

# THE CORRUGATED EDGE



RICE UNIVERSITY

**THE CORRUGATED EDGE**

by

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A Thesis Submitted In Partial Fulfillment Of  
The Requirements For The Degree

**MASTER OF ARCHITECTURE**

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August, 2016



## **ABSTRACT**

### THE CORRUGATED EDGE

by Amanda Li Chang

This thesis reasserts the Spatial Model, spatial quality and experience, back into the development of housing. Spatial quality thus becomes an amenity, an attractor. The Spatial Model is also equally fit in developing housing at no compromise to the spreadsheet model. Architecture's agency to project alternative domestic situations through spatial means is key to creating dense urban environments that are spatially-rich, and invested in their urban locales, resonating with middle-income renters. Even more, architecture plays a central role in producing a new "multi-family" market, one that truly serves the desires of families looking to live in the city.

This project negotiates mixed-use program using the corrugated edge which is a spatial idea about seriality, depth and orientation. The corrugated edge is a filter through which the horizontal bleeding of space is managed. Small units can have a spacious feel as a result of alignments out to the gardens, and multiple sun orientations.

## **ACKNOWLEDGEMENTS**

Thank you to:

Mark Wamble, for his encouragement, criticism and the wealth of knowledge he generously shared with me.

Scott Colman, for pushing me to pursue my ideas with more clarity.

Srijaya, Steven, Wenqi, MaPi, Steven, Toshiki and Colin: for their skill and dedication, and for lifting my spirits.

My wonderful classmates, for the friendship, intellectual growth and inspiration over the last three-and-a-half years.

Austin, for his outside perspective and constant support.

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## UNDERSTANDING HOUSING FINANCE

Housing is one aspect of architecture that is commodified, and is seen as an investment. The big apartment complexes you see out in the city are a product of complex financial structures that attract investors from all over the world. Multi-family housing is thus developed, bought, and sold based on its earning potential. The goal of the game is to generate revenue. Understanding investors and their role in multi-family development is important because architecture has to work with the capitalist markets, meaning it needs to repay investors with a profit.

Figure 1  
How the majority of housing gets developed -- investors that invest in a merchant building platform. It's a short-term investment with large gains without the hassle of operating a housing development.

Merchant Builders (investors that invest in merchant building platform)

70% of all apartments in the U.S. are developed by merchant builders.  
Merchant builder model builds a majority of what's out there today.  
Short-term investors who build, lease-up, and sell as soon as possible.

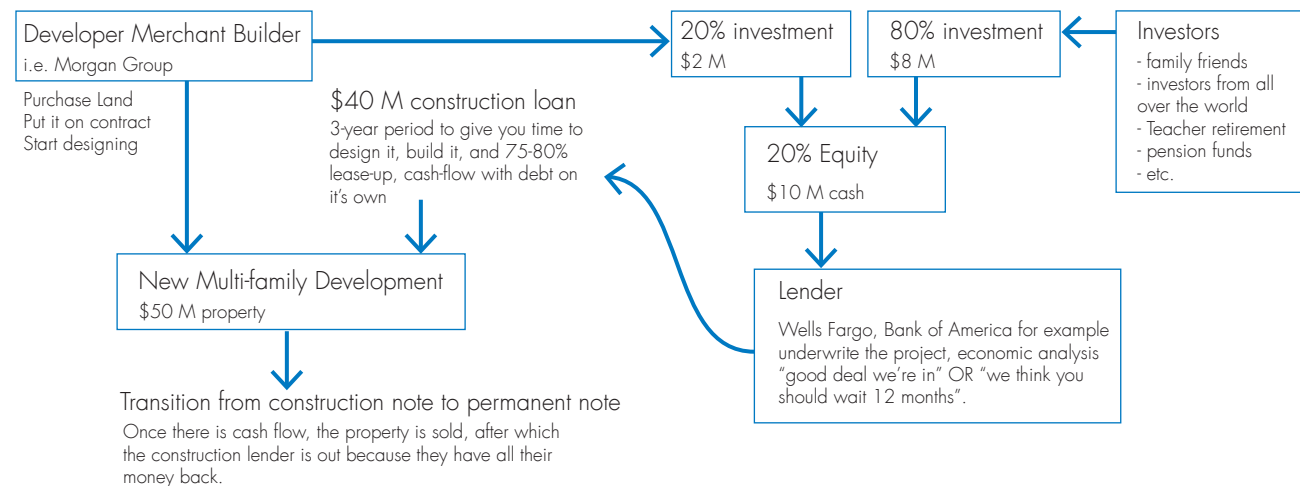


Figure 2  
Private-Public Partnerships.  
Case Study: Houston's 380  
Ordinance which gave the  
private developers land and  
a road in exchange for a  
parking garage and future  
property taxes.

380 Ordinance from City to encourage growth

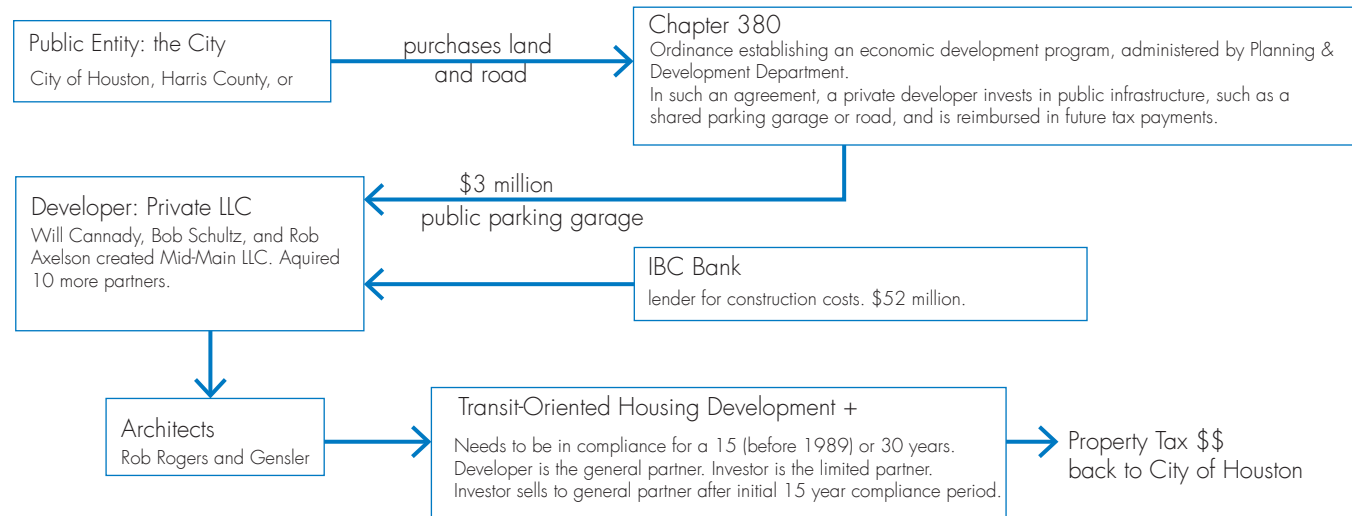
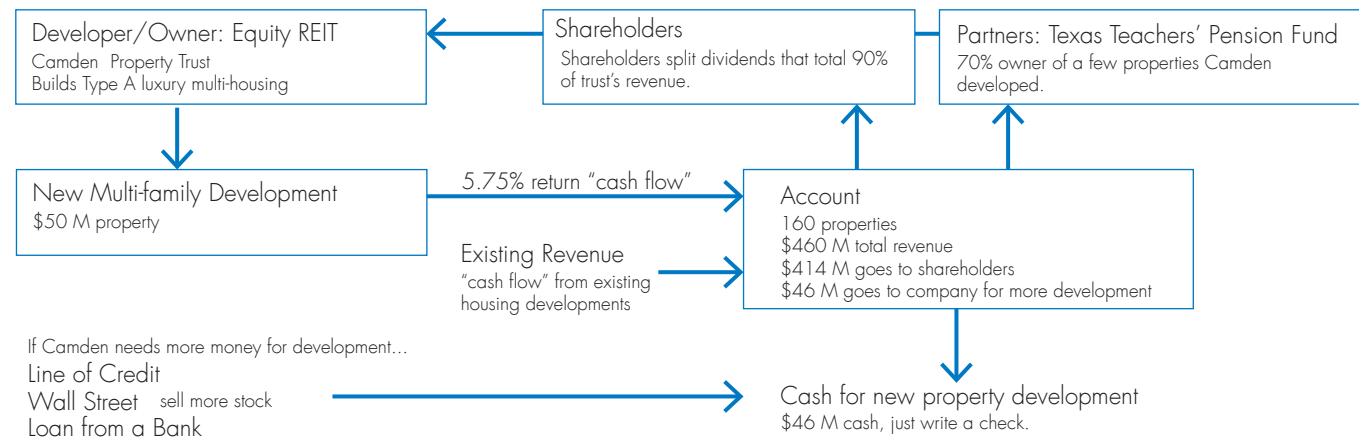


Figure 3  
Financial flow diagram of a  
Real Estate Investment Trust.  
Long-term investment and  
the company manages and  
operates its developments  
for 25 years. Required to  
maximize profits for  
shareholders.

Real Estate Investment Trust (REIT)

The purpose of this designation is to reduce or eliminate corporate tax, thus avoiding double taxation of owner income. In return, REITs are required to distribute at least 90% of their taxable income into the hands of investors - that means they are strong income vehicles. About 30% of multi-family housing out there is developed and owned by REITs.



## MULTI-FAMILY DEVELOPMENT IN HOUSTON

Multi-family housing investment in the U.S. has steadily increased ever since the financial crisis in 2008. After the single-family housing market bubble burst, the multi-family housing market proved to be a safe and reliable investment. All around America, there has been increasing demand for rental housing due to various economic and social reasons. (Slow job growth means families less likely to buy homes. Also millennials are more likely to rent than buy houses.) Last June, annual investment in the U.S. reached over 127B a year - the highest four quarter total in history (figure 4). And given the significant amount of investment capital out there, the need to invest in multi-family has never been greater.

Houston is one of the cities that has attracted this capital. Only second to New York City, Houston is building over 20,000 multi-family units each year (figure 5). So it would seem like there is a good supply of housing in Houston. But the units are not distributed equally. The large majority of units are Class A Luxury, where the return on investment is highest (figure 6).

Figure 4  
In June 2015, investment in multi-family housing in the United States reached over 127B a year, the highest four-quarter total in history.  
Source: CBRE U.S. Multifamily Marketview, Q2 2015

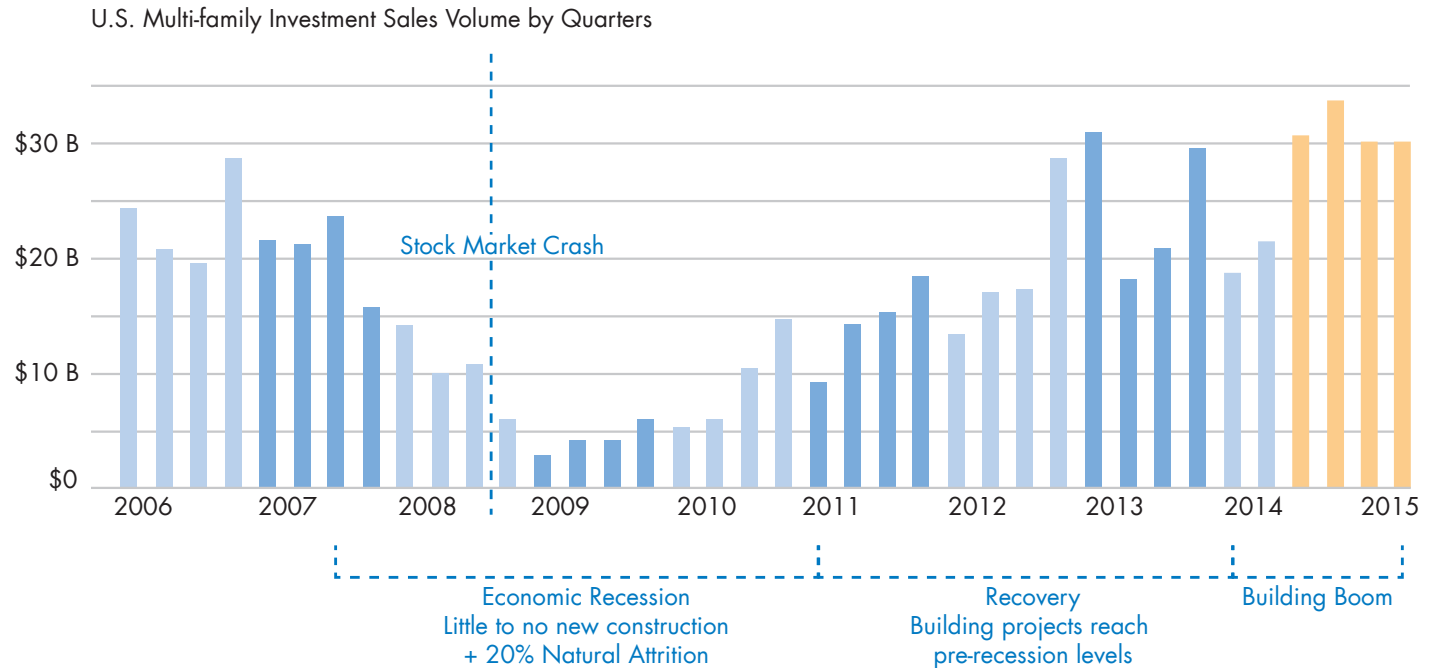


Figure 5  
Houston is building a large quantity of multi-family units, only second to New York.  
Source: <http://www.bizjournals.com/houston/news/2015/07/15/houston-leads-nation-in-apartment-growth.html>

