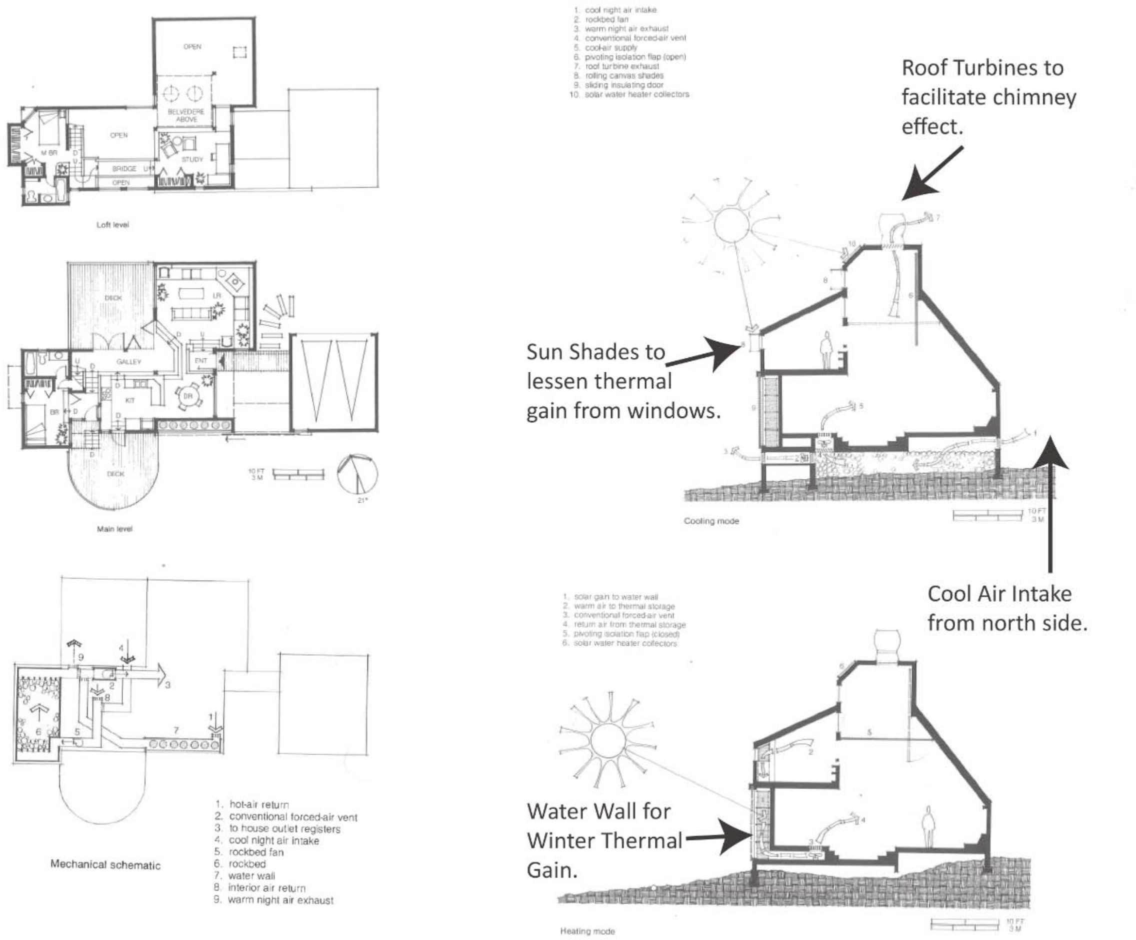
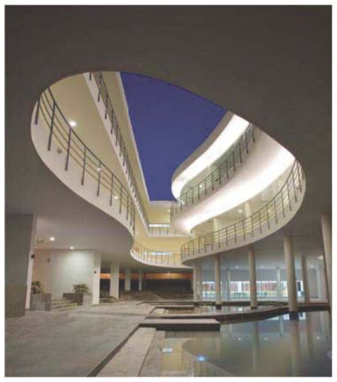



**Figure 2**

# Pearl Academy of Fashion, Jaipur, India

Architect: Morphogenesis

2008



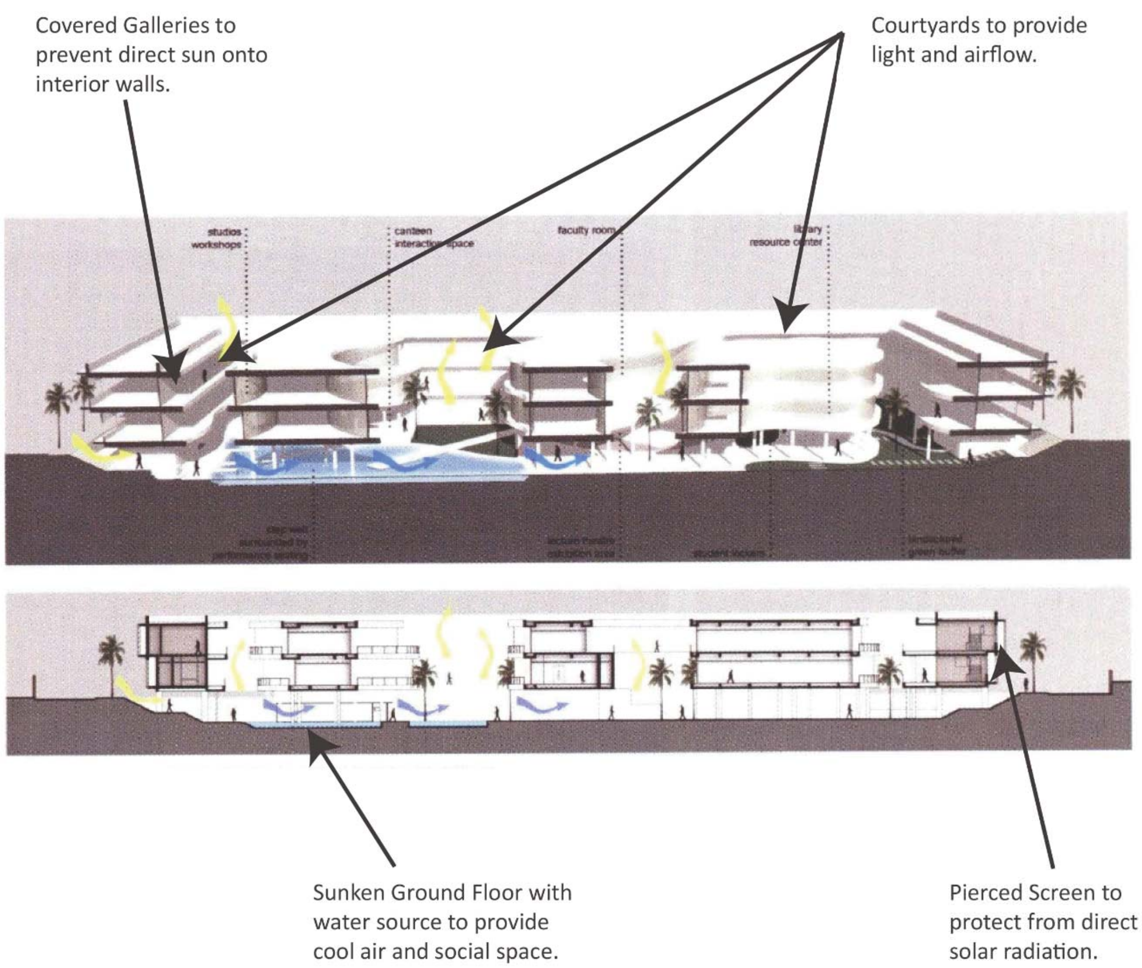
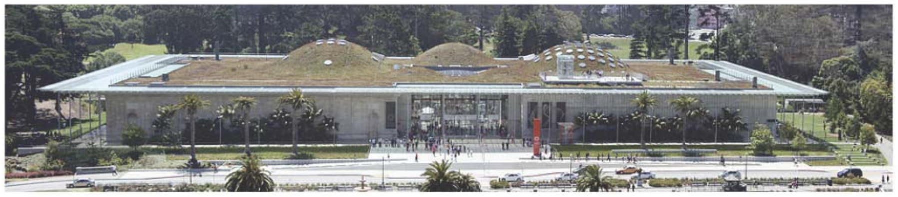


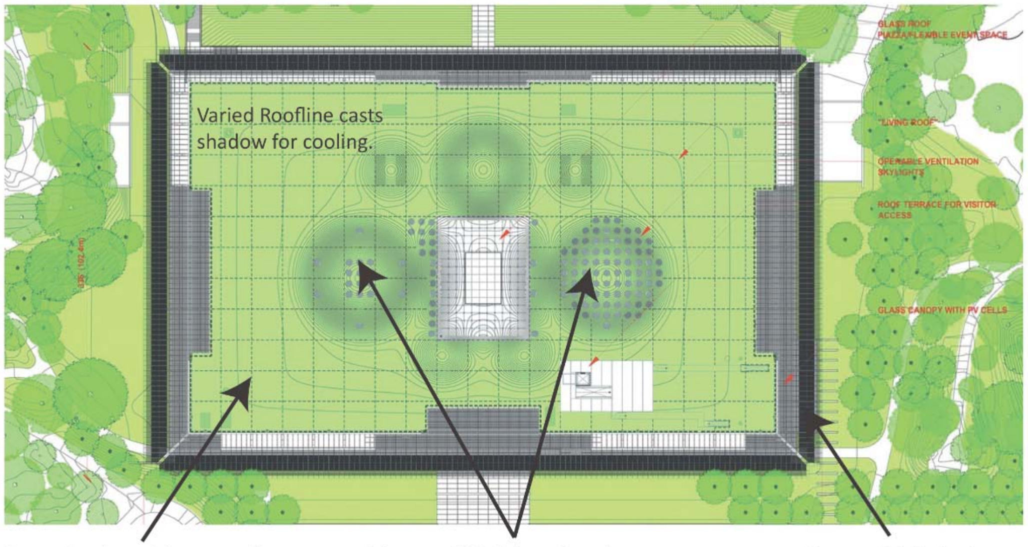

**Figure 3**

# California Academy of Sciences, San Francisco, California

Architect: Renzo Piano

2008

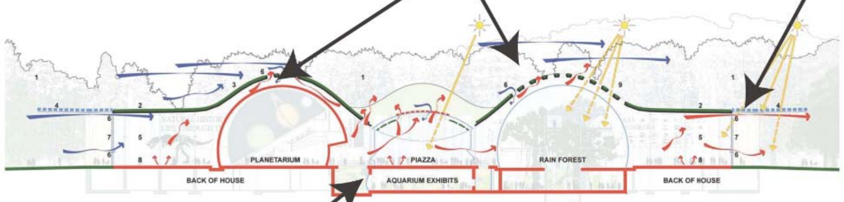





Green Roof provides naturally insulative layer similar to vernacular turf houses.

Vents and Skylights allow for natural light as well as escape of hot air, acting much like wind catchers.

Covered Galleries to prevent direct sun onto interior walls.




Underground Exhibit space with water allows for natural temperature stability.

Thick Concrete walls add thermal mass to provide thermal lag time.

**Figure 4**

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# CASE STUDIES

# CASE STUDIES

## Site

In preparation it was important to gain an understanding of a project where an existing structure had been refit with sustainable / low energy technologies within a tight urban setting. The Friends Center at 1501 Cherry Street in Center City, Philadelphia was chosen as they had recently (2004-2009) completed a refit of a 1974 brick office building.

It was of interest to note that after a tour and interview with the Executive Director, Chris Mohr, it seemed that the most passive, least technology driven upgrades were the most satisfying from a management and use standpoint (green roof, spectrally selective glass, open planning, daylighting).