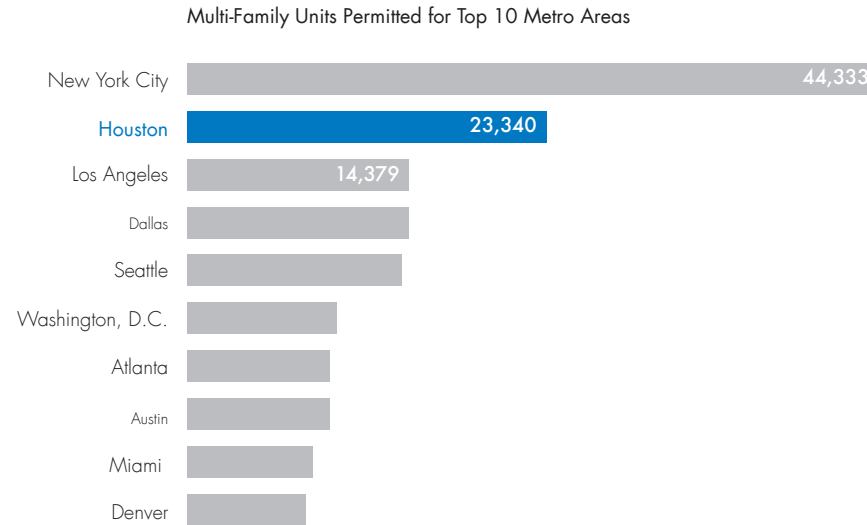
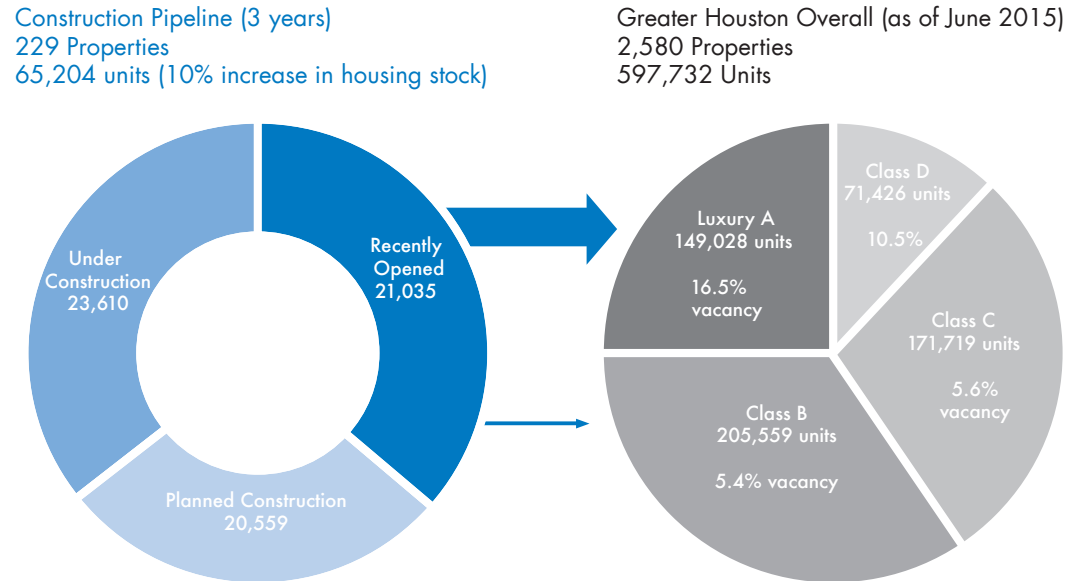


Figure 6  
Houston's construction pipeline shows about 20,000 new units being brought online every year for the next three years. Source: [http://www.bizjournals.com/houston/morning\\_call/2015/09/forget-class-a-houston-s-class-b-multifamily.html](http://www.bizjournals.com/houston/morning_call/2015/09/forget-class-a-houston-s-class-b-multifamily.html)

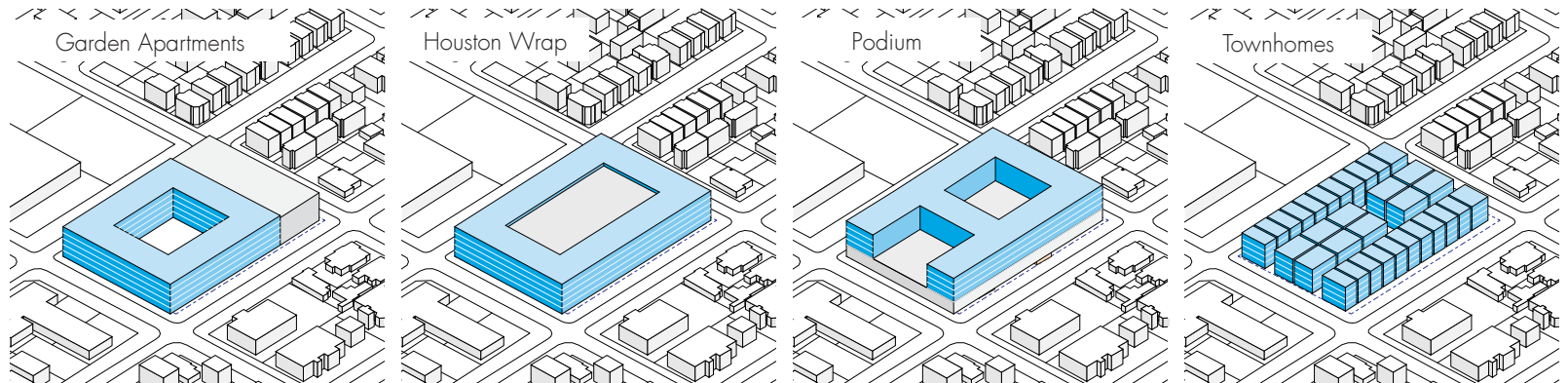


## THE SPREADSHEET MODEL

In luxury housing, investors develop, buy and sell properties based on the earning potential they see on a spreadsheet, often on sites unseen. The spreadsheet makes everything quantifiable: sq. footages, construction costs, rent, etc. Private space is maximized into discrete units with rentable areas, and packaged with a constant array of new amenities to attract buyers and justify increases in rent.

We have all seen the results of this developer-driven model. The building is located either in posh areas with night life and entertainment or along transportation/commercial corridors with little greenery around it. Developers build up to the property line and apply a generic design on the site adjusting a few dimensions. The unit layouts are repetitive, private, opaque boxes along a double-loaded corridor with maximized interiors, upscale finishing, and packaged with amenities. All space is divided up discretely and is privatized.

Figure 7  
Typical developer strategies  
for multi-family residential.





## Class A Luxury Amenities

- Genuine Oak Flooring
- Full Size Washer/Dryer
- Premium view + large windows
- Upgraded features
- Air-conditioning
- Private Balcony
- Gourmet Kitchen with Pantry
  - Granite Countertops
  - dishwasher
  - Gas-range
  - Stainless Steel Appliances
  - Built-in Wine chillers
  - Refrigerator
  - natural stone backsplash, kitchen island,
- custom wood cabinets
  - Generous storage space
  - French doors
  - Deluxe master bedrooms
  - Built-In Desks
  - Semi-Custom Walk-In Closets
- Bathroom
  - Nickel Plated Fixtures,
  - Framed Bathroom Mirrors
  - Oversized Soaking Tubs
  - Ceramic Tile Bathrooms
  - Double Vanity Sinks
  - Upgraded Carpeting
  - Ceiling Fans
  - Frameless glass showers
- Dramatic 10 ft. Ceilings with Crown Molding
- 2-Inch Blinds
- Upgraded Lighting
- Cable with HBO included
- Intrusion Alarms with Monitoring
- USB charging ports in kitchen and bedrooms



Typical Unit Mix in Luxury Apartment:  
 26% Studio Efficiencies  
 53% 1-Bedroom Apartments  
 21% 2-Bedroom Apartments

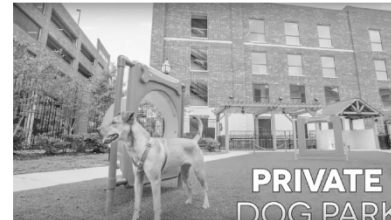


Figure 8

A sampling of the types of amenities listed by Class A Luxury complexes to justify higher rental rates and attract a specific clientele: young professionals and millennials.

Figure 9

The unit mix in class A luxury housing does not easily accommodate families. Also the double loaded corridor organization with discrete boxed units does not provide the lifestyle that families desire.

Figure 10

In a promotional video for a luxury apartment complex, there is an emphasis on finishes, resort-style leisure amenities, and social activities that young professionals prefer.

## CLASS A HOUSING REACHING A CRITICAL POINT OF SATURATION

Most of the units under construction, being planned or being brought online now is class A luxury housing where the return on investment is highest. For the last 10 years, market strategies for developing luxury housing in the loop has fulfilled investors and banks, but the luxury market is now reaching a saturation point. There is an over-supply of class A housing and raising the vacancy rate to 16.5% and forcing some companies to give out concessions to encourage move-ins.

Simultaneously, there is this persistent need for affordable, middle-income housing inside the I-610 loop that is neglected by the market. A larger portion of middle-income families want to move from other urban environments to the center, for a variety of reasons, but there are few options that provide the spaces they desire. There is capital that needs to be invested, and it can be used to developed affordable housing.

Figure 11 (Left)  
Left: The Class A luxury housing market is reaching a critical point of saturation, with net absorption hovering around 15,000 units per year for the last 3 years.  
Source: CBRE Houston Multifamily Marketview, Q2 2015

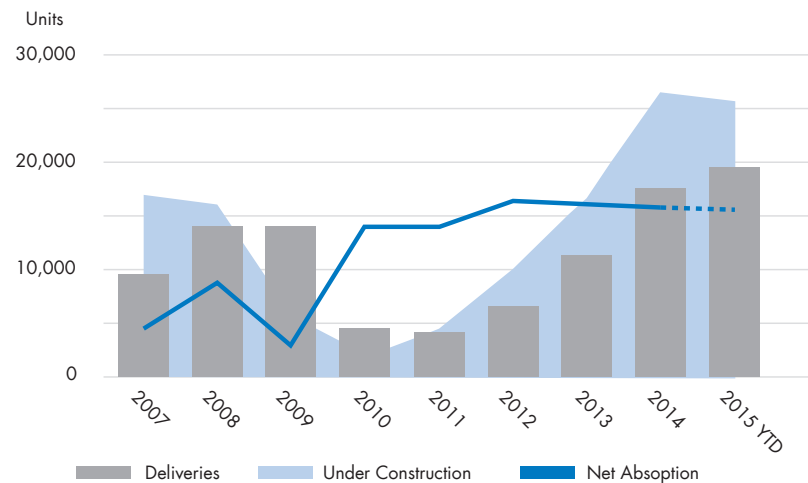


Figure 12 (Right)  
Most multi-family deliveries are Class A Luxury which has a high vacancy rate, and concessions are beginning to be given in order to achieve full lease-up.

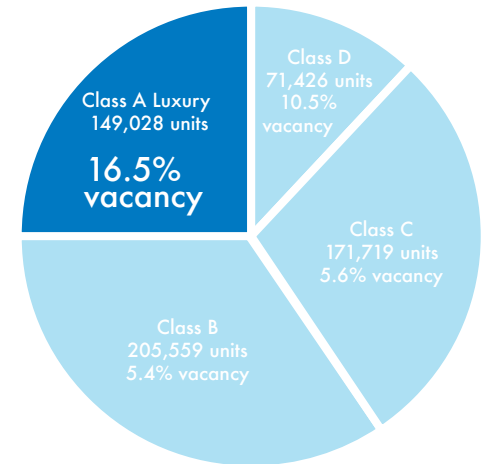


Figure 13  
 In The 5th Houston Sustainability indicators Report, released in September 2015 by Dr. Lester King and the Shell Center for Sustainability, it was shown that Houston is no longer an affordable city due to increasing distances people drive. Housing and transportation costs for Houston is 46% AMI.



**BUSINESS**

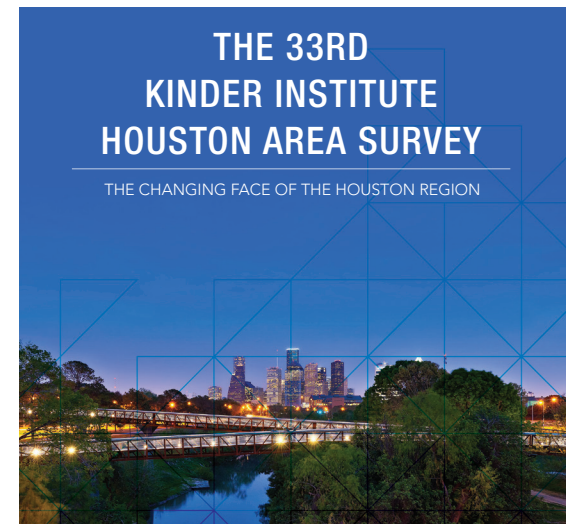
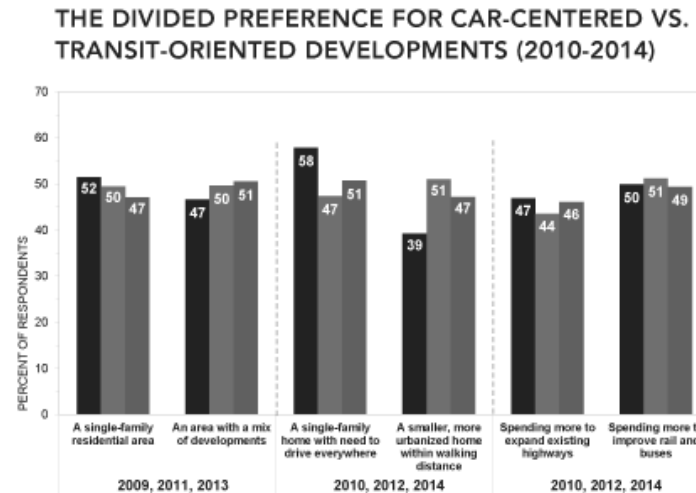
## Report: Houston No Longer An 'Affordable' Place To Live

According to federal standards, a region is considered affordable when housing plus transportation cost a resident no more than 45 percent of household income.

By: Andrew Schneider, September 30th, 2015 05:20 PM



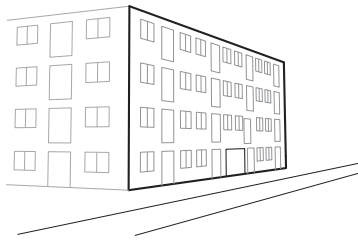
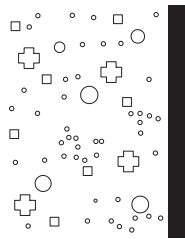
Figure 14  
 In Dr. Stephen L. Klineberg's 2014 Houston Area Survey, 50% of Houstonians say they would prefer to live in transit-oriented, more urbanized areas, rather than a subdivision and be forced to drive everywhere. As Dr. Klineberg concludes, "The challenge today is not in finding people who would like to live in more compact, urbanized communities, but in building places across the region that can accommodate them."



## THE SPATIAL MODEL

The Spatial Model reasserts that spatial quality and experience is fundamental to the development of housing at no compromise to the spreadsheet model. Architecture's agency to rethink domestic situations through spatial means is key to creating dense urban environments that are spatially-rich, and invested in their urban locales, resonating with middle-income renters.

In the Spatial Model, the spatial quality itself is the attractor -- the spatial quality is the amenity. Instead of large and expensive interiors, the spatial model provides a smaller unit that feels big with shared outdoor space. And this is attractive to families who make the hard decision to buy into living in a great place for the long term. These families are moving from from the periphery where land and green space is abundant into a more urban environment to be near other people and services. Yet they want that same connection to the landscape. The Spatial Model addresses those needs.

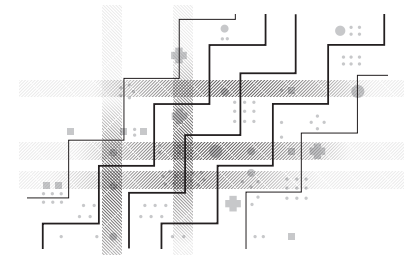


### Spreadsheet Model

- Amenity-driven
- Discrete Spaces
- Maximize private interior
- Material
- Generic
- Abrupt Transitions
- Large Windows
- Private Views
- Designed to satisfy investors
- Young Professionals
- Near entertainment
- Controlled Access
- Reliance on cars
- Country Club Amenities

### Spatial Model

- Spatially-driven
- Spatial Ambiguity
- 'Spacious' Interior + shared exterior
- Spatial Quality
- Architecturally Specific
- Choreographed Thresholds
- Space-appropriate Windows
- Shared Views
- Designed as a place to live
- Families
- In good school districts
- Open Access
- Near Public Transportation
- Shared Gardens



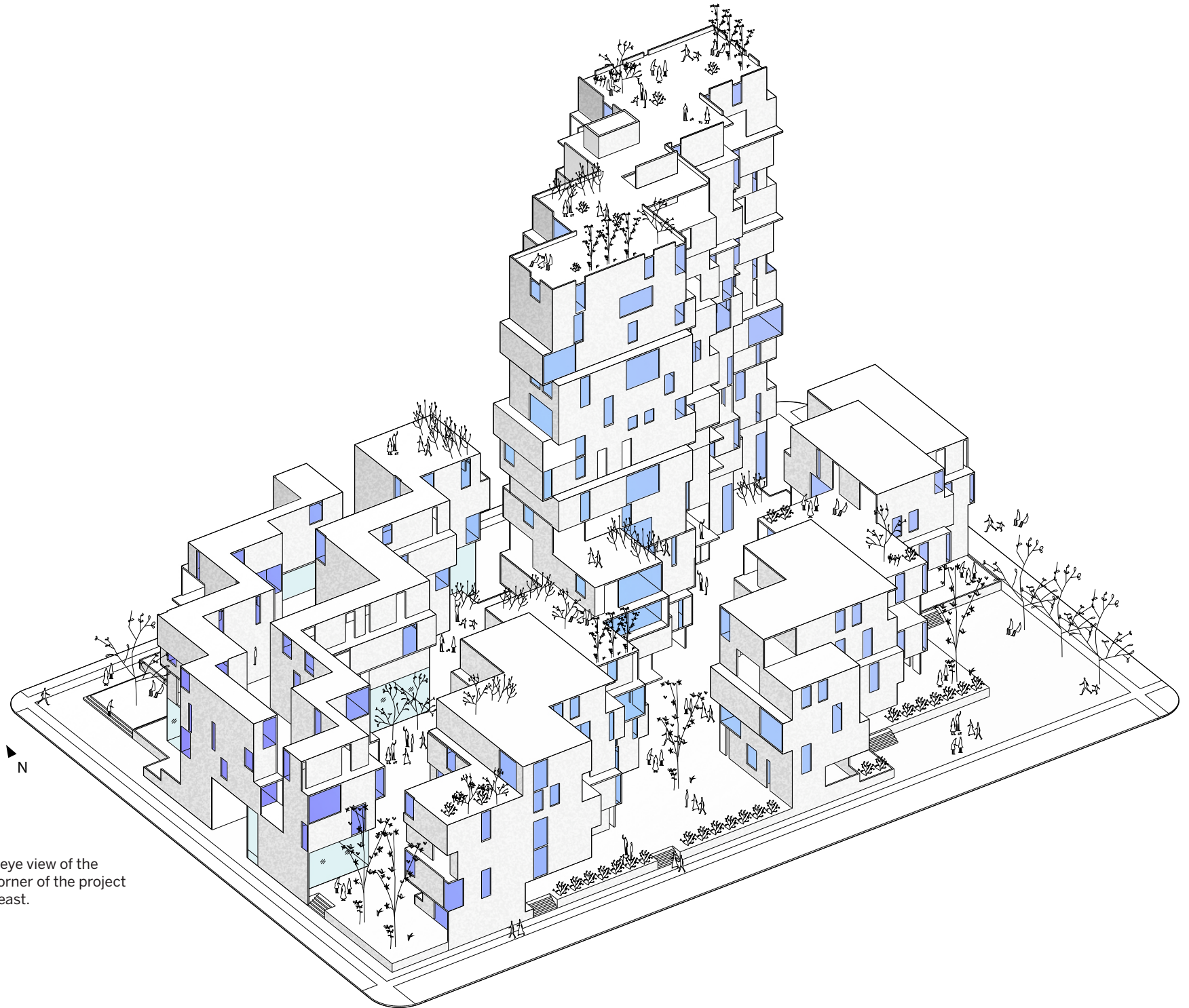
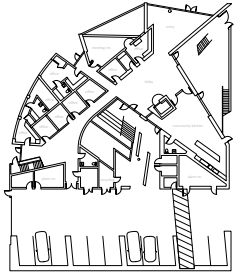
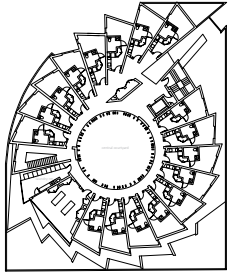


Figure 15  
Overall birdseye view of the  
southwest corner of the project  
facing northeast.

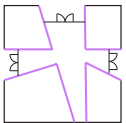


## PRECEDENTS

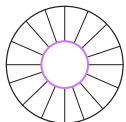
Interesting and spatially-rich housing requires a multi-faceted approach, one that produces expansive interiors, while engaging the edge between the collective and individual, to produce shared space. Here are studies of non-linear forms and their external and internal organizations.



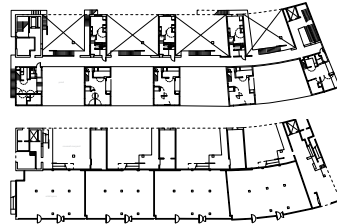
Carver Apartments (2009), Los Angeles, CA  
Michael Maltzan  
97 residential units  
size: 53,000 sf  
cost: \$18.4 million



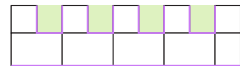
figured void entry



radial organization of units orients to many directions and views while forming a whole



Void/Hinged Space (1991), Fukuoka, Japan  
Steven Holl  
mixed use, 28 residential units  
size: 45,671 sf



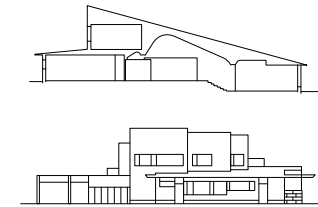
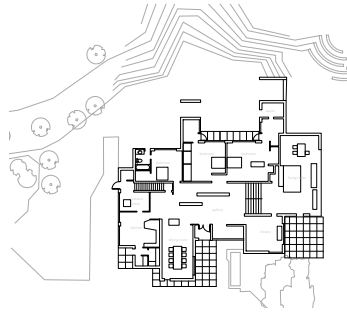
level 1: street level / courtyard entry



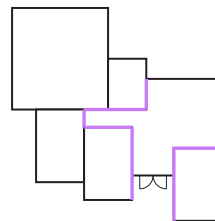
level 2 open courtyard and void pond space along corridor



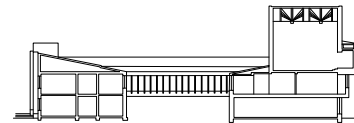
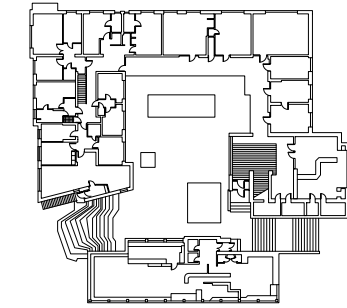
upper levels, rhythm of pond voids



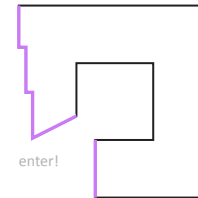
Maison Louis Carre, 1959  
Bazoches-sur-Guyonne, France  
Alvar Aalto  
single family residence  
size: 4,854 sf



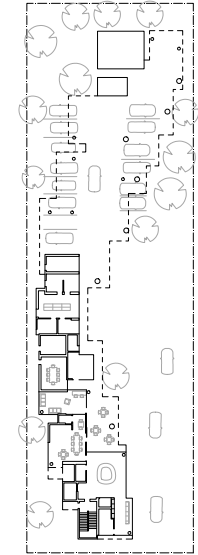
Interior communal shaped by different shaped rooms around it.



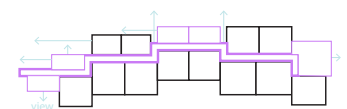
Säynätsalo Town Hall, Finland (1951)  
Alvar Aalto  
mixed use, with shops, administration offices, a library and council chamber.



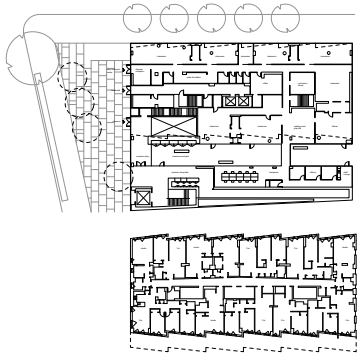
Corrugated edge suggests entry and the closed square is opened.



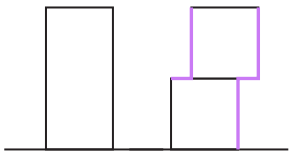
Crest Apartments, Los Angeles, CA (1951)  
Michael Maltzan  
64-units affordable housing project  
size: 28,000sf  
cost: \$13.2m



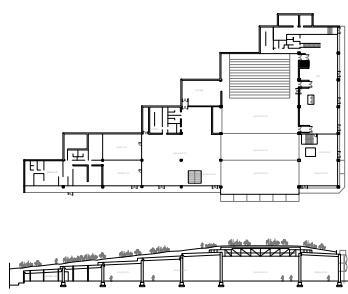
staggering modular units along a corrugated corridor break open the to views out, and collective, social spaces.



Sugar Hill Apartments, 2014  
New York, New York  
David Adjaye  
124 affordable apartments,  
early childcare, and museum  
size: 191,000sf



staggered section creates a viewing terrace for residents.



Polyvalent Theatre, 2014  
Lille, France  
Lacaton & Vassal  
type: event spac/theater  
size: 40,806 sf

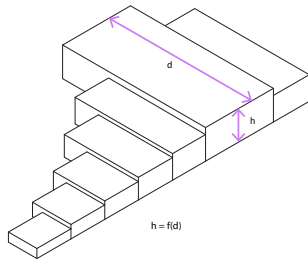
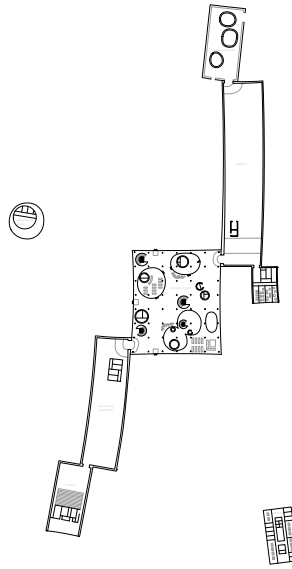
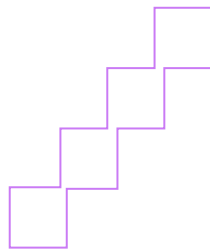


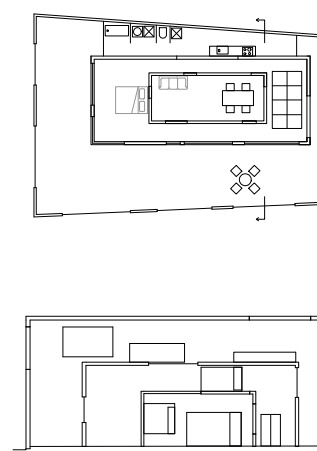
Diagram of the variable bay heights as a function of depth.



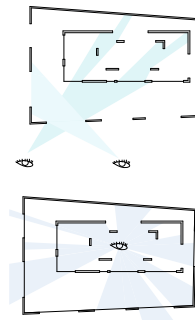
Louvre Lens, 2012, France  
Sanaa  
type: museum  
size: 30,138 sf



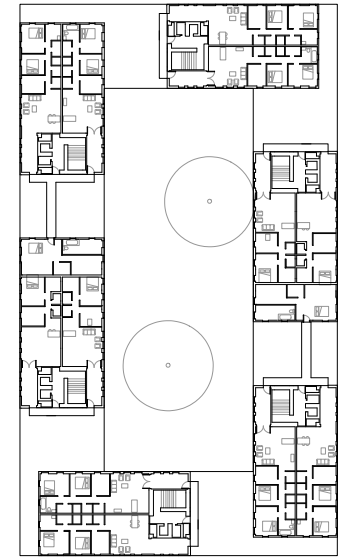
narrow thresholds defined by form



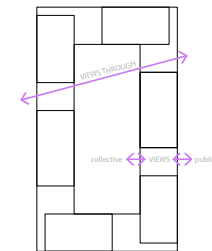
House N, 2008, Oita, Japan  
Sou Fujimoto  
single-family  
size: 1615 sf



alignments determine privacy



Celosia Madrid, Spain  
MVRDV  
146 affordable units  
size: 231,962 sf  
cost: \$13.7 m  
cost/sf: \$59



organization allows for connection on both sides of building, and through also.