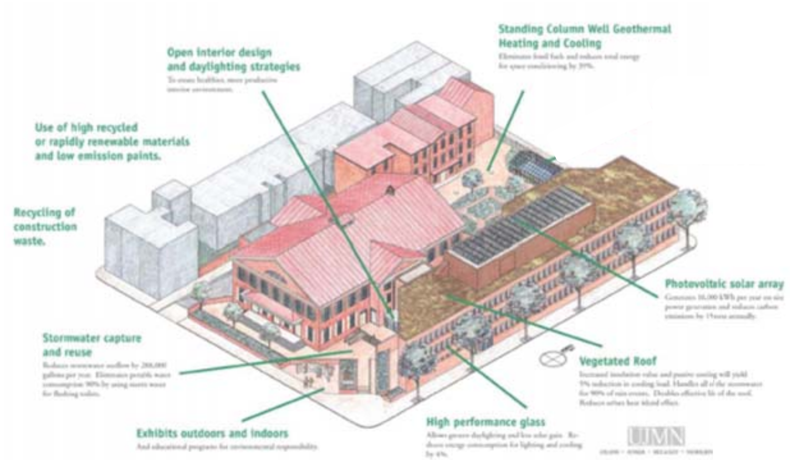



Image Courtesy of The Friends Center

**Green Roof**

Collects ~1 inch of rainwater
Provides thermal mass for cooling of building
Operates without issue
Requires routine weeding and bird carcass removal.

**Spectrally Selective Glass**

Provides light, reduces heat gain
Aluminum frames not well insulted, reducing gain from glass quality

**Open Plan / Daylighting**

Office areas divided into various sized open plan zones
Partition walls within zones removed to allow for light penetration
Fluorescent lighting controlled by daylight and motion sensors
Required cultural shift to quieter habits

**Small Scale Solar Array**

Provides 1-2% of office needs at most
Forgettable element
Sourcing of energy thru wind / solar companies of more value

**Cisterns**

Collects ~1 inch of rainwater from historic Meeting Hall
Provides grey water for flushing office toilets
Supplemented with city water as needed
Operates without issue
Requires ozone generator to control microbial growth
Impact is dependant on rain filling cistern

**Geothermal Heating / Cooling**

Early Design deep drill, small field wells
Heat / Cold excahnge from well water to internal system
Requires 2x / year total shutdown and maintenance for one day
Unable to handle load for extreme weather
Planned Passive Management untenable as recovery time lasts into mid afternoon
Allows for individual zone +/- 2 degreess
Shut down during shoulder seasons in favor of natural ventilation

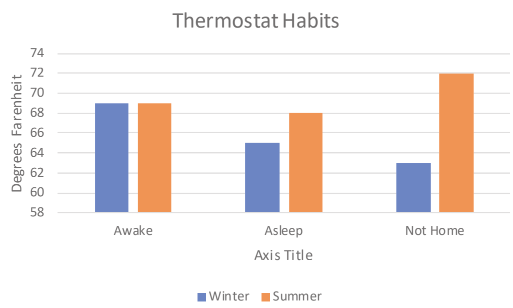
## User

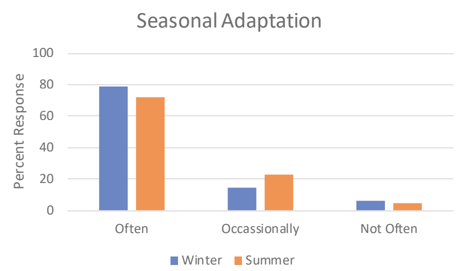
While data exists within the literature on overall thermal comfort related habits, it was important to gain an understanding of habits within the North Eastern United Sates. A 22 question survey was distrbuted online using Survey Monkey with social media distrubution via Facebook. Over a 7 day period 85 responses were gathered, with 75 of the respondants currently living within the North Eastern United States.

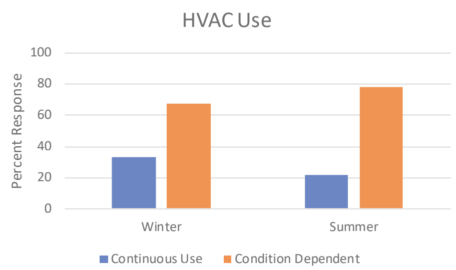
Data analysis indicated that the average temperature at which respondants set their thermostats was 69$^{o}$ farenheit in both summer and winter, indicating a leaning towards a static comfort model. However, when asked about the frequency with which they adapt themselves to seasonal conditions, ~75% of respondants said that they often practiced behaviours such as opening windows and wearing lighter clothing in the summer to stay cool or wearing heavier clothing and using blankets in the winter to keep warm, indicating that under the right conditions a majority were amenable to adaptive comfort ideas. This was further supported by the finding that 66% (winter) to 78% (summer) of respondants reported turning their system on and off depending on external conditions.

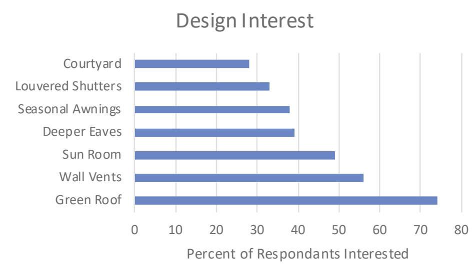
When provided a list of sustainable technologies and asked to gauge their interest, respondants chose those items which least impacted light and sight lines within the home. Items like awnings, deeper eaves and louvered shutters, all of which block light and or sight, were least favoured. Courtyards ranked last, perhaps due to lack of understanding of impact and experience of use as they are not a strong building typology within the Philadelphia region.

## Summary Graphs



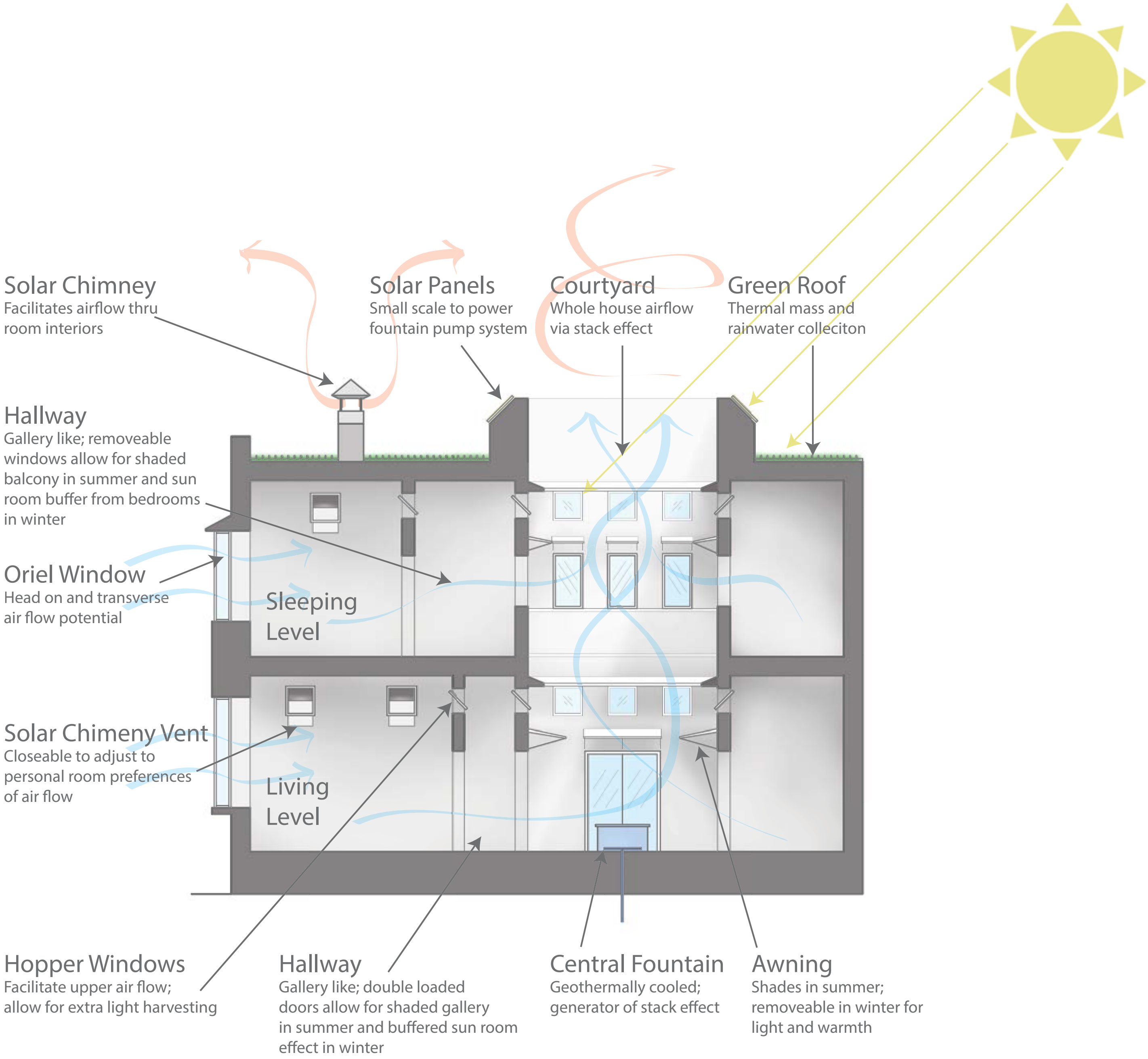



# INITIAL STATEMENT OF DESIGN INTENT

## INITIAL STATEMENT OF DESIGN INTENT

Vernacular inspired architectural design will be used to generate a comfortable, aesthetically pleasing residential machine for living that lowers the users need and desire to use traditional HVAC systems to achieve thermal comfort, thus lowering overall household energy needs. These design solutions will be adapted to units of varying size within a repurposed warhouse structure in a dense urban setting.




Diagrammatic example of potential use and combination of vernacular inspired design elements at the whole unit level. Design solutions will also be provided at the individual user level to maximize user experience.