## SITE

Location is important to families in the following ways: located in a good school district, access to public transportation, near parks or bikeways, near a grocery store, and close to work. Houston's historic first ward is one of the last pockets of affordability in the I-610 loop to densify and develop. Houston is known for its affordability in the single-family market, but prices in the loop are increasing quickly. It has not trended in a specific direction yet, so there is opportunity for a shift in the housing model here. Many of the industrial sites in the area redeveloped in the coming years into stores, offices, or housing. The Spatial Model will sew back together the many different parts of the city, engaging both public and private and ultimately recapturing a kind of collectivity that was otherwise lost in this diverse landscape.

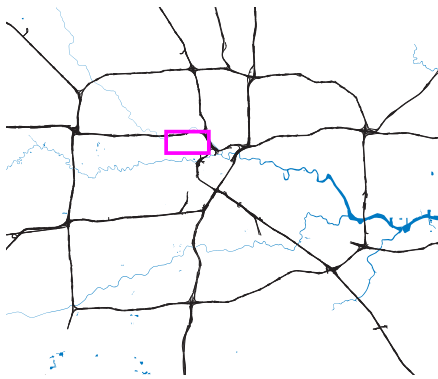








Figure 16 (Right)  
The site is located just northeast of downtown Houston in the First Ward. When looking for a place to live, families want to be near their jobs, near good schools, near parks and outdoor recreation, and public transportation.

-  030 Clinton / Eilla Bus
-  044 Acres Homes Bus
-  Crocket Elementary
-  Hike and Bike Trail
-  Site
-  First Ward Historic District

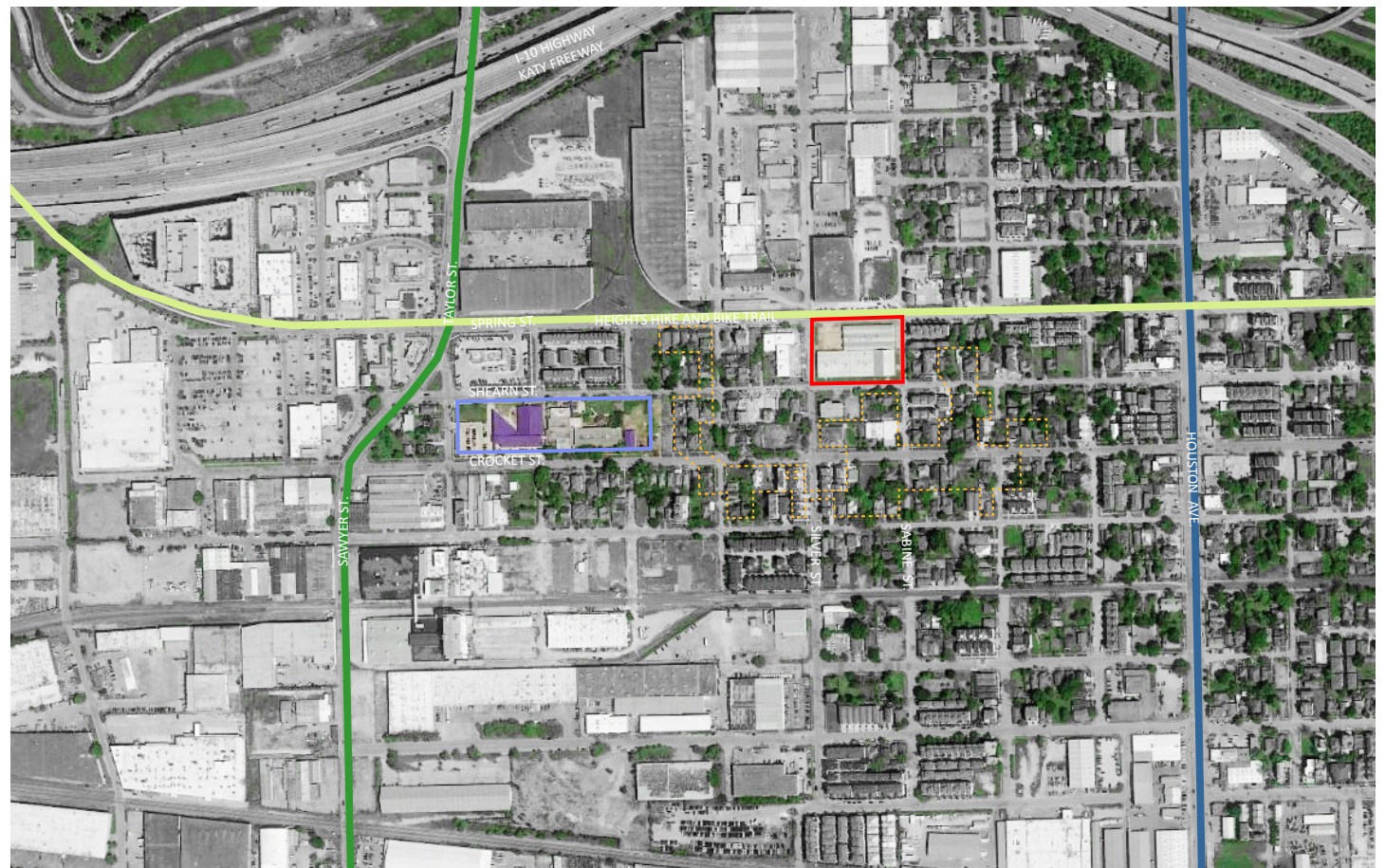




Figure 17  
 Site Conditions  
 01 Industrial/Commercial  
 02 Artist Studios  
 03 Developer Townhomes  
 04 Historic District  
 05 Office  
 06 Cross-fit

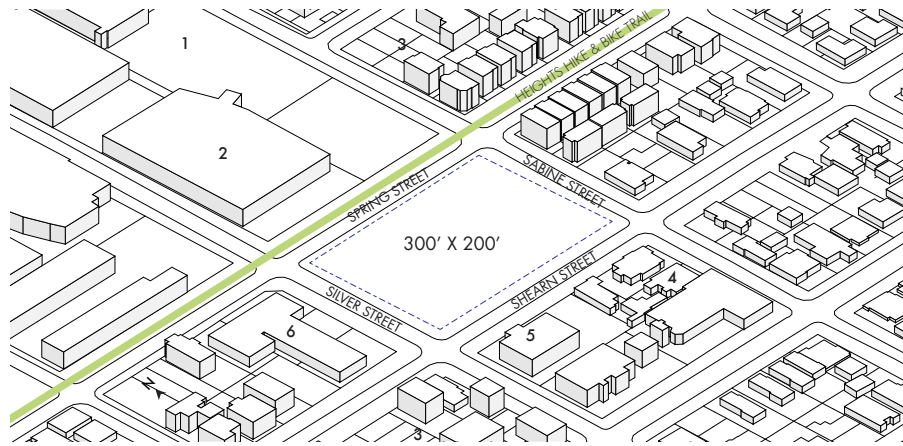
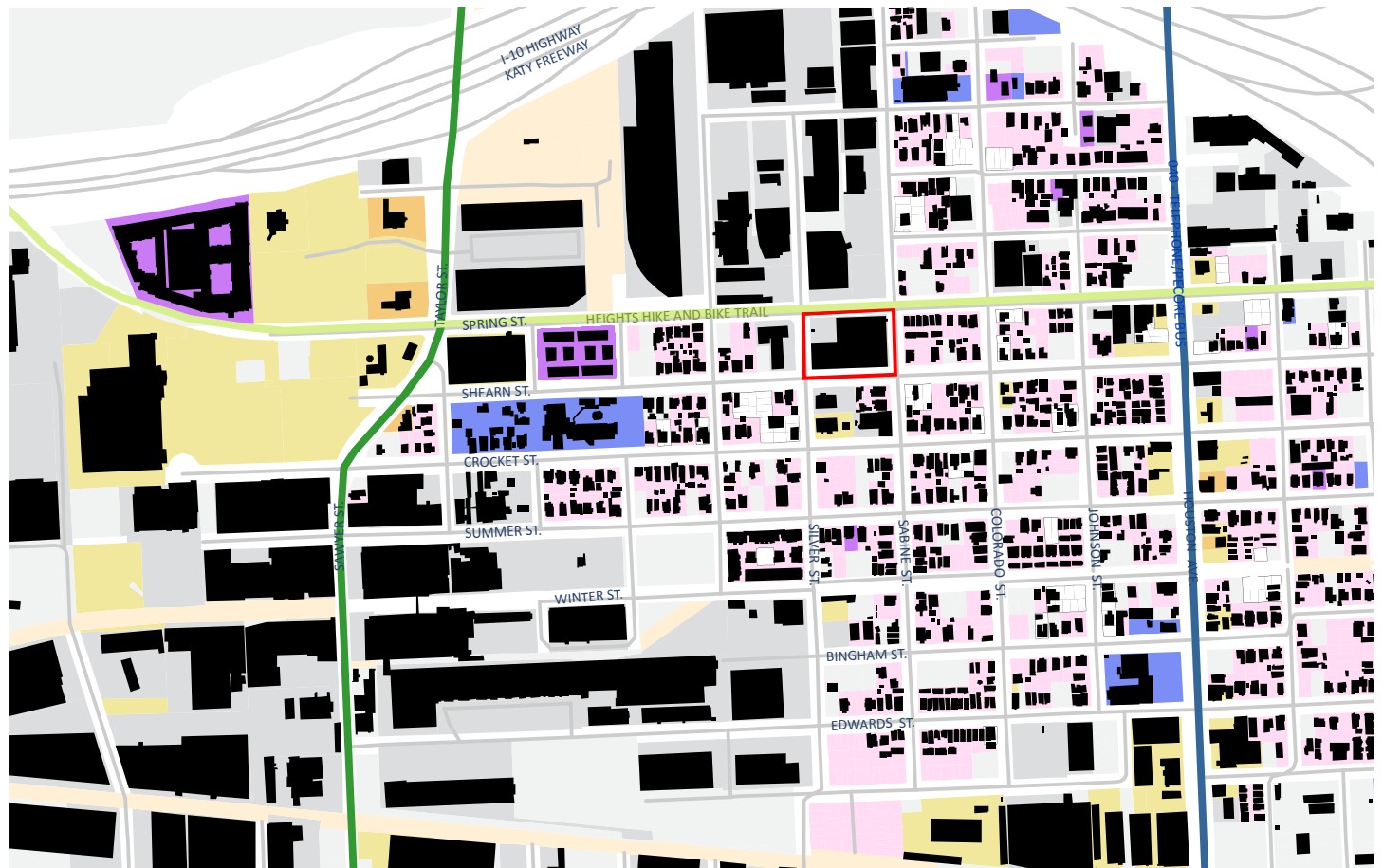


Figure 18  
 Land use study. Industrial sites will eventually transition into new types of uses.

- single-family residential
- multi-family residential
- industrial
- commercial
- office
- public/institutional
- park/open space
- undeveloped
- utility



## PROGRAM

Residential, commercial and community programs are joined together to create a mixed use project with abundant shared outdoor space. In addition to requiring commercial space in order to be economically viable\*, the added program activates the shared space to make it a successful and vibrant place. The community program similarly activates the shared space by acting as a social condenser while providing some spaces for public use.

\* For complete project underwriting, see appendix.

Square footages of the residential units are kept to a minimum but the space appears visibly larger and more spacious due to window placement and floor-plan layouts.



Figure 19  
Shared outdoor spaces are used by residential, community and commercial programs.

RESIDENTIAL

Efficiency (5 units @ 320sf)	1,600
1-Bedroom (10 units @ 550sf)	5,500
2-Bedroom Unit (20 units @ 750sf)	15,000
3-Bedroom Unit (30 units @ 900sf)	27,000
4-Bedroom Unit (25 units @ 1100sf)	27,500
Laundry Rooms (8)	1,600
Bike Storage	560
Staff Offices and Mail Room	450

COMMUNITY

Library/Reading	380
Classroom	800
Computer Classroom	560
Daycare	480
Lounge	300
Event Kitchen	500
Game Area	300
Main Lobby	350

COMMERCIAL

Leasable Space (3)	3,000
Cafe (leased out)	1,000

---

subtotal 82,880

Circulation (15%) 12,432

Mechanical (5%) 4,144

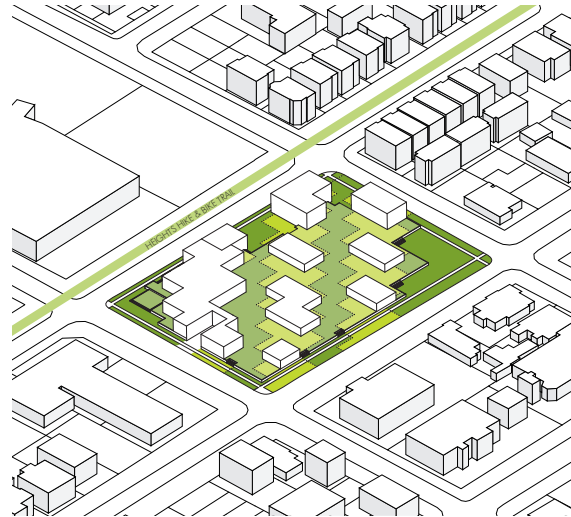
Construction (15%) 12,432

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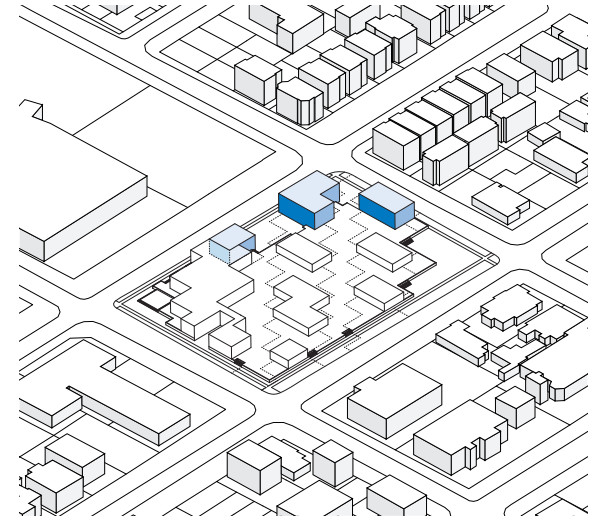
TOTAL AREA 197,168

Shared Outdoor Space 65,000

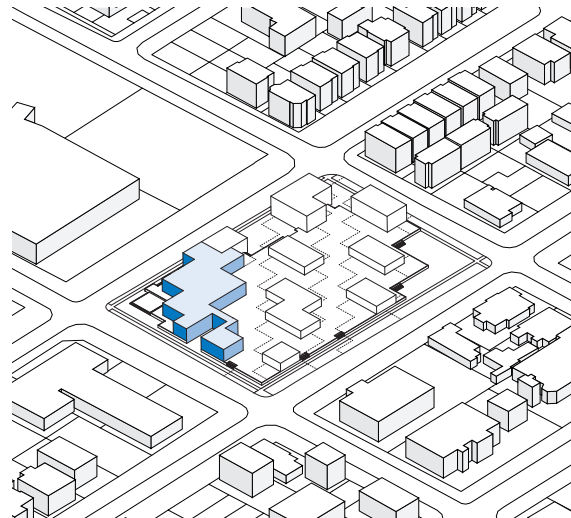
Underground Parking (185 spaces) 74,414



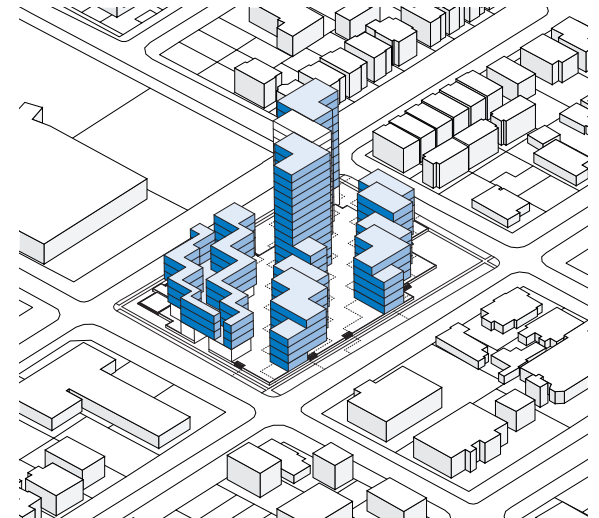
Gardens



Commercial



Community

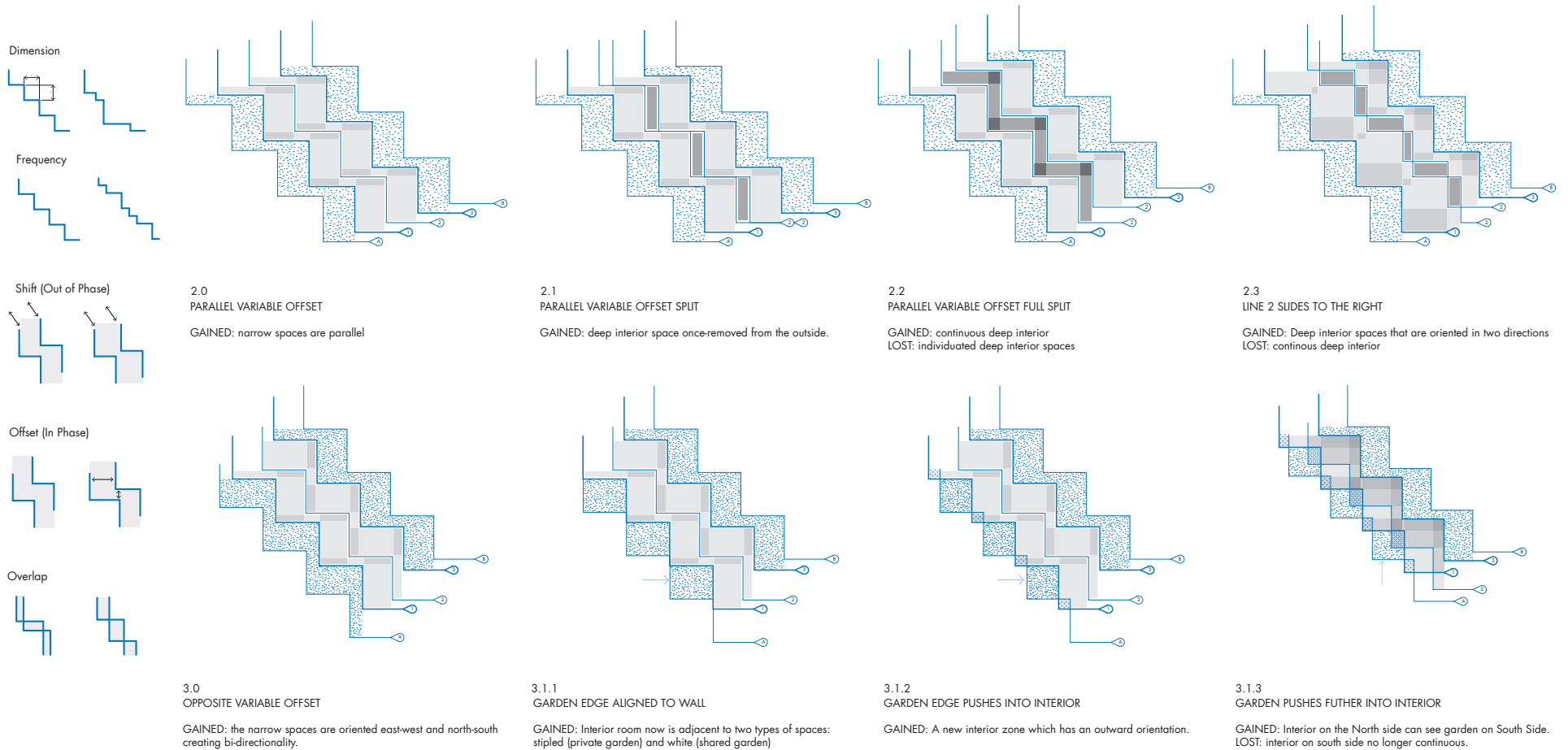


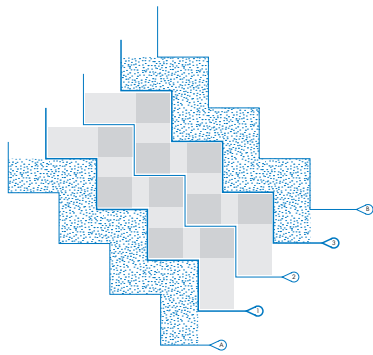
Residential

## THE CORRUGATED EDGE

The corrugated edge is about space and seriality. Introducing this geometric set of rules allows for housing to multiply in many different permutations. The corrugated line is inherently bi-directional and variable offsetting produces spaces of different lengths and widths, and thus orientations. Intersecting these lines produces unique transitional spaces. The corrugated edge is employed to create a unit plan which flows and is connected to the surrounding gardens by trajectories of circulation within each unit.

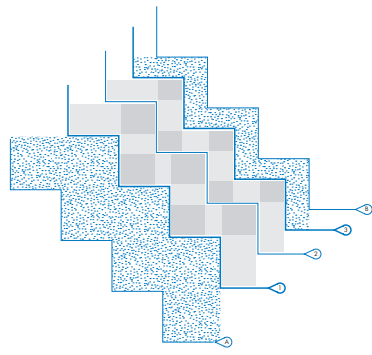
Figure 20  
Study of operations on the corrugated line and the spatial ramifications.





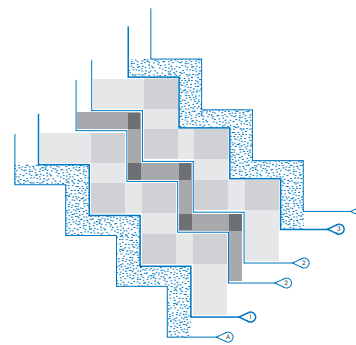
1.0  
EVEN OFFSET

GAINED: More overlapping, shared spaces; spaces with same dimension  
LOST: directionality



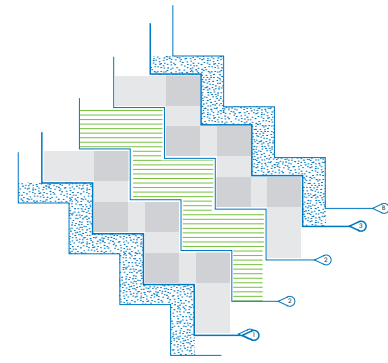
1.1  
VARIABLE OFFSET

GAINED: Spaces with different dimensions and widths.  
LOST: symmetry



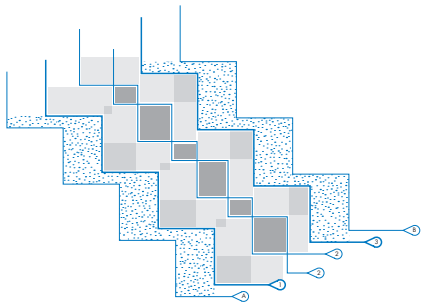
1.2  
SPLIT

GAINED: A third type of space that is once-removed from the outside.



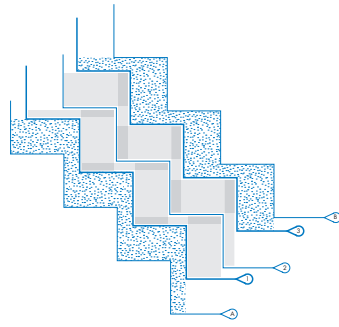
1.3  
COURTYARD

GAINED: A planted garden space between two spaces  
LOST: Deep interior.



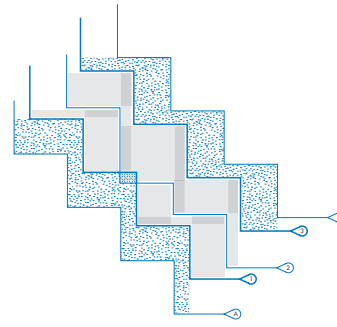
2.4  
LINE 3 SLIDES TO THE LEFT

GAINED: square deep interior spaces  
LOST: directionality



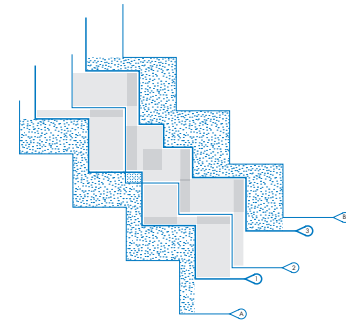
3.0  
OPPOSITE VARIABLE OFFSET

GAINED: the narrow spaces are oriented east-west and north-south creating bidirectionality.



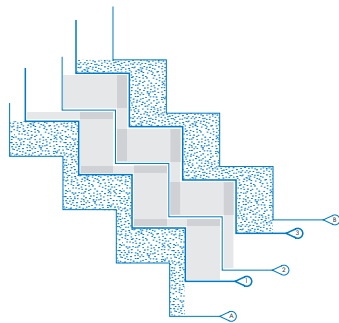
3.0.1  
A CORNER OF LINE 2 SHIFTS DOWN BEYOND EXTERIOR WALL

GAINED: a transitional space that is composed of a room on the north side and the garden on the south side.



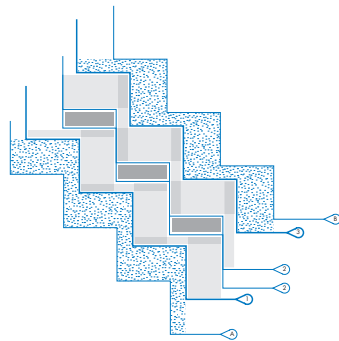
3.0.2  
TWO CORNERS INSTEAD OF ONE

GAINED: increased the implied divisions in the space.



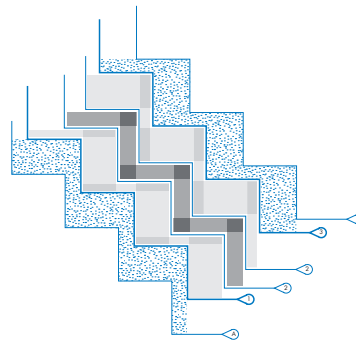
3.0  
OPPOSITE VARIABLE OFFSET

GAINED: the opposite staggered pattern create a bidirectionality.



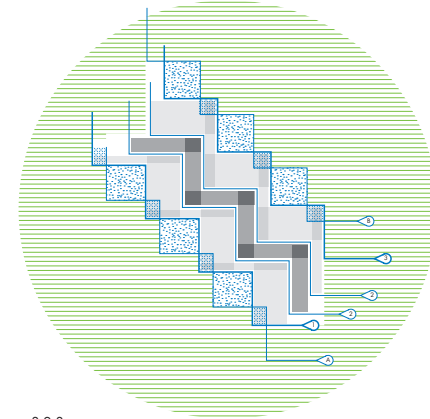
3.2.1  
OPPOSITE VARIABLE OFFSET SPLIT

GAINED: Deep interior space



3.2.2  
OPPOSITE VARIABLE OFFSET SPLIT FURTHER

GAINED: Continuous deep interior.



3.2.3  
GARDEN EDGES INTERSECT WITH INTERIOR

GAINED: Transitional zones where the garden edge and exterior wall edge overlap, producing moments of outwarness looking at the garden.

## ORGANIZATION

When the corrugated plan organization is combined with window apertures, the dimensions of space can be visually augmented by windows making the relatively modest but comfortable living spaces flow out to capture shared outdoor garden space. The corrugated line and the window operate as a filter through which the horizontal bleeding of space is managed. Alignment of window apertures, justified to an edge or a ceiling of a room, produces lines that push you out visually, and thus expands the space. Thus, the dwelling unit can be private when the windows are all covered, or allow one to visually occupy shared outdoor space when they are open.

Figure 21  
Study of window types in the project. Top left: window justified to wall and ceiling. Top middle: window justified to ceiling that extends outward. Top right: Floor-to-ceiling window with floor extending outward. Bottom left: floor-to-ceiling window erases the barrier between inside and out. Bottom middle: Glass wall that extends beyond the corner of the room. Bottom right: a window that brings your attention around a corner but also outward.