# PROGRAMMING

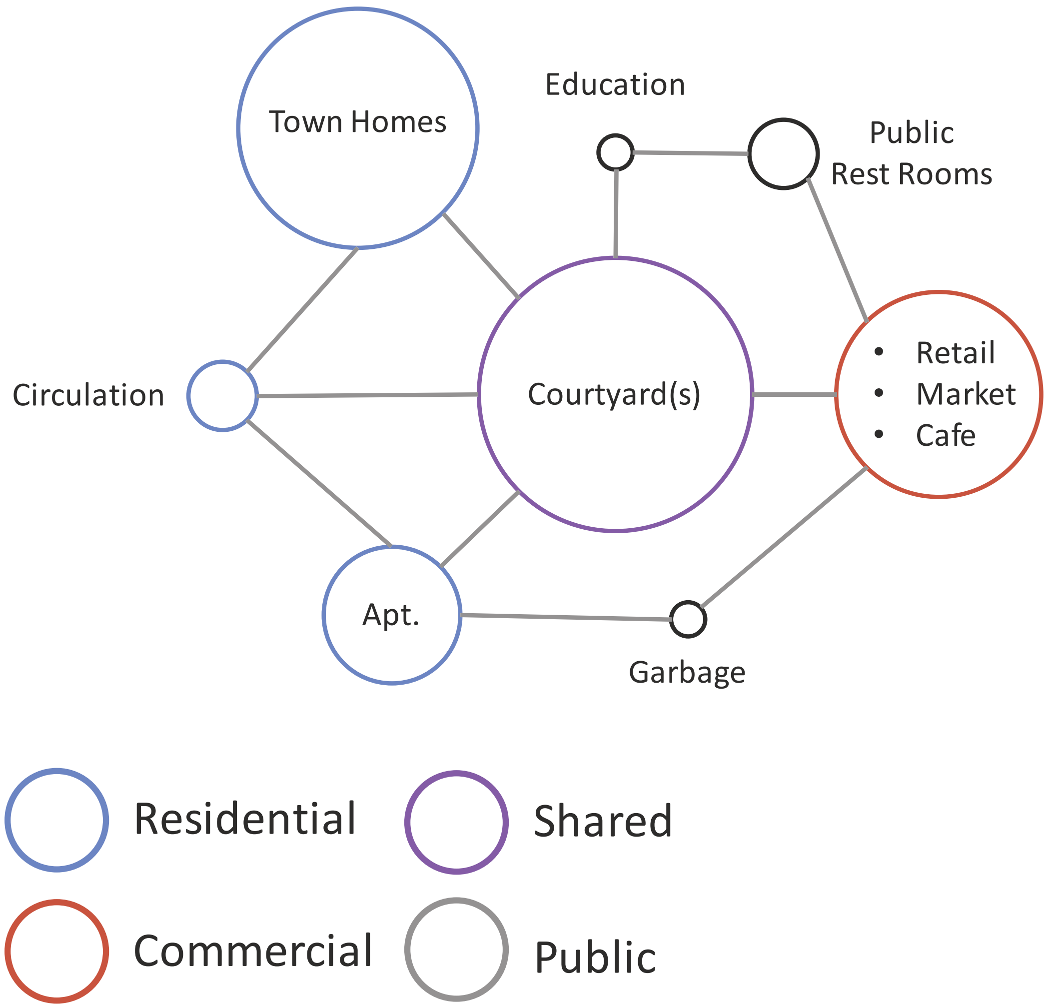
## MIXED ADAPTIVE REUSE
**(75% Residential / 25% Commercial)**

Residential ~ 32,000 ft$^2$
Town Homes - 1,200 - 2,000 ft$^2$ per unit (7 units)
 2 bedroom town homes w/ private courtyard options
Apartments - 700 - 1,000 ft$^2$ per unit (7 units)
 1-2 bedroom apartments w/ shared courtyard

Commercial ~ 11,000 ft$^2$
Product Market - 2,000 ft$^2$
 Locally Grown
Coffee Shop - 1,200 ft$^2$
 Locally Owned
Other Retail - 6,800 ft$^2$
 Locally Owned
Educational - 1,000 ft$^2$

## BUBBLE DIAGRAM

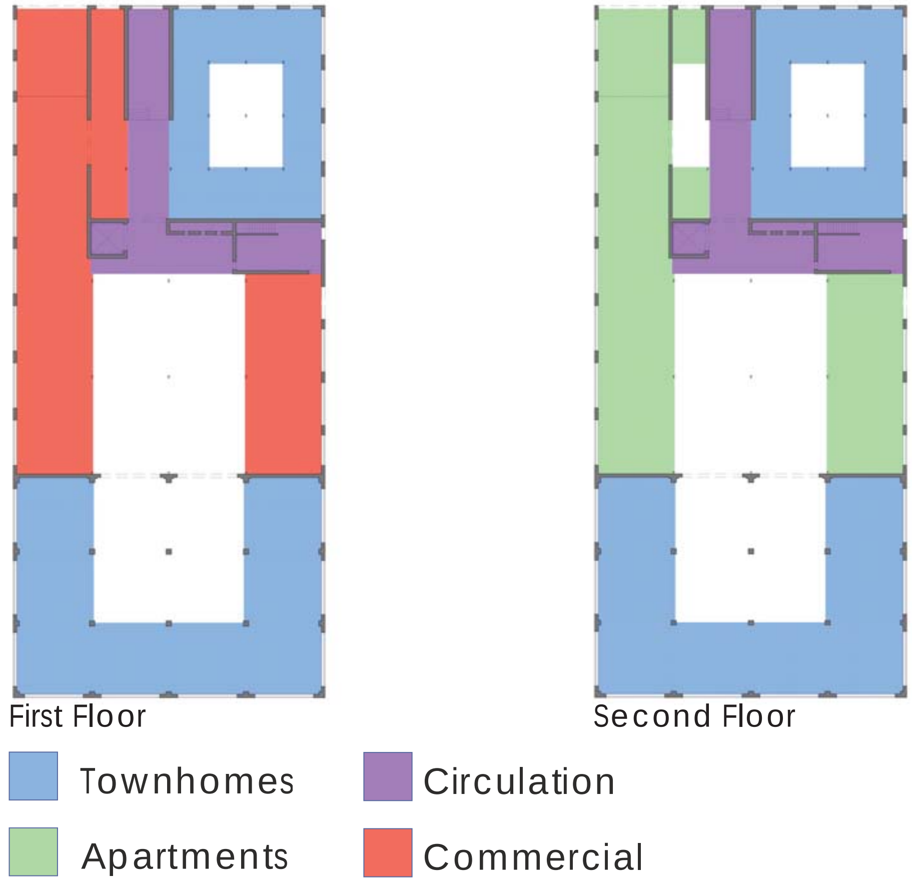
The central organizing element of the project wil be a series of courtyards. This will provide a private oasis for some units, a community gathering spot for others, while serving as an engineering tool for passive cooling strategies in both set ups.




## BLOCKING DIAGRAMS

Commercial spaces will be restricted to the first floor area, with some having direct access to the shared courtyard and some having only visual access.

Apartments will be set above the commercial space. Town homes are set at either end of the building, with one set enjoying larger units and private courtyards. Smaller units at the other end of the building will share a common courtyard.

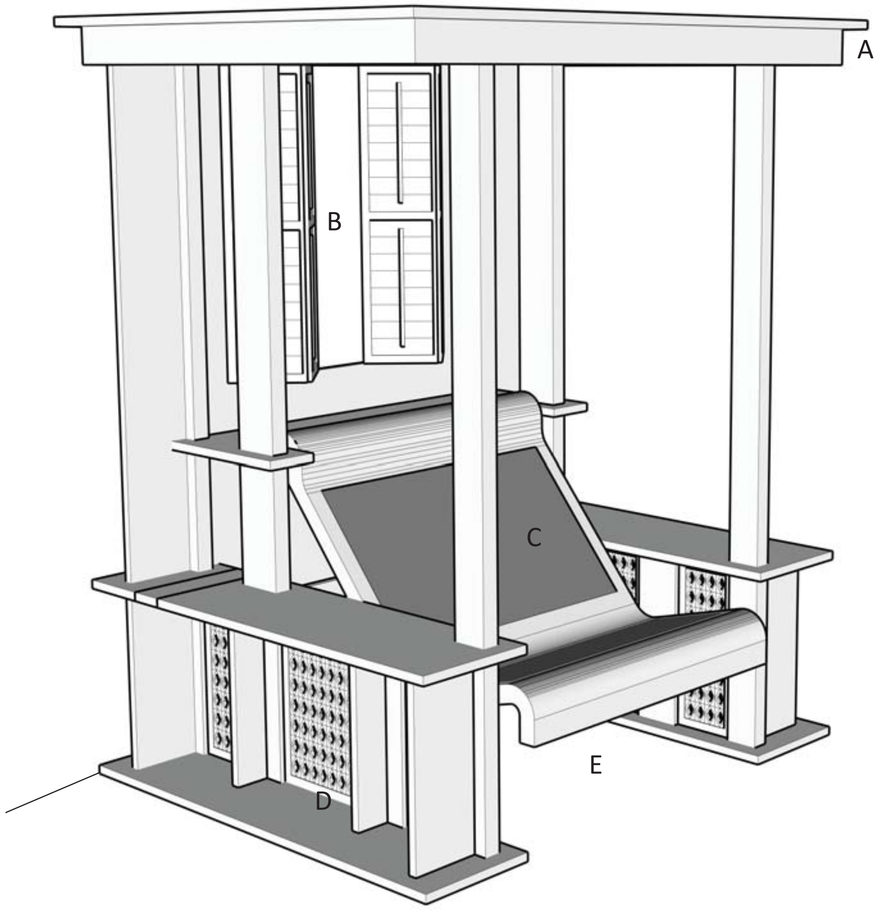


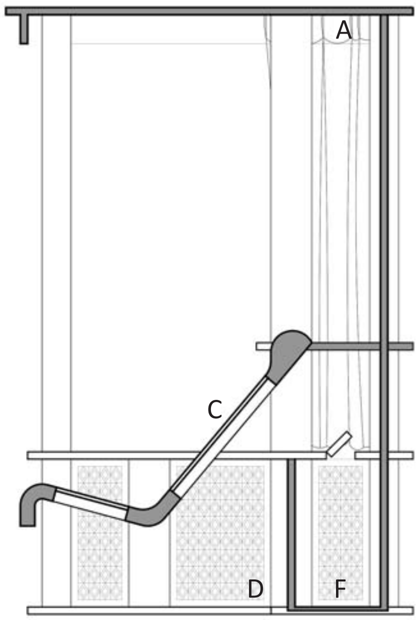
# DESIGN PROBES

## SCALE

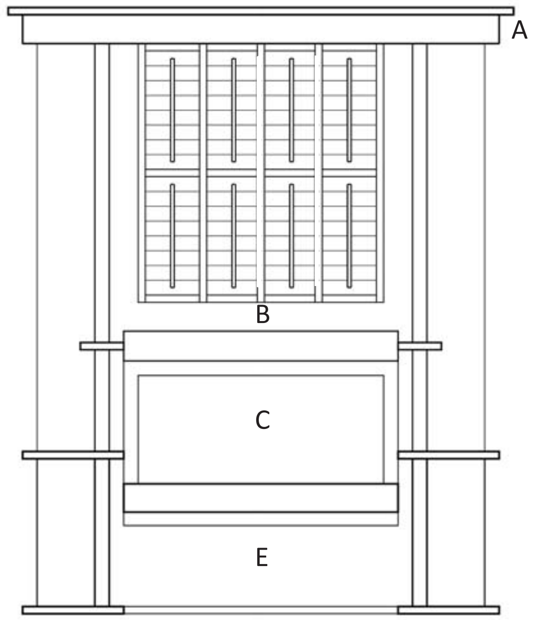
The design intent of this project is to provide hedonistic sustainability (that which brings an increase in quality of life and experience for the user) at both the whole unit scale and the individual user scale. Below is a design probe intended to explore a piece of furniture as a way to regulate personal thermal comfort year round.

# Window Seat




Section
Scale: 1" = 1' - 0"




Elevation
Scale: 1" = 1' - 0"

A - Overhead Canopy with curtains for privacy and warmth.

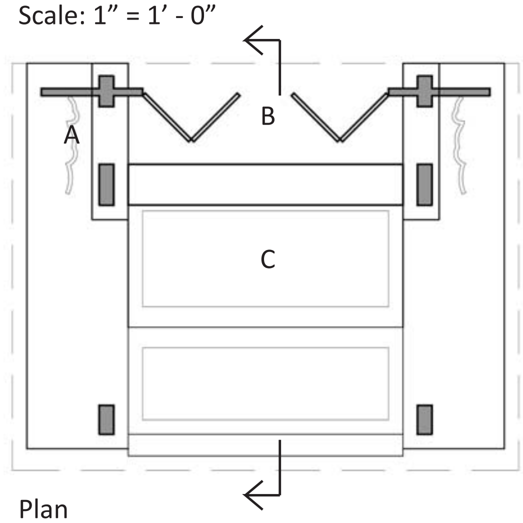
B - Operable Shutters to adjust airflow / sunlight from adjacent window.