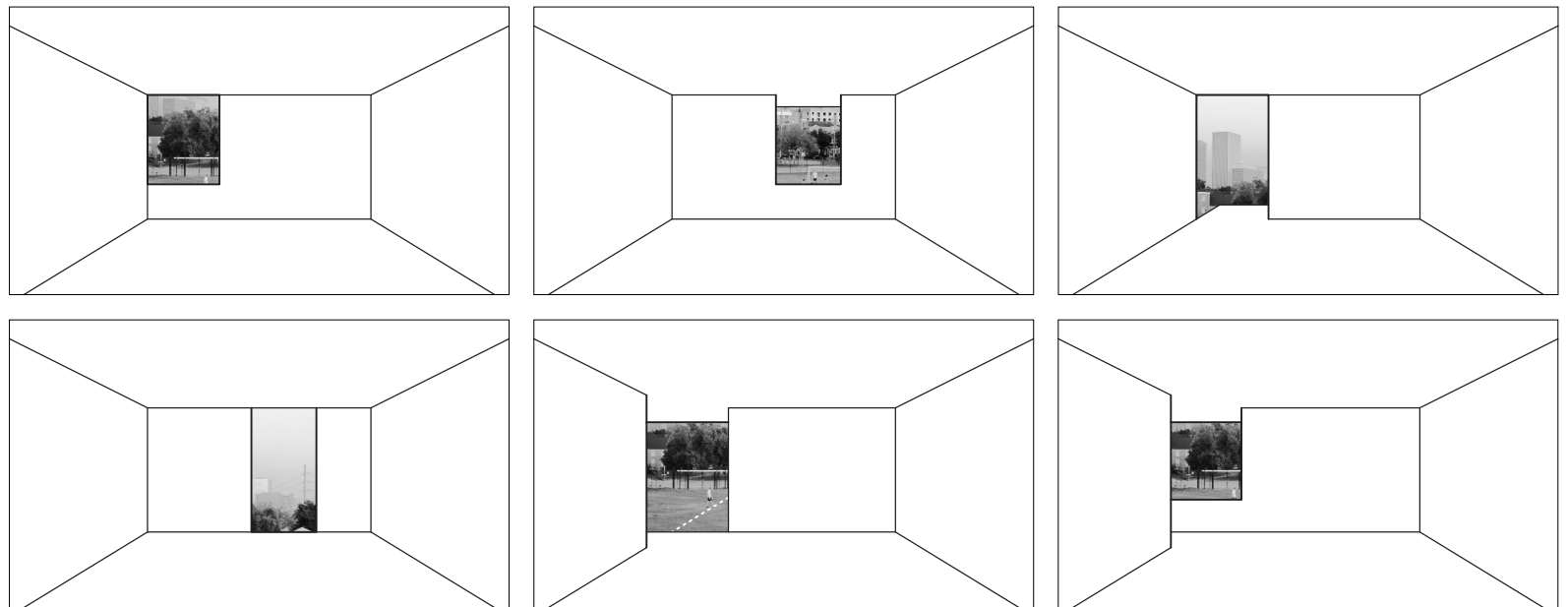
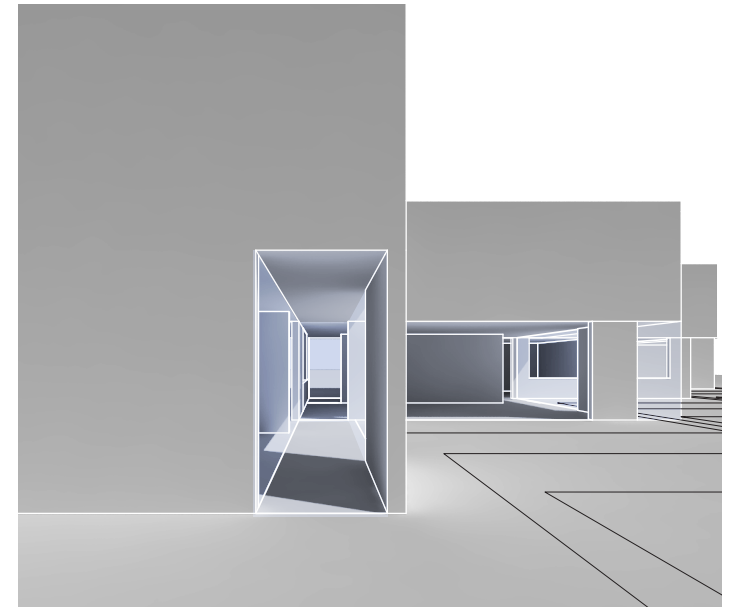
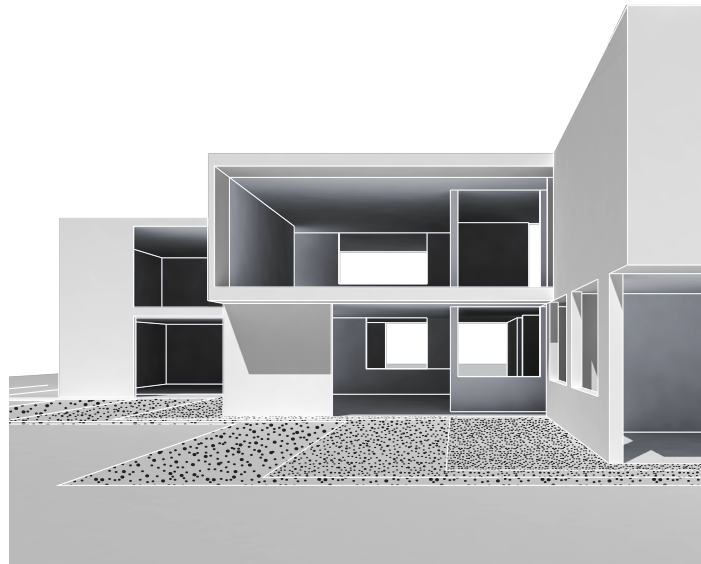
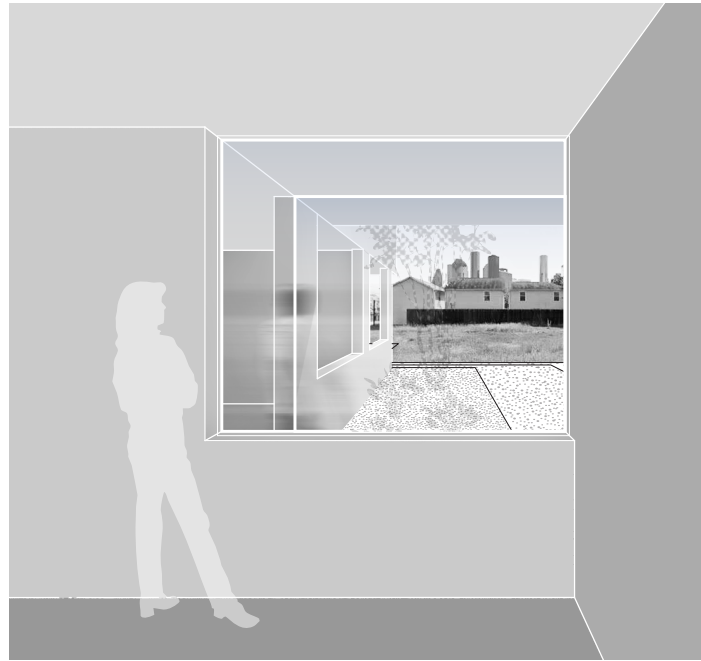




Figure 22  
Early studies on the relationship between corrugated wall and window apertures. Top left: view from deep interior room looking out toward garden. Top right: view of room with soffit and wall extending outward. Bottom left: how the clear boundaries of ownership get blurred. Bottom right: narrow long hallways always have a view out.



## DESIGN

Two public gardens are created on the northwest and southeast corners of the project, acknowledging the hike and bike trail and the historic single-family fabric on these sides respectively. Vehicular access to the project is the west side on Silver Street. The interior gardens are open for pedestrians and public use, but are located three feet above street level.

Based on the initial exploration of the corrugated edge as a serial and bi-directional organizational strategy, the first floor of building A is the community and amenity area where there is maximum horizontal bleeding. Window apertures are punched through the walls frame views across and out. The garden bleeds into the space. For the residential units on the ground floor, narrow floor-to-ceiling apertures visually extend the unit into shared outdoor spaces and while also territorializing outdoor spaces of their own.

Figure 23  
Perspective view of northwest corner looking southeast at building A, the community building. People living in the neighborhood arriving on foot or by bike for activities enter through the corner garden.





Figure 24  
Steet Level Plan

- A Building**  
 1 Entry  
 2 Lobby  
 3 Lounge  
 4 Game Area  
 5 Library  
 6 Classroom  
 7 Garden View  
 8 Computer Room  
 9 Event Room  
 10 Childcare  
 11 Office  
 12 Bicycle Storage  
 13 Retail Space

- B Building**  
 101 4bd/1.5b  
 102 3bd/1.5b  
 103 3bd/1.5b  
 104 4bd/1.5b  
 105 3bd/1.5b  
 106 3bd/1.5b  
 107 3bd 1.5b  
 108 4bd/2b  
 109 2bd/1.5b

- C Building**  
 101 4bd/1.5b  
 102 3bd/1b  
 103 3bd/1.5b  
 104 3bd/1.5b  
 105 4bd/1.5b

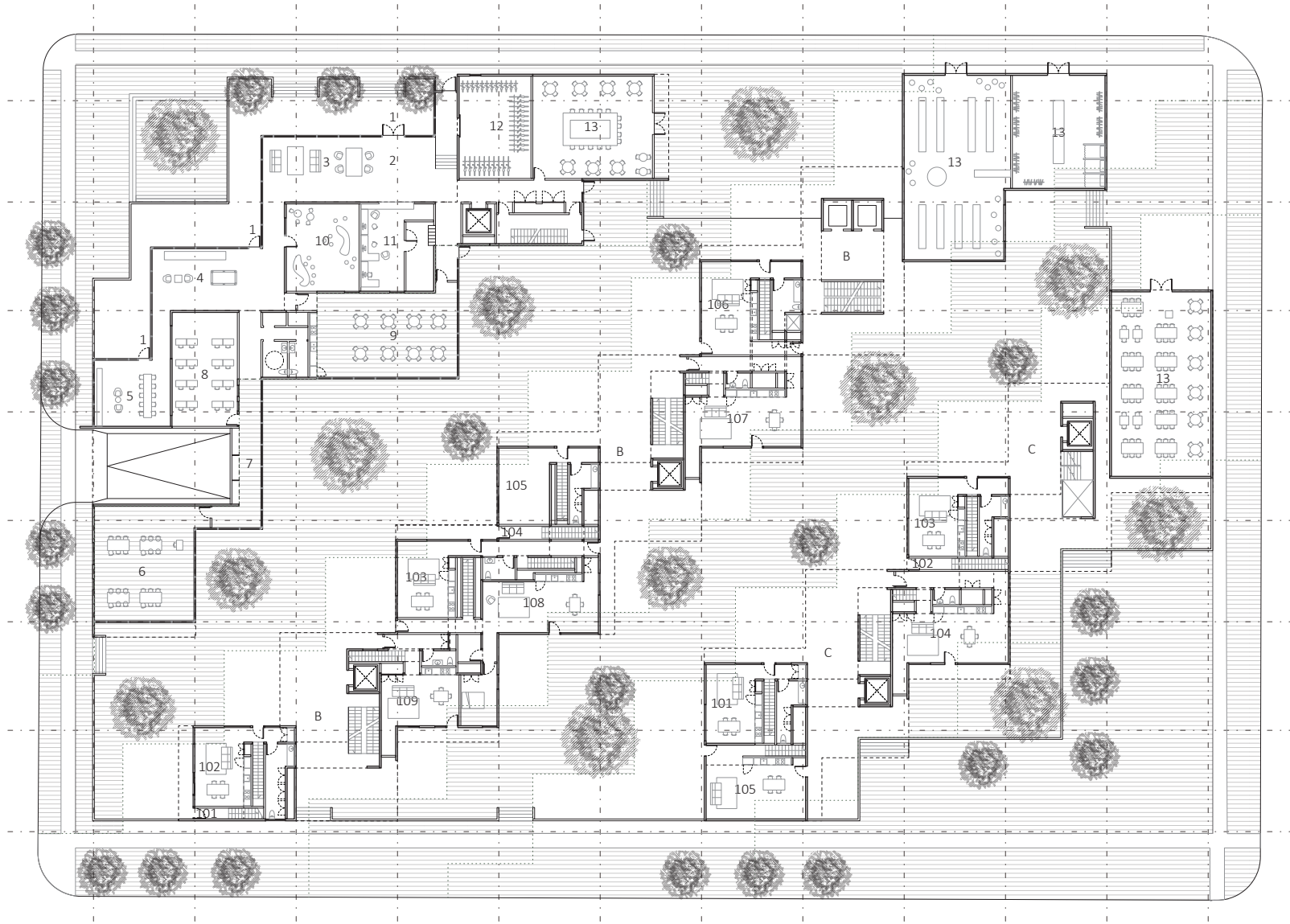
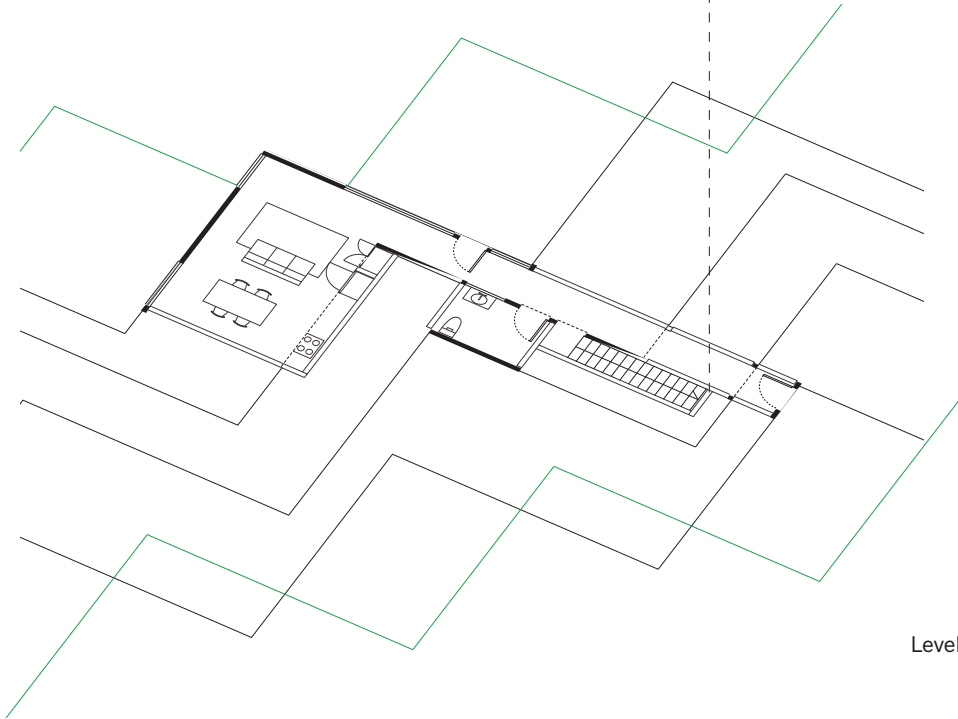
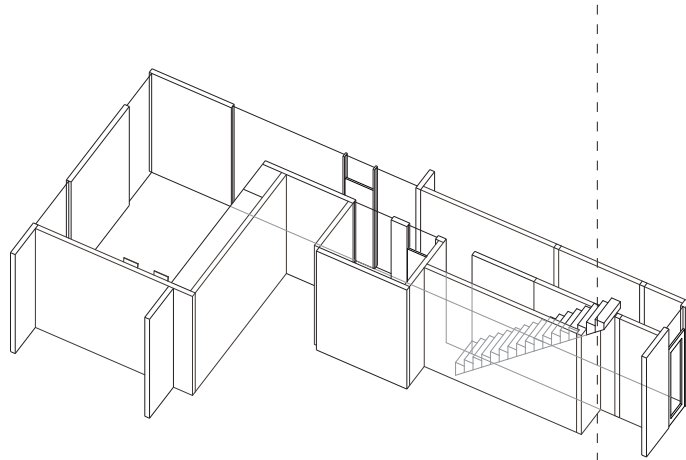


Figure 25  
Exploded Axon of Unit B-103

The kitchen, dining, and living programs are agglomerated together into a large open living configuration. In this unit, the first level is oriented north and west. One then transitions down the hall to the more private bedrooms. There is also a front and back door to the unit, much like a house.