C - Caned Panels in back and bottom of seat to facilitate airflow.

D - Perforated Panels to facilitate airflow.

E - Open Frame construction to facilitate airflow.

F - Storage Space for Winter Cushions




Plan
Scale: 1" = 1' - 0"

Window Seat rethinks the traditional idea of its namesake, providing an all season, personalizable thermal experience for relaxed indoor sitting. Intended to be placed in front of a favorite window, the operable shutters allow for varying levels of directed airflow in warm weather and warmth via direct sun light in cooler weather.


Brian Thiel
INTR 894 Fall 2017
Design Probe I: Scale
Part: 2

## EXPERIENCE

The short story below was written as an exploration of the feelings and experiences the designed spaces are intended to invoke and provide for the user.

### A Brief Story of Fictional Jane's Return from Work and Eventful Dinner Party

It's a Warm Summer Day in Philadelphia. Jane rides her bike home form work. After 20 minutes she is sweaty, but home and ready to relax. She locks up her bike and makes her way to her front door, looking forward to the pleasantly cool, shady interior that awaits her. She has friends coming for dinner, but for now she wants to relax, check her social media and cool down. A small, air-conditioned lounge space greets her, its small sofa and chair looks restful after a long day. She kicks off her shoes and wiggles her toes, feeling the cool of the tile floor. She heads thru an arch into the kitchen, grabs a glass of iced tea and heads back to the sofa to rest.

Thirty minutes later, thoroughly caught up on social media, having posted a few cat pics, she heads into the kitchen and looks in the fridge. Nothing inspires her. She gazes out thru glass doors into her living room. A sliver of setting sun makes a spot on the floor, or more precisely a spot of cat. The curtains are blowing softly in the breeze of the open window. A bird fusses in the feeder in the courtyard, unobserved by the dozing cat.

Jane shrugs, closes the fridge and heads out through a sliding door into the living room. She curls into a chair and lets the breeze drift by her while she texts her guest to get their take out order. She reads a book by the setting sun as the orders come in. Shortly before they arrive she grabs a blanket and some cushions and spreads them out in the courtyard for a take-out picnic. The sky above is turning brilliant shades of red and orange in the gathering clouds.

Half way thru the meal the first drops begin to fall. Laughing, everyone grabs something and heads across the courtyard to the dining room. They open the large doors and listen to the rain while they finish their dinner. More than one bottle of wine later the rain has stopped, the clouds have blown out and the temperature has dropped pleasantly.

Jane gathers her remaining guest and leads her to the spare bedroom. Unexpected sleepover seen to, Jane heads into the kitchen. She turns off the air conditioning and opens the windows, feeling the gentle breeze stir thru the usually closed room. She ambles around the house checking to make sure she's opened all the shutters. She softly, but robotically says "Cross Breeze Activated," and giggles to herself.

Jane lays in bed and checks the weather. She has until the weekend before the dry, pleasant summer weather is displaced by some of Philadelphia's high humidity. She sighs, knowing she'll have to close up part of the house and use the AC. She'll close the shutters on the southern exposure, spending most of her time towards the courtyard where the indirect light filters in without too much heat gain. Still, she smiles thinking of the magic of early morning coffee outdoors. The heat won't have made the humidity oppressive yet and she can enjoy watching birds by the feeder before she hops on her bike and heads to work. As she drifts off to sleep she reminds herself to pick up more coffee beans on her way home or her fantasy will be for naught.

## MATERIALITY

Given the underpinning of sustainability to the project material usage is intended to be as sustainable as possilbe. Where available, sustainable, locally sourced natural materials will be used. Other considerations will include recycled / reused materials, rapidly renewable materials, as well as materials with low VOCs and those manufactured under sustainable conditions.

Due to the vernacular underpinnings of the project, materiality will take into consideration the function of original materials and work to replicate funcitonality with appropriate contemporary materials meeting the above listed goals.

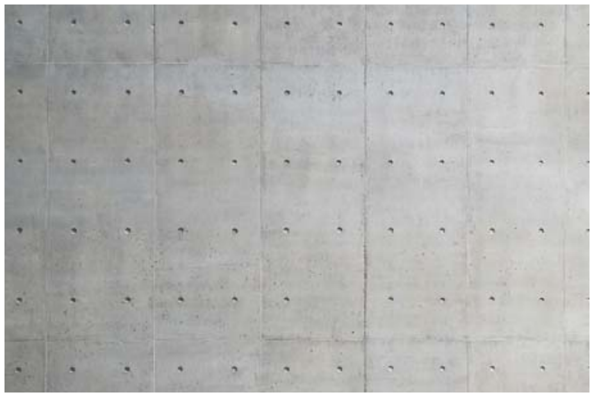
Below is a selection if images representing initial thoughts on materiality for the project.

**Carved Wood**

**Water**

**Green Roof**

**Wood Shingle**



**Concrete**

**Glass Block**

**Tile**

# DESIGN DEVELOPMENT

# DESIGN DEVELOPMENT

## Code Analysis

A code analysis was initially conducted to determine guidelines during the design process. After completion the analysis was applied to the final design to indicate compliance with relevant IBC 2015 codes.

## Process

The design phase of Three Court Green lasted approximately 22 weeks with two major juried checkpoints before the final presentation. The first checkpoint shown focused on general space planning efforts. The goal of this portion of the process was to firm up general shapes and locations of designated spaces. The second checkpoint shown focused on a firmer arrangement of interior spaces along with a concerted effort to define the look and function of the building facade as it related to interior space planning and exterior shading requirements. After completing this phase of the process focus turned back to detailing the interior spaces for a final realization of the livabilitiy of the space, the results of which are shown as the final drawings in Plans and Sections and Interior Analysis.

## Wayfinding

The design of Three Court Green as individual residential units did not require a complex wayfinding plan, though delineation of commercial and residential space was addressed through design elements. Commercial spaces are detailed with metal framed, industrial window grids at roughly 2' x2'. Each commercial window is capped by a fabric awning whose coloration and design are brand specific and ultimately left to the occupant. Entrances that serve both commercial and residential needs are capped by fabric awnings bearing the Three Court Green name. Entrances to individual residential units are accessed via one or more stairs leading to a low walled front porch area. Window treatments here are metal clad casement or awning, distinctly different from the store front grid style of the commercial spaces. Access points to residential areas from within the building are controlled via a secrutiy system and so not physically accessible to non-residents.

## Materials

Three Court Green is designed as a mixed use residential and commercial building. As such, a large amount of materials are left to the discretion of its occupants. Below is a general discussion of building materials as they relate to hard surfaces such as walls, floor and countertops.

### Exterior Facades

The exterior envelope of brick has been kept and painted white to reflect sunlight and help cool the interior. Additional window surrounds of bronze with areas of white add contrast and visual distinction to the facdes on each side.

### Courtyard Facades

As the courtyard facades are entirely new material choice played a larger role in the design process. To give visual texture and add thermal mass the courtyard facades are rendered in bottle dash, a combination of small pebbles and tumbled glass pieces adhered to a mortar surface. The tumbled glass adds an additional visual element as it reflects light within the courtyard, making the walls sparkle when hit with direct light. Window surrounds are done in bronze Regulating elements breaking up the facades of the courtyard are rendered in light cement as are stairs, landings and parts of the fountain system. Additional parts of the fountains are made using copper sheet and slate tile. Courtyard floors are done in red brick in a herringbone pattern. Some portions of the courtyard walls are clad in wood shingles for visual texture as well as their ability, as a natural material, to retain moustiure at night and help cool surrounding spaces during the day via evaporation. Copper is used as an accent material.

### Interior Spaces

While the ultimate materialitiy of these spaces is up to the occupants, proposed designs call for natural bamboo flooring in most living spaces with Pennsylvania bluestone in the first floor loggia areas and Calcutta gold marble for bathroom floors. Where possible reclaimed oak for cabinetry and interior wood elements is proposed. Some elements, like custom under stair cabinetry, basboard and window surrounds are proposed painted in Benjamin Moore Dark Olive. Countertops throughout are shown in granite. The remaining soft materials are shown as examples only.

## SQUARE FOOTAGE

Commercial Space - 4,300 sq. ft.
Commercial Courtyard - 3,000 sq. ft.
Central Court Apartments - 5,640 sq. ft. total
- 1 Bedroom - 720 sq. ft.
- Studio - 575 sq. ft.
- ADA Accessible - 1,200 sq. ft.
- Walk Up - 990 sq. ft.
- 2 Story - 860 sq. ft.

North Court Units - 2,000 sq. ft. per unit
175 sq. ft. per courtyard
South Court Units - 2,000 sq. ft. per unit
525 sq. ft. per courtyard
Sun Deck - 2,000 sq. ft.

## CODE ANALYSIS

### Commercial Space

Commercial Occupancy (IBC 1004.1.1) - 120 Persons Max.

Public Restrooms (IBC 2015 2902) - A2 Occupancy requires 1 per 200.  4 are provided.

Exit Access Travel Distance (IBC 1017.2) 250’ with Sprinklers

### Residential Space

Common Path of Travel with 1 Exit (IBC 1006.3.2(1)) - 125’ with Sprinklers

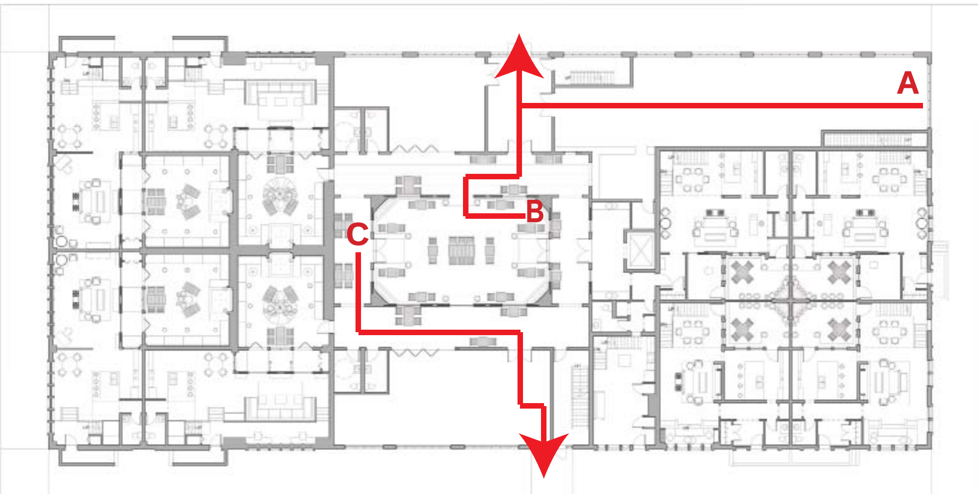
Exit Access Travel Distance (IBS 1017.2) - 250’ with Sprinklers

### Commercial Exit Path Distance

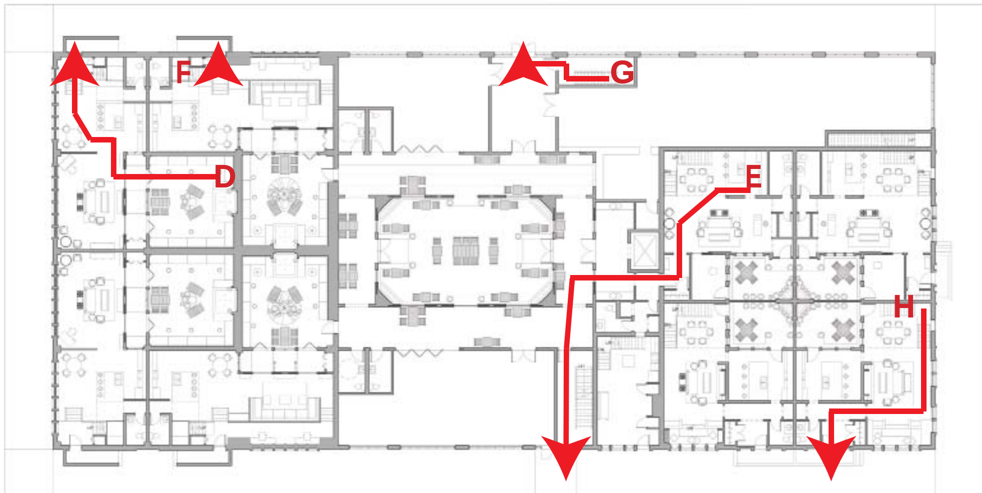
A - 110’
B - 68’
C - 88’

### Residential Exit Path Distance

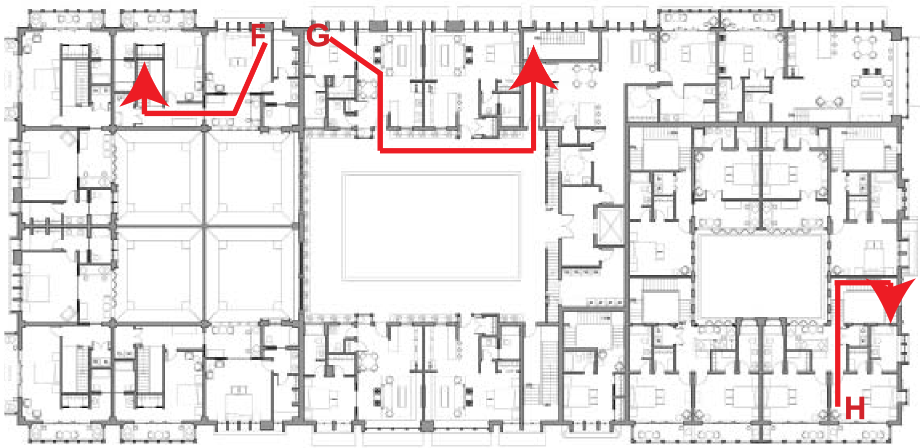
D - 62’
E - 88’
F - 75’
G - 150’ (Common Path - 25’)
H - 108’