The second floor of the unit is oriented south and east, overlooking another garden.



Level 1

Level 2

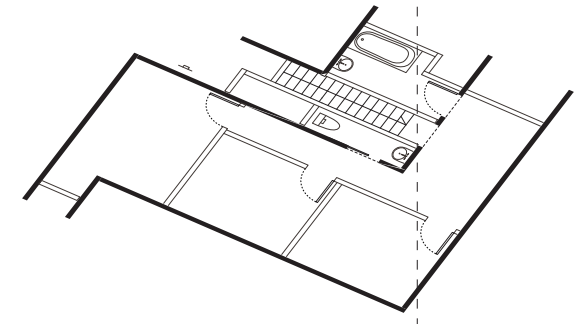
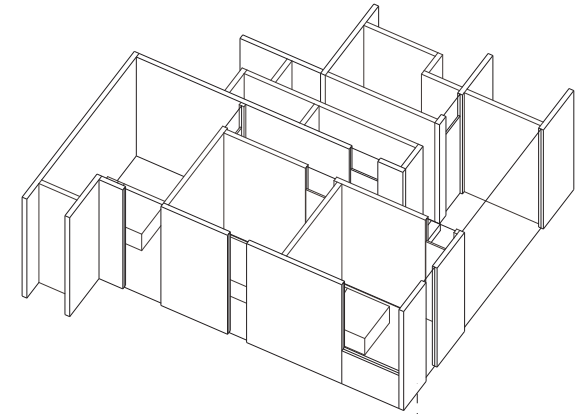


Figure 26  
Level 2 Plan

- 1 Outdoor Lobby
- 2 Outdoor Space
- 3 Lounge
- 4 Laundry Room

- A Building
- 101 1bd/1b
  - 102 1bd/1b
  - 103 1bd/1b
  - 104 1bd/1b
  - 105 1bd/1.5b
  - 106 1bd/1b
  - 107 2bd/1b
  - 108 1bd/1b
  - 109 1bd/1b
  - 110 1bd/1b

- B Building
- 101 4bd/1.5b
  - 102 3bd/1.5b
  - 103 3bd/1.5b
  - 104 4bd/1.5b
  - 105 3d/1.5b
  - 106 3bd/1.5b
  - 107 3bd 1.5b
  - 108 4bd/2b
  - 109 2bd/1.5b

- C Building
- 101 4bd/1.5b
  - 102 3bd/1b
  - 103 3bd/1.5b
  - 104 3bd/1.5b
  - 105 4bd/1.5b

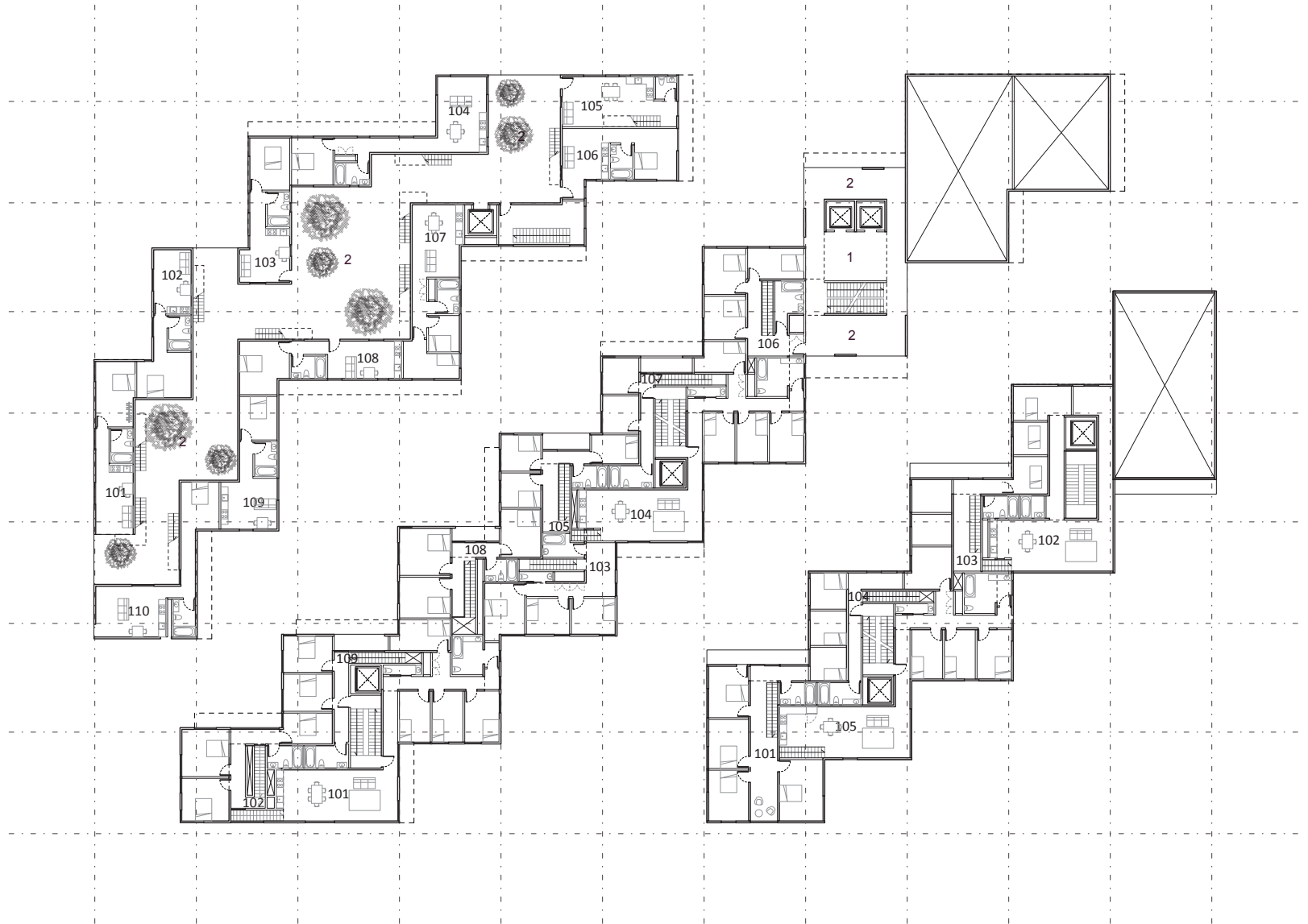
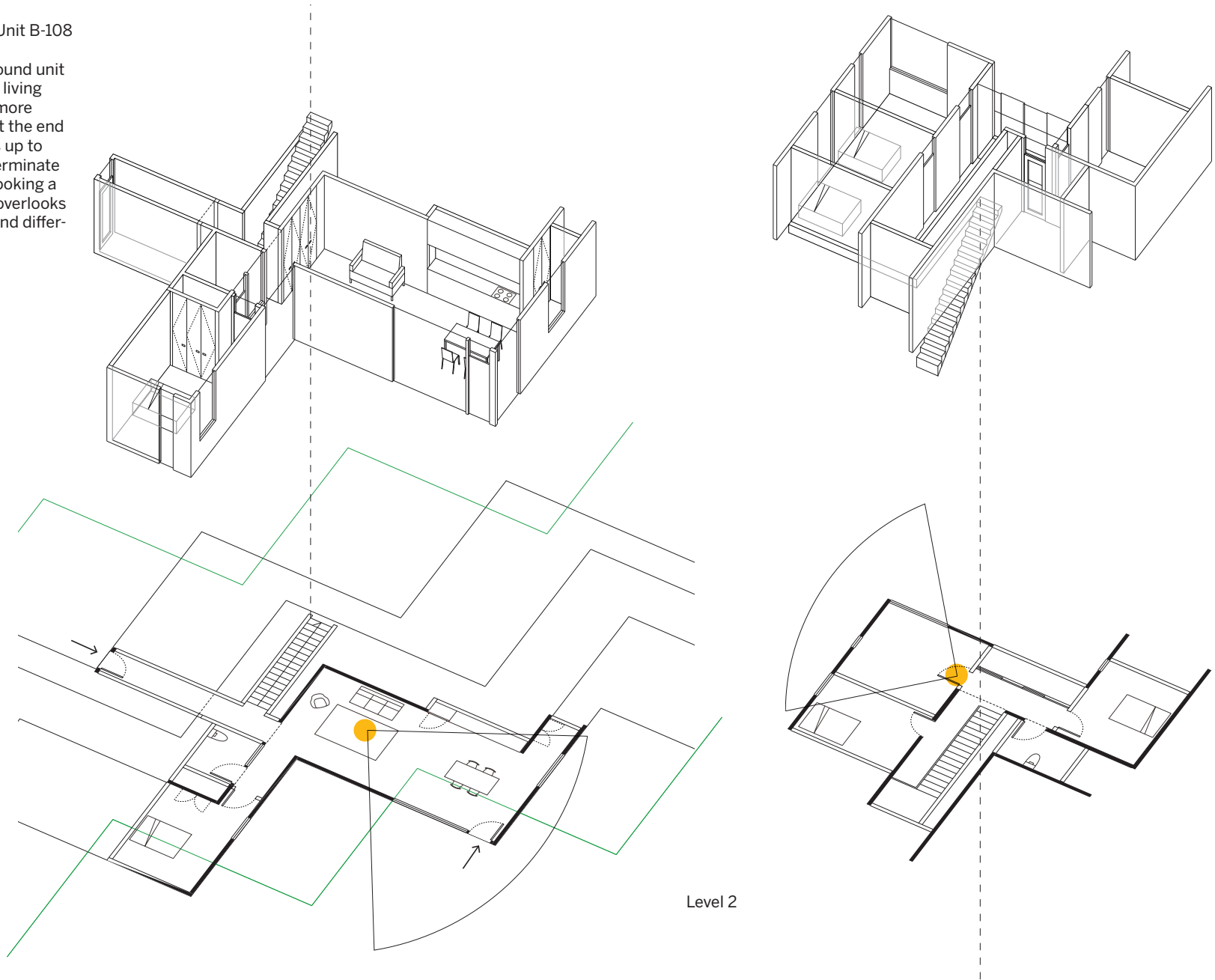


Figure 27  
Exploded Axon of Unit B-108

This unit wraps around unit B-103. Again, open living transitions to the more private bedroom at the end of a hall. The stairs up to the second floor terminate at a window overlooking a garden. Each unit overlooks multiple gardens and different orientations.



Level 1

Level 2

Figure 28  
Interior Perspective of Unit B108  
Level 2 Corner B bedroom



Figure 29  
Interior Perspective of Unit B108  
Level 1 kitchen/living room facing out toward garden.

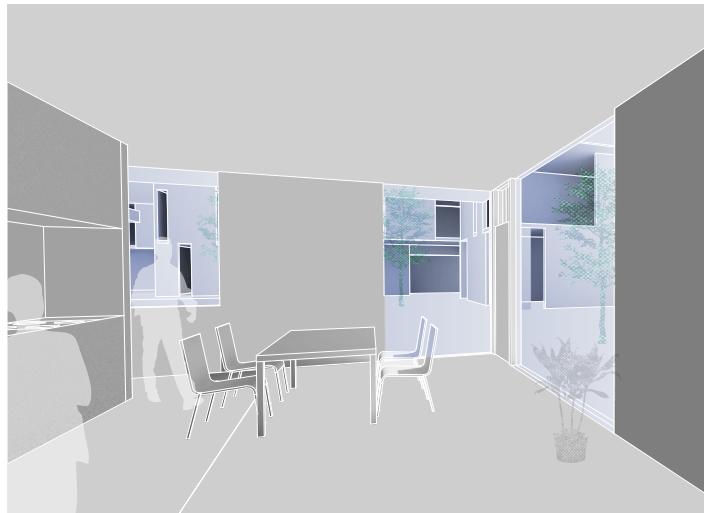


Figure 30 (right)  
Perspective view of garden.