**Commercial Exit Path Plan**

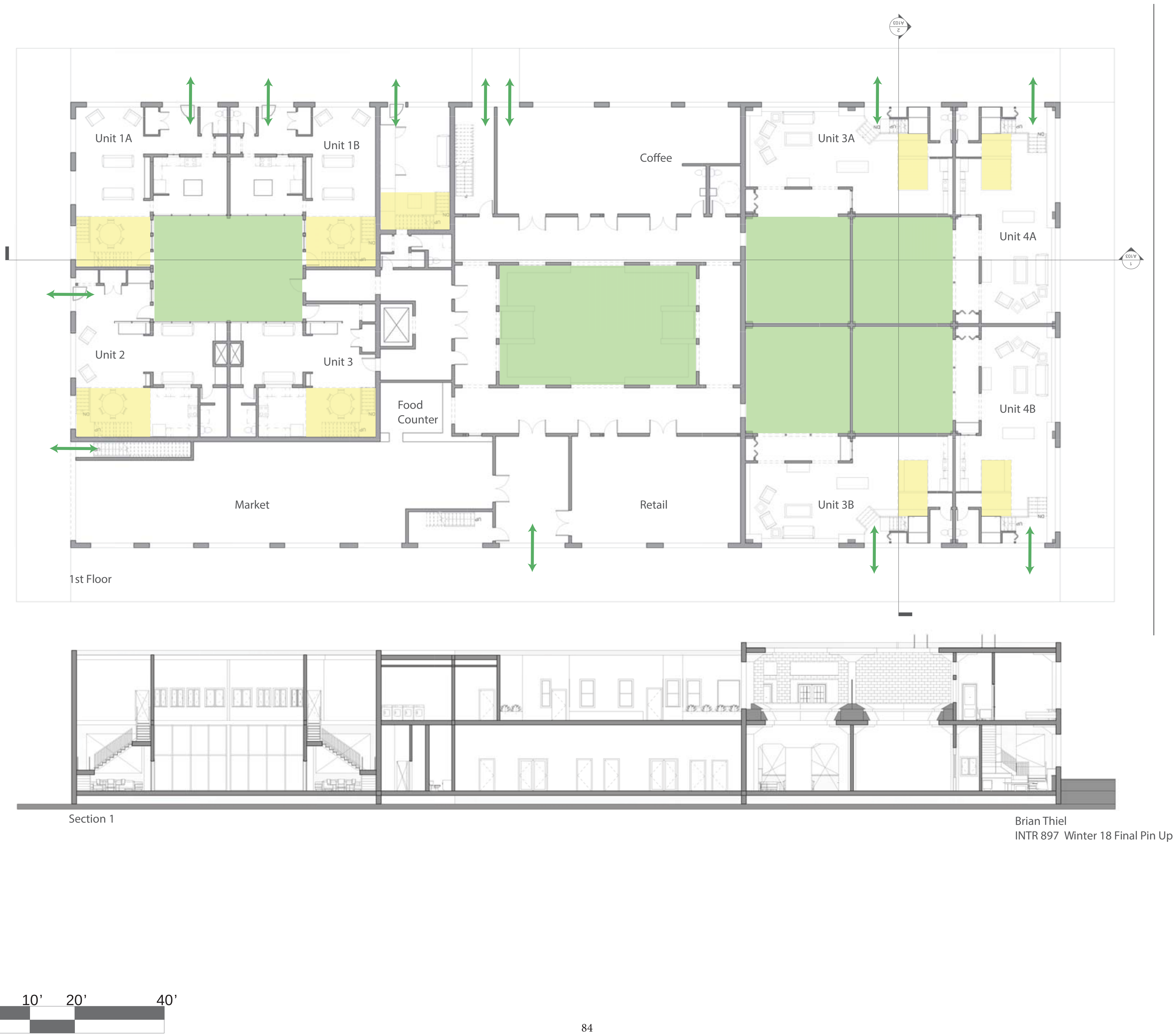



**Residential First Floor Exit Path Plan**



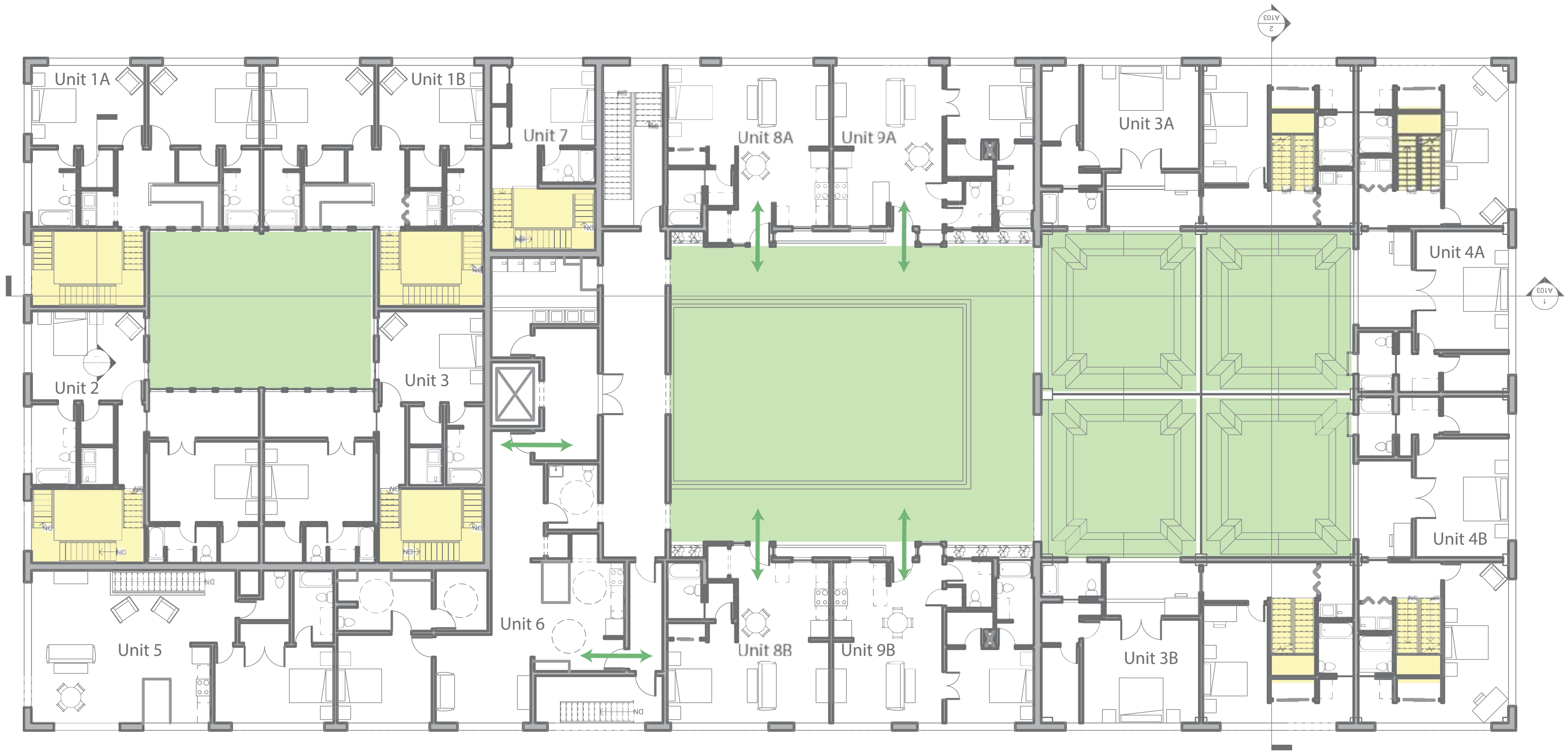

**Residential Second Floor Exit Path Plan**

# First Checkpoint

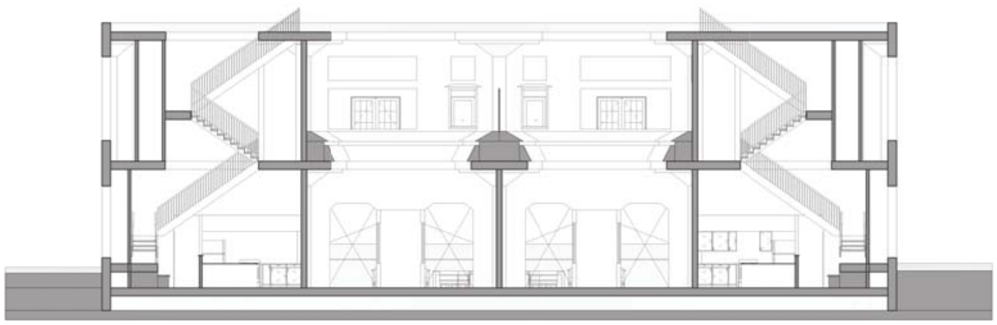



Brian Thiel
INTR 897 Winter 18 Final Pin Up

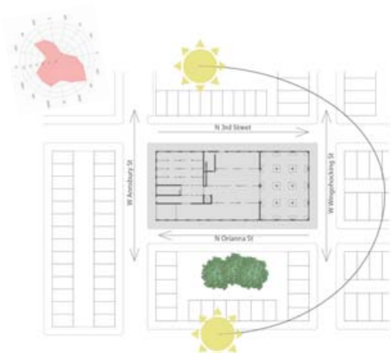
## First Checkpoint




2nd Floor



Section 2



Site Analysis

Site Map

Brian Thiel
INTR 897 Winter 18 Final Pin Up

## First Checkpoint

Central Courtyard

Unit 4B

Unit 4B

Unit 4B Courtyard

Unit 9A

Unit 1B

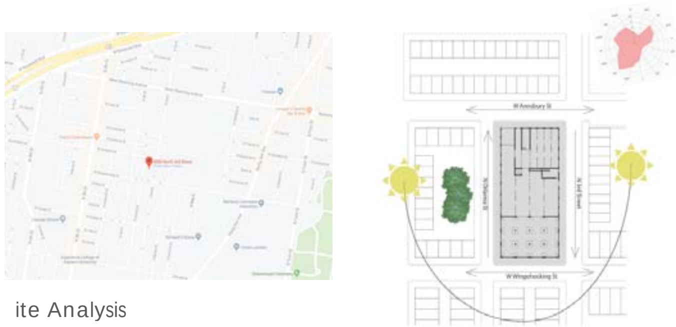
## Second Checkpoint

# Three Court Green

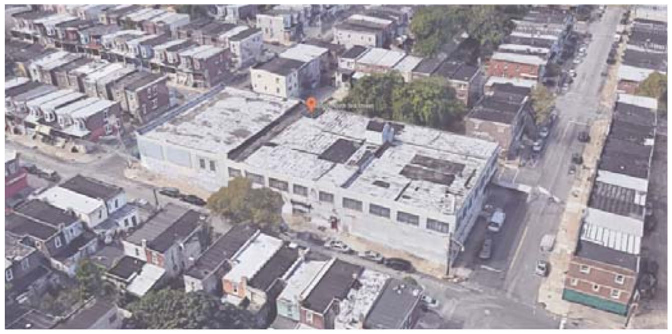
A Mixed Use Residential Project Offering Luxurious Urban Living
Centered Around Three Unique Courtyard Experiences

1st Floor Key Plan

2nd Floor Key PlanS



ite Analysis



Existing Conditions: View From The North East

Existing Condtions: View From The South West

### The Central Court

Mixed Use Courtyard
~4,300 sq. ft. Commercial Space
~5,800 sq. ft. Residential Space
~3,000 sq. ft. Shared Courtyard

Secured Residential On 2nd Floor
( 4) 1 Bedroom / 1.5 Bath Apartments
( 1) 1 Bedroom / 1.5 Bath ADA Accessible Apartment
( 2) 1 Bath Studio Apartments

### The South Court

Private Courtyards
~540 sq. ft. Outdoor Space
~100 sq. ft. Logia
Private Entrances

Two Story Residential Units
~1,000 sq. ft. 1st Floor
O pen Plan w/ Powder Room
~1,000 sq. ft. 2nd Floor
2 Bedroom w/ En Suite, Sunrooms & Logia

### The North Court

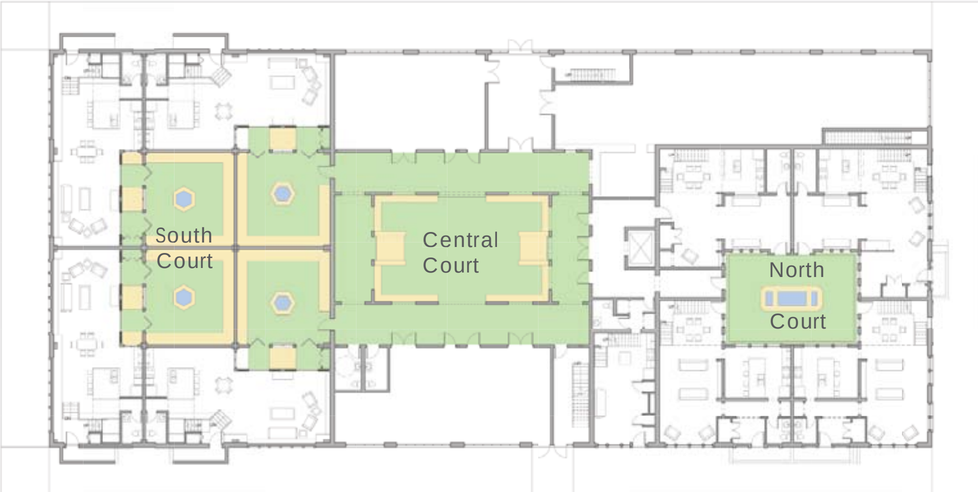
Shared, Secured Courtyard
~540 sq. ft. Outdoor Space

Private Entrances

Two Story Residential Units
~1,000 sq. ft. 1st Floor
D ining Area, Powder Room
~1,000 sq. ft. 2nd Floor
2 Bedroom w/ En Suite, Sunrooms & Logia

Brian Thiel Thesis Walk Thru 4/21/18

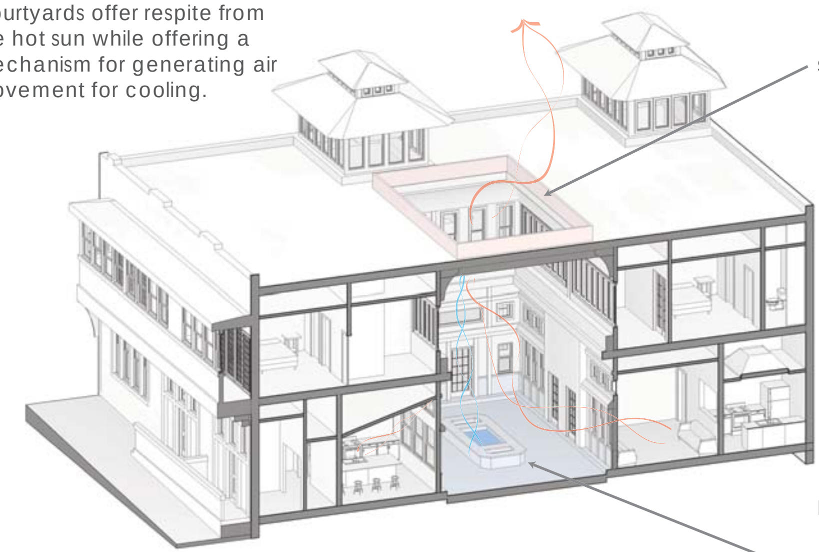
# Courtyards




Courtyard Key Plan

Courtyards offer respite from the hot sun while offering a mechanism for generating air movement for cooling.

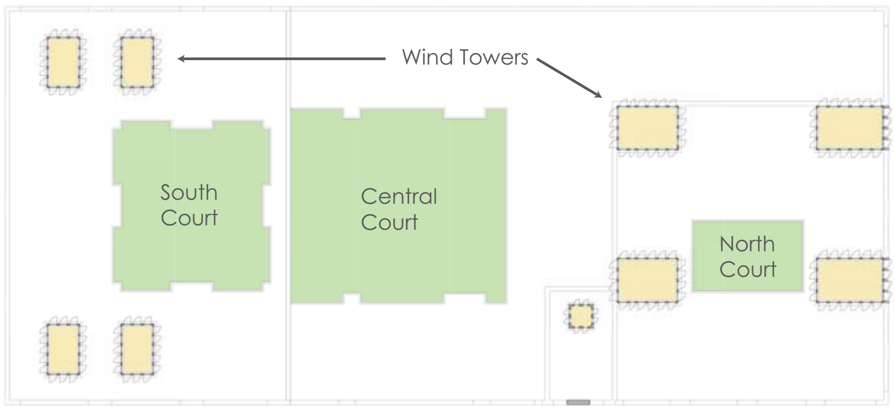
Metal clad parapet walls with dark exterior absorb summer sun and act as a generator for airflow up and out of the courtyard.



Large openings at various levels along with ceiling design allow for airflow out of the rooms surrounding the courtyard.

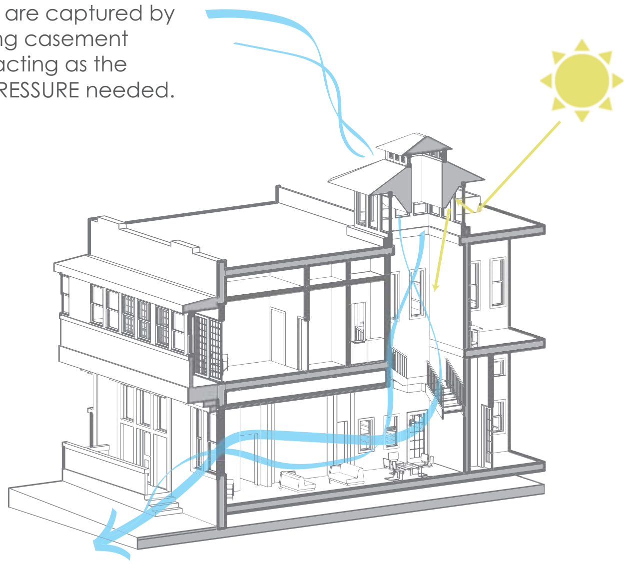
Fountains and high thermal mass surfaces (stone, brick) maintain a cool base for the generation of stack effect in combination with the heated air at the top of the courytard.

# Towers of Wind and Light




Roof Key Plan

Prevalent Winds from the south west are captured by open facing casement windows, acting as the POSITIVE PRESSURE needed.

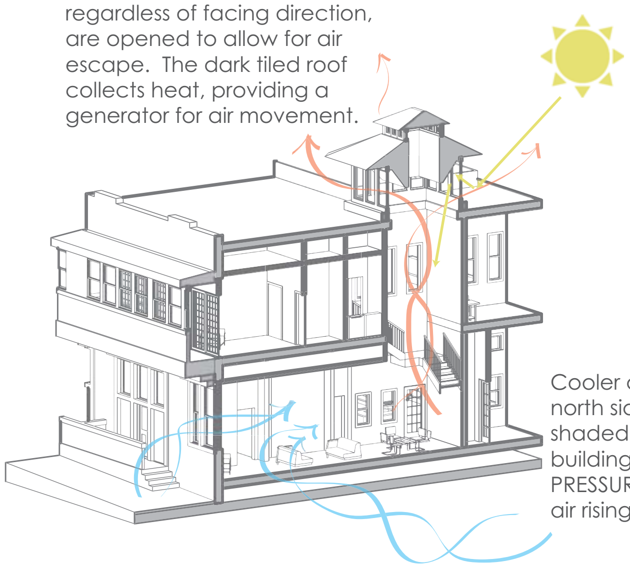


Windows on the first floor east side are opened, providing a source of NEGATIVE PRESSURE to activate the airflow process.

Wind Catcher Scenario

Angled fins allow for physical direction of wind flow in and out of the tower. The white surface of the fins and central shaft assist in channeling light down into the tower.