Figure 31  
Level 3 Plan

- 1 Outdoor Lobby
- 2 Outdoor Space
- 3 Lounge
- 4 Laundry Room

- A Building
- 301 2bd/1b
  - 302 2bd/1b
  - 303 3bd/2b
  - 304 1bd/1b
  - 305 4bd/2b
  - 306 2bd/1b
  - 307 2bd/2b
  - 308 3bd/1.5b
  - 309 3bd/2b
  - 105 1bd/1.5b

- B Building
- 301 3bd/1.5b
  - 302 3bd/1.5b
  - 303 4bd/2b
  - 304 3bd/1.5b
  - 305 3bd/1.5b
  - 306 4bd/1.5b
  - 307 3bd/1.5b
  - 308 2bd/1.5b
  - 309 2bd/1b
  - 310 4bd/2b
  - 311 4bd/1b

- C Building
- 301 0bd/1b
  - 302 4bd/1b
  - 303 4bd/1.5b
  - 304 3bd/1b
  - 305 3bd/1b
  - 306 3bd/1b

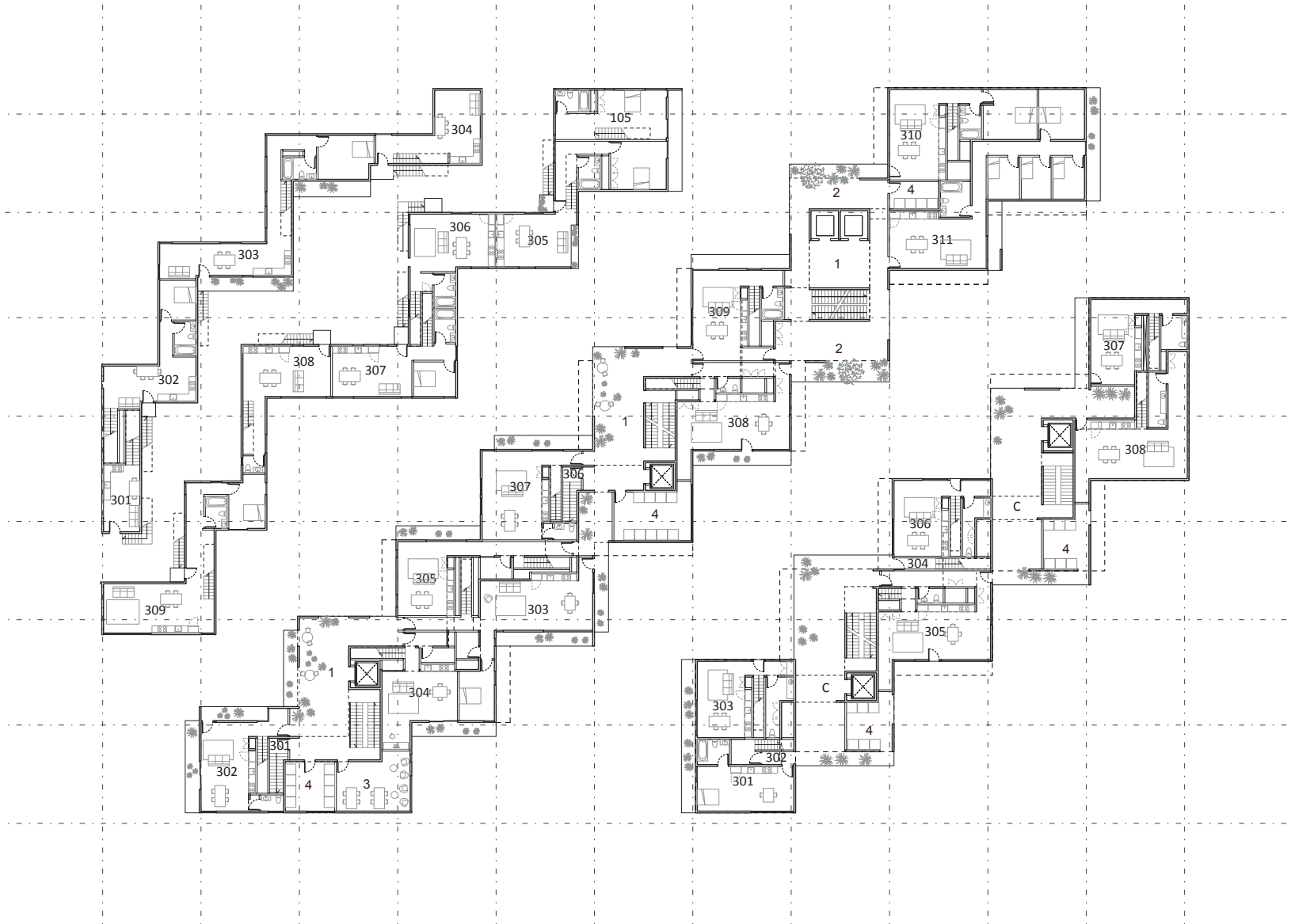


Figure 32  
Level 4 Plan

- 1 Outdoor Lobby
- 2 Outdoor Space
- 3 Lounge
- 4 Laundry Room

- A Building
- 301 2bd/1b
  - 302 2bd/1b
  - 303 3bd/2b
  - 304 1bd/1b
  - 305 4bd/2b
  - 306 2bd/1b
  - 307 2bd/2b
  - 308 3bd/1.5b
  - 309 3bd/2b

- B Building
- 301 3bd/1.5b
  - 302 3bd/1.5b
  - 303 4bd/2b
  - 304 3bd/1.5b
  - 305 3bd/1.5b
  - 306 4bd/1.5b
  - 307 3bd/1.5b
  - 308 2bd/1.5b
  - 309 2bd/ 1b
  - 310 4bd/ 2b
  - 311 4bd/ 1b
  - 401 1bd/ 1b
  - 402 0bd/1b

- C Building
- 301 0bd/1b
  - 302 4bd/1b
  - 303 4bd/1.5b
  - 304 3bd/1b
  - 305 3bd/1b
  - 306 3bd/1b

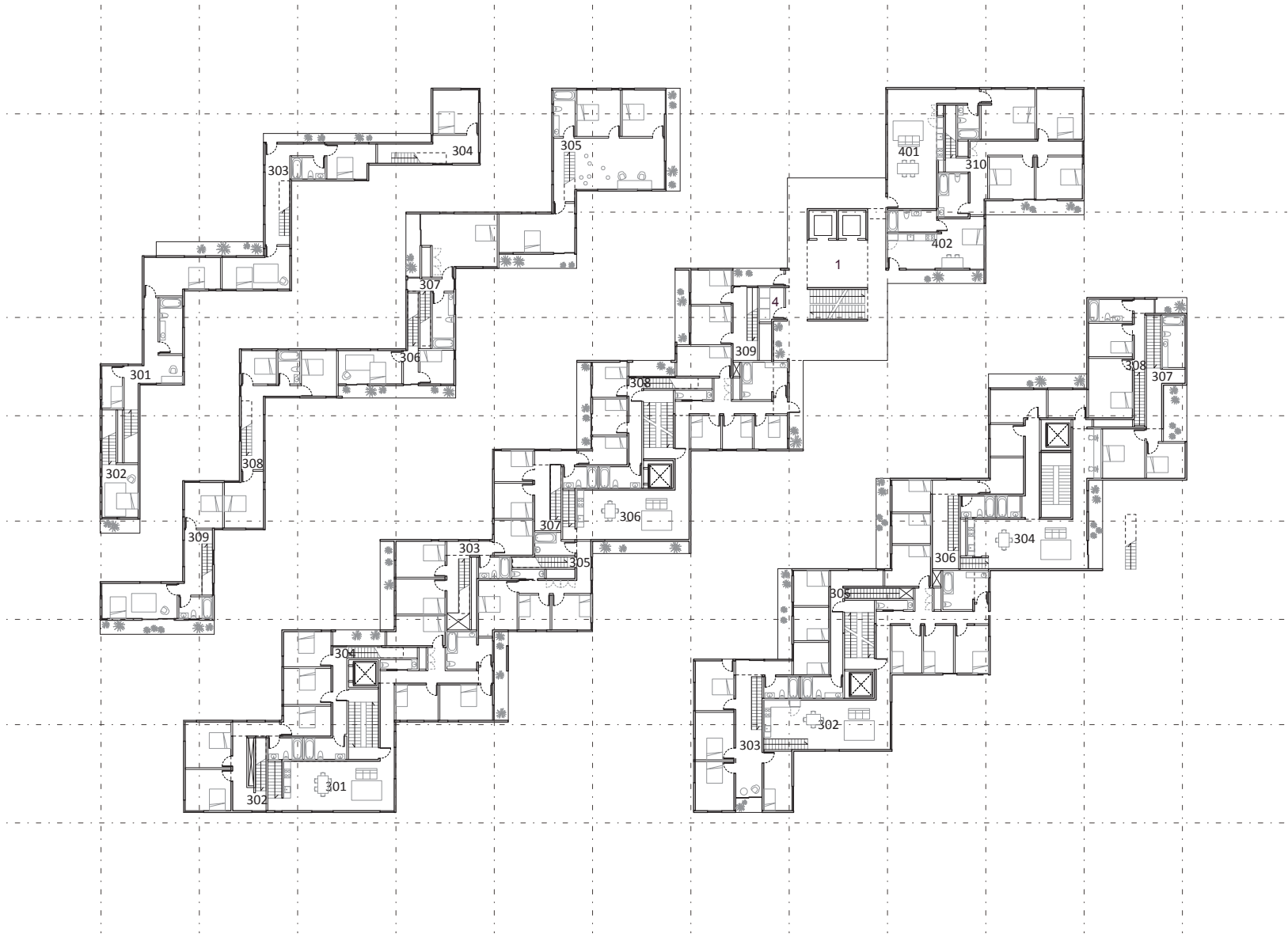
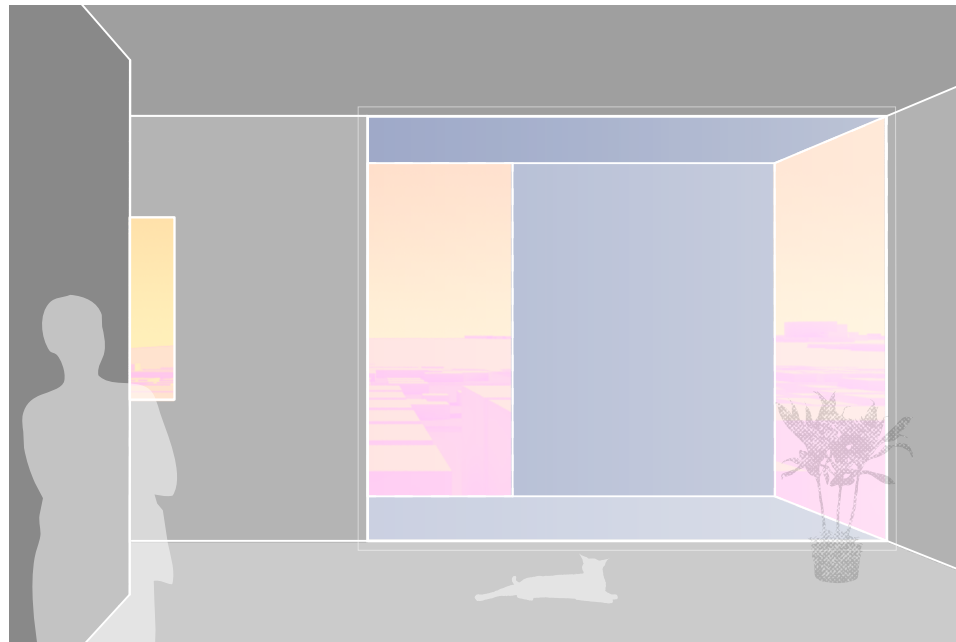




Figure 33  
Perspective view from the  
tower outdoor lobby.



Figure 34  
Perspective view from the  
living room of a tower unit  
looking out.



By exploring the architectural ideas of space and boundary, this thesis rethinks multi-family housing by introducing spatial bleeding to produce domestic situations that reflect the desires of middle-income families that want to live in the city. In the Spatial Model, spatial quality is an amenity that is marketable and contributes to the well-being of urban space and inhabitants alike.

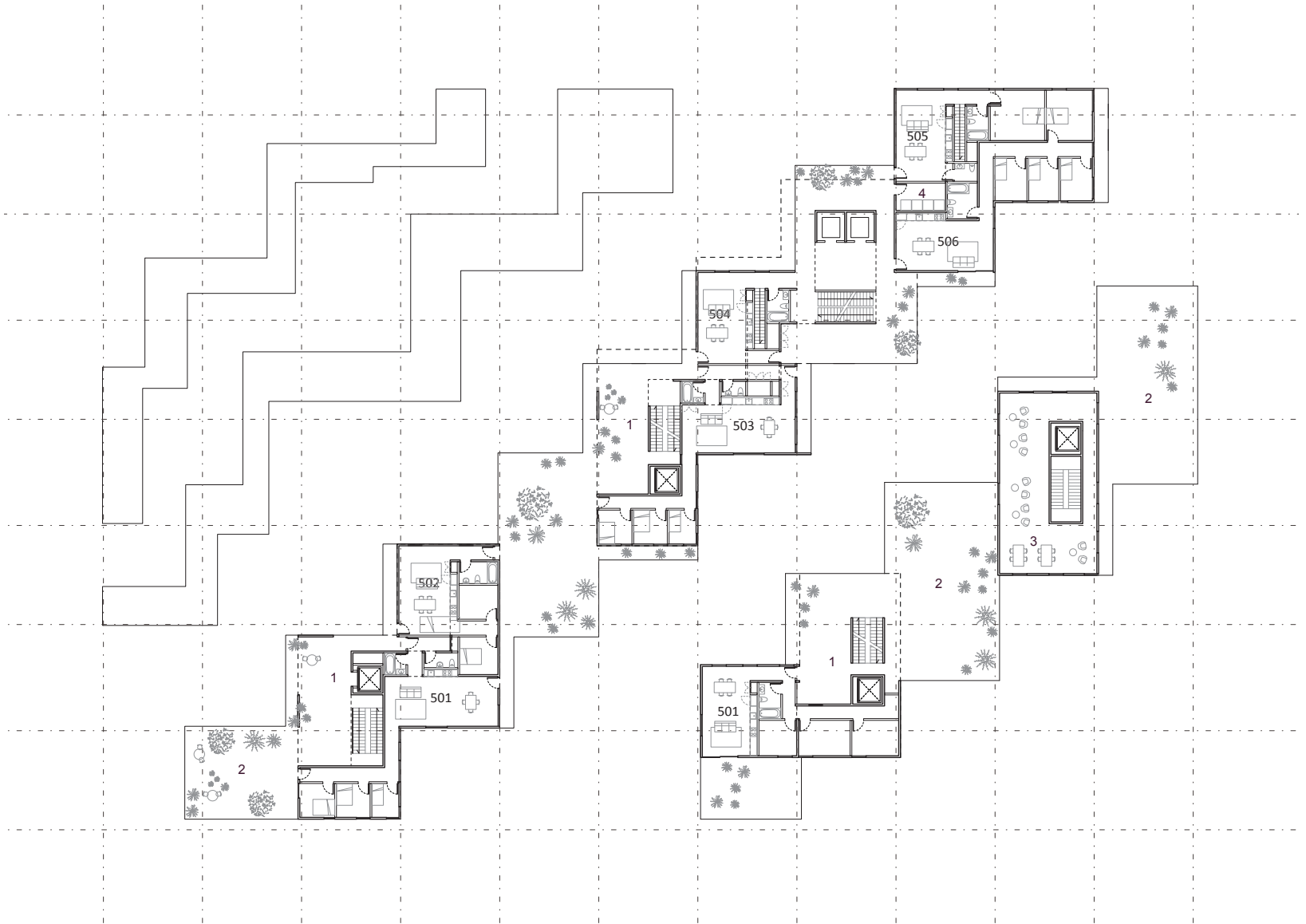