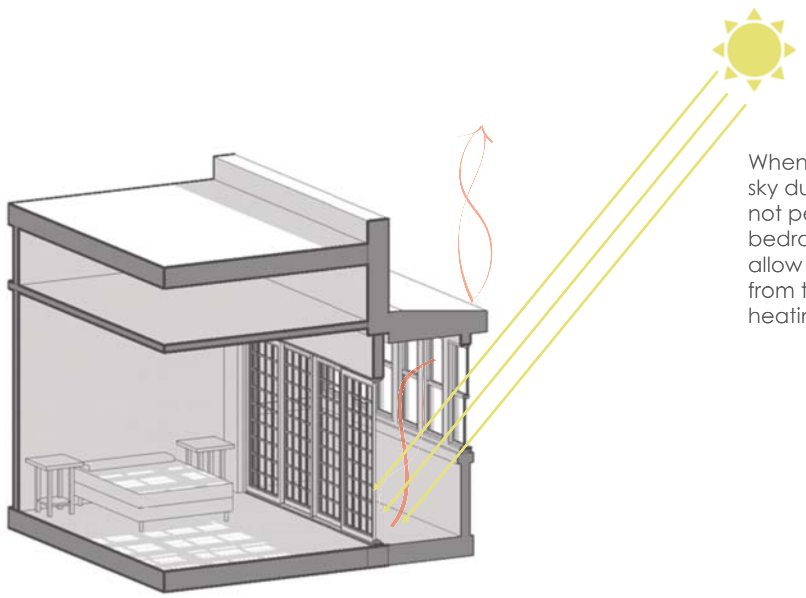
On windless days all of the windows in the tower, regardless of facing direction, are opened to allow for air escape. The dark tiled roof collects heat, providing a generator for air movement.



Cooler air is drawn from the north side of the building / shaded courtyards thru the building by the NEGATIVE PRESSURE created by the hot air rising out of the tower.

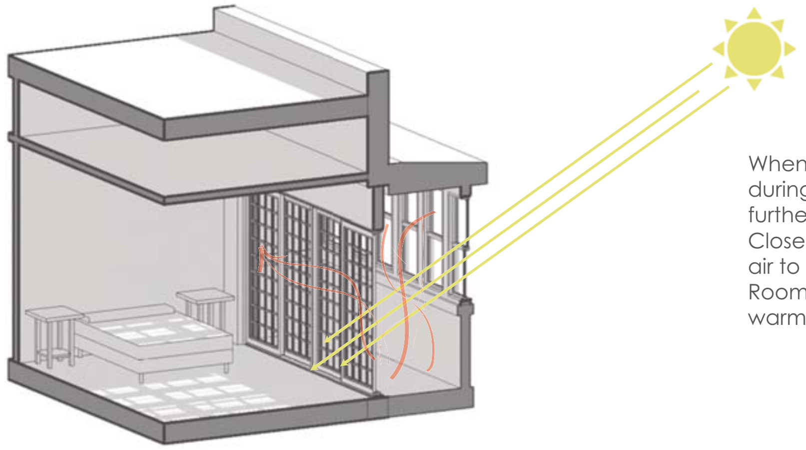
Solar Chimney Scenario

# Windows



When the Sun is higher in the sky during summer light does not penetrat as far into the bedroom. Opens windows allow for hot air to escape from the Sun Room without heating the bedroom.

Summer

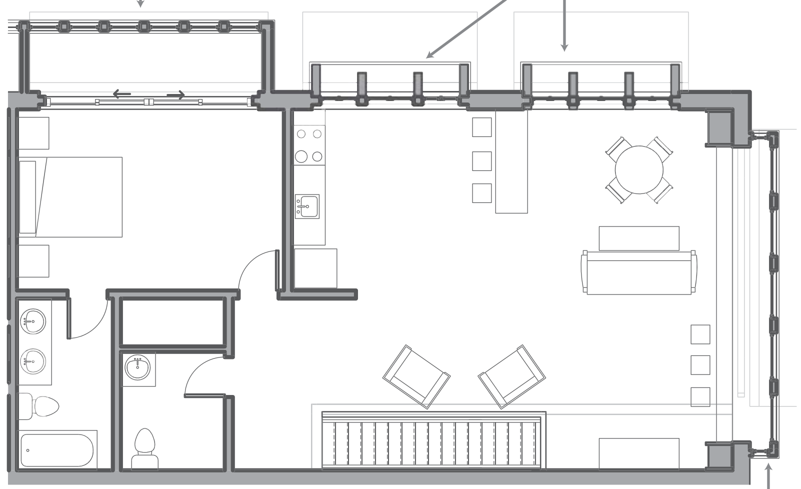


When the Sun is lower in the sky during winter light penetrates further into the bedroom. Closed windows allow for hot air to build up within the Sun Room providing a source of warmth for the bedroom.

Winter

Sun Rooms provide buffer space from direct sun during the summer when windows are open while collecting heat during winter with windows closed.

Deep Projecting Fins help provide shading as well as visual structuring of window units.



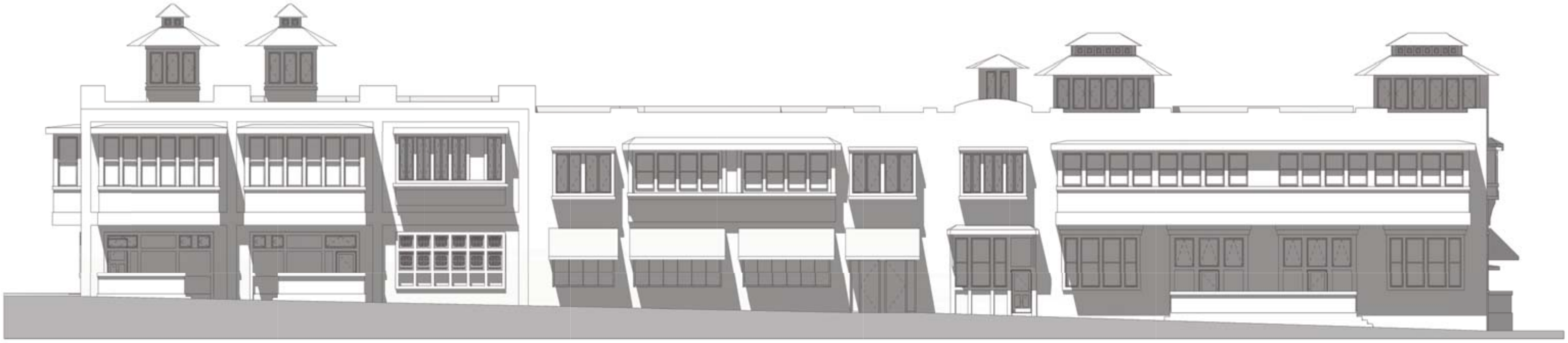
Walk Up Apartment

Deep Windows at counter height provide space for reading, working, entertaining or just growing plants.

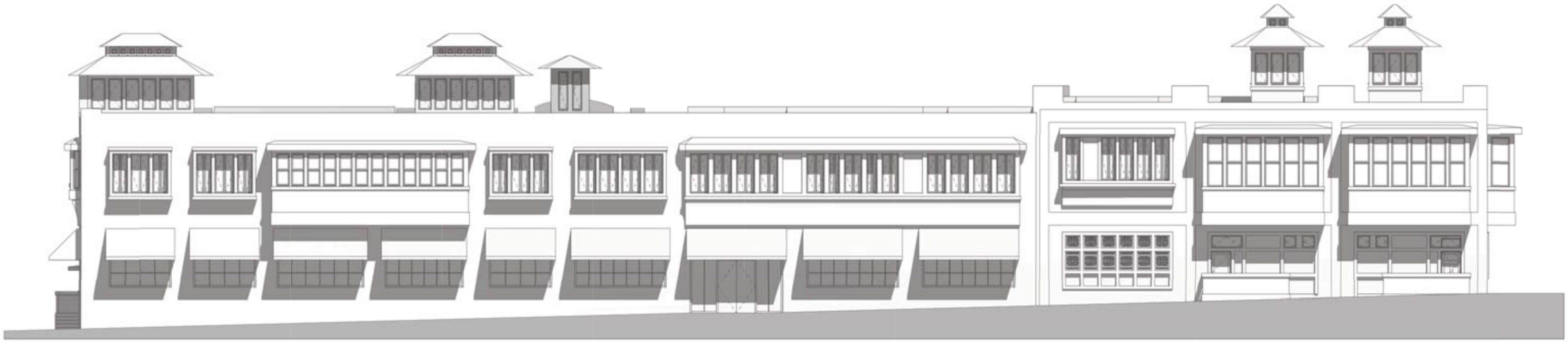
## Second Checkpoint

North Elevation: 9 AM on 6/30

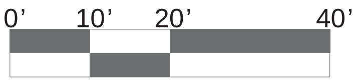
South Elevation: 1 PM on 6/30



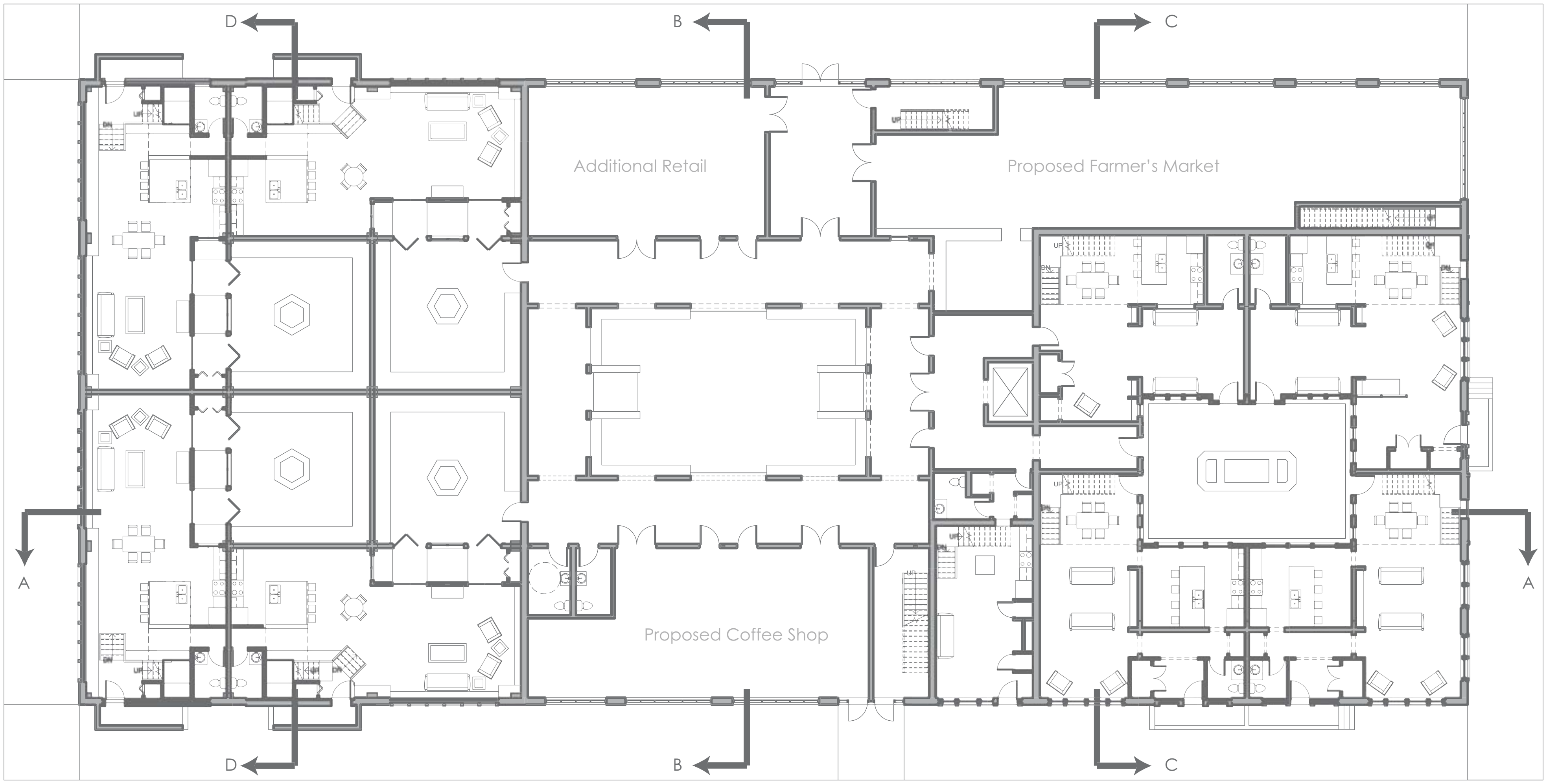
East Elevation: 11 AM on 6/30



West Elevation: 3 PM on 6/30

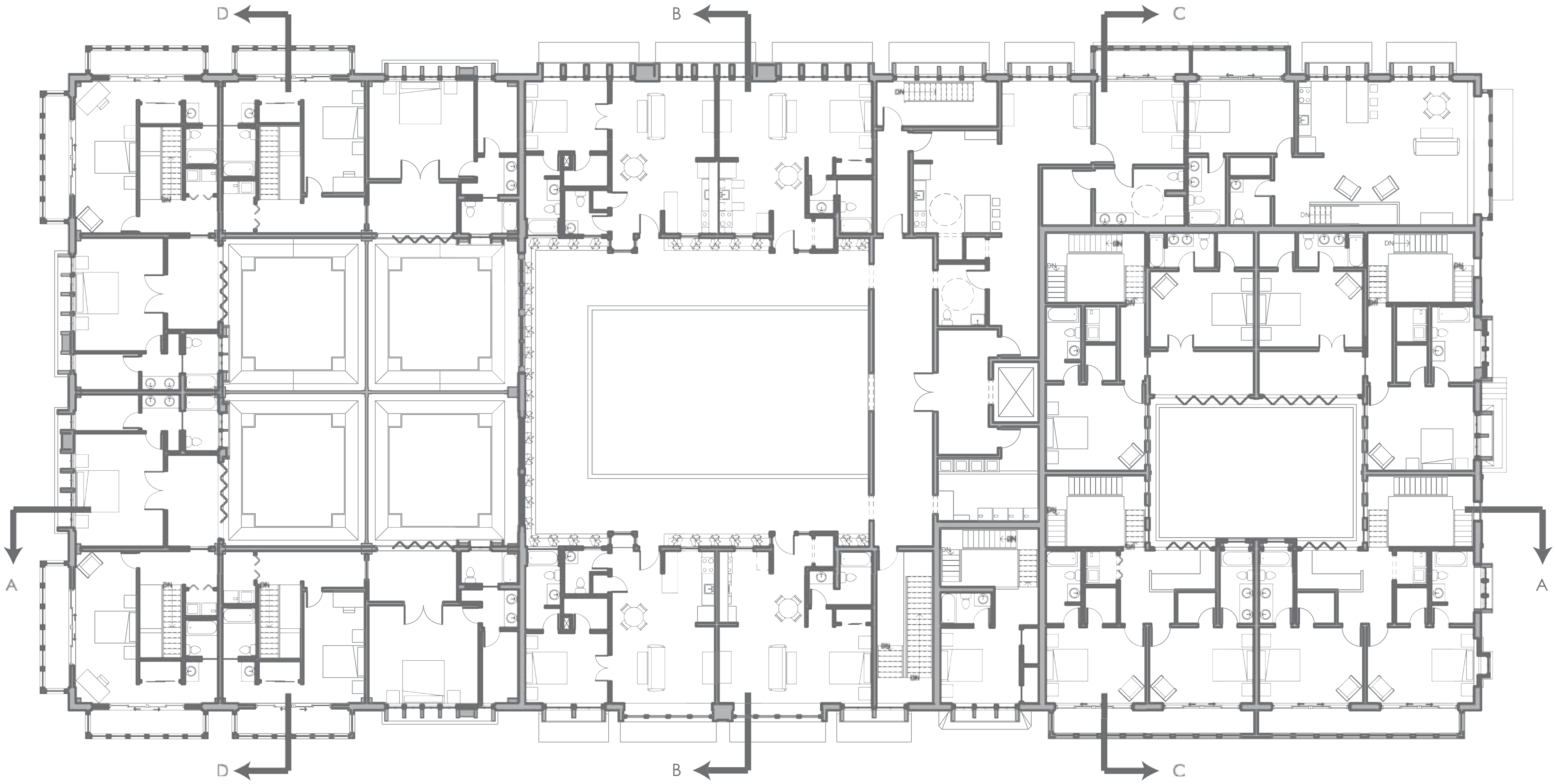


## Second Checkpoint



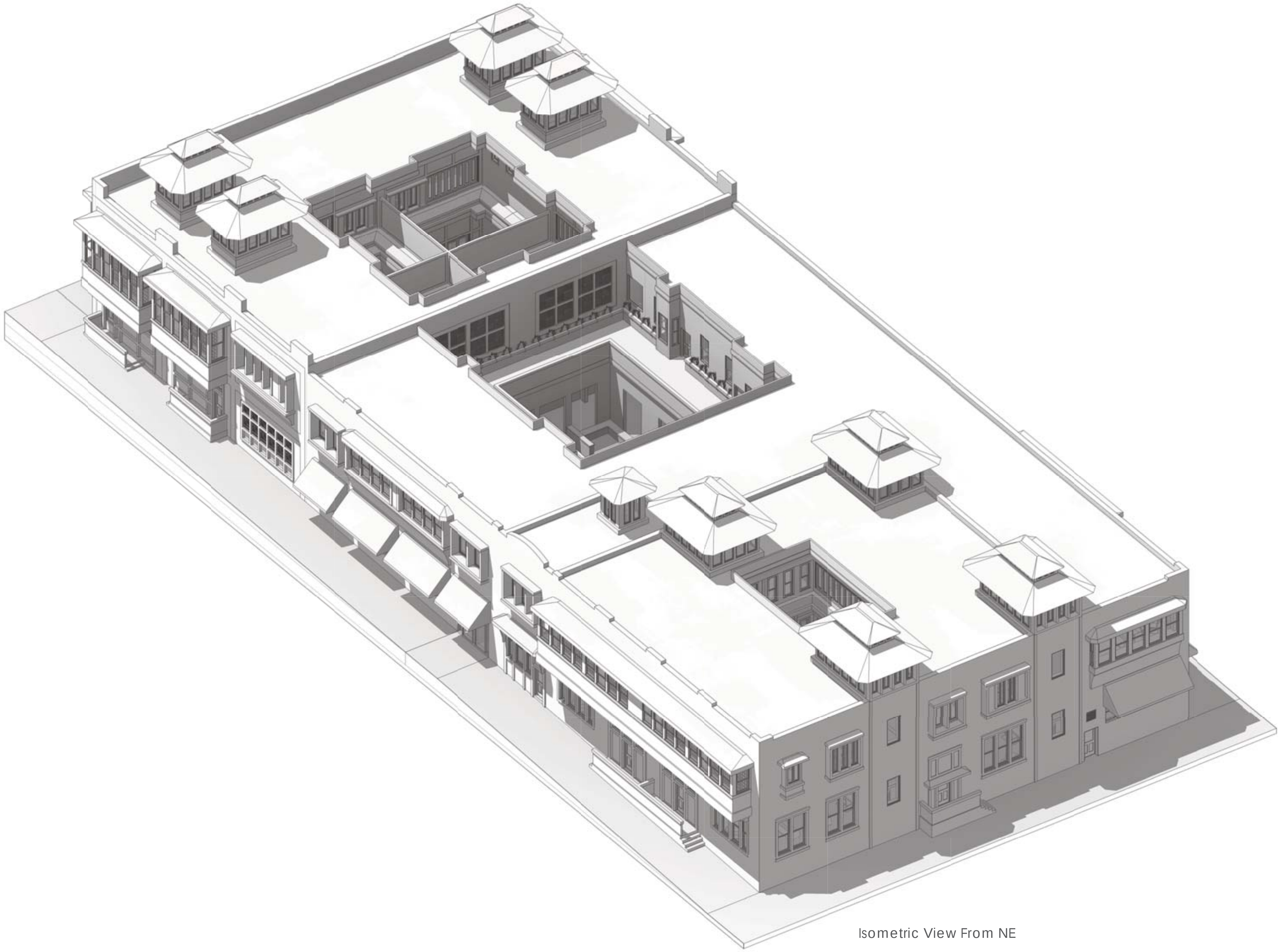

1st Floor Plan

## Second Checkpoint



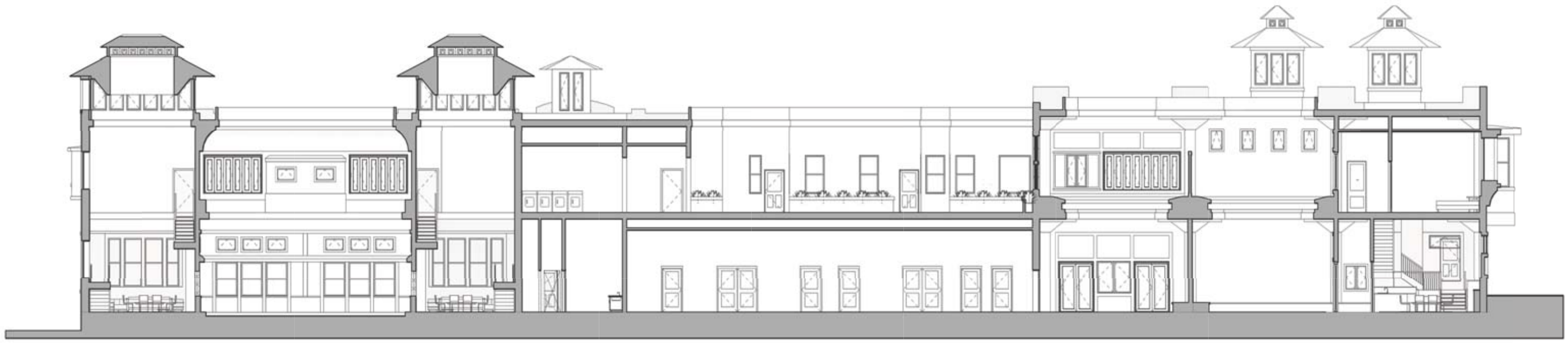

2nd Floor Plan

## Second Checkpoint



Isometric View From NE

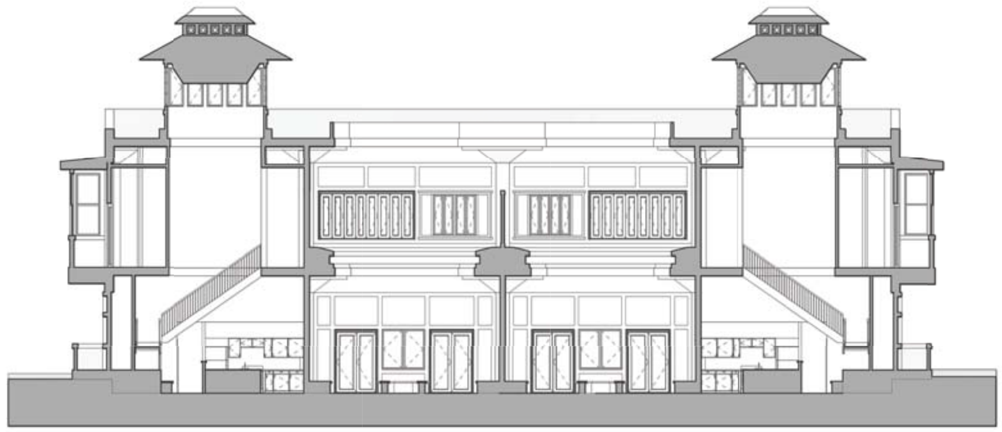
## Second Checkpoint



Section A - A

Section B - B

Section C - C



Section D - D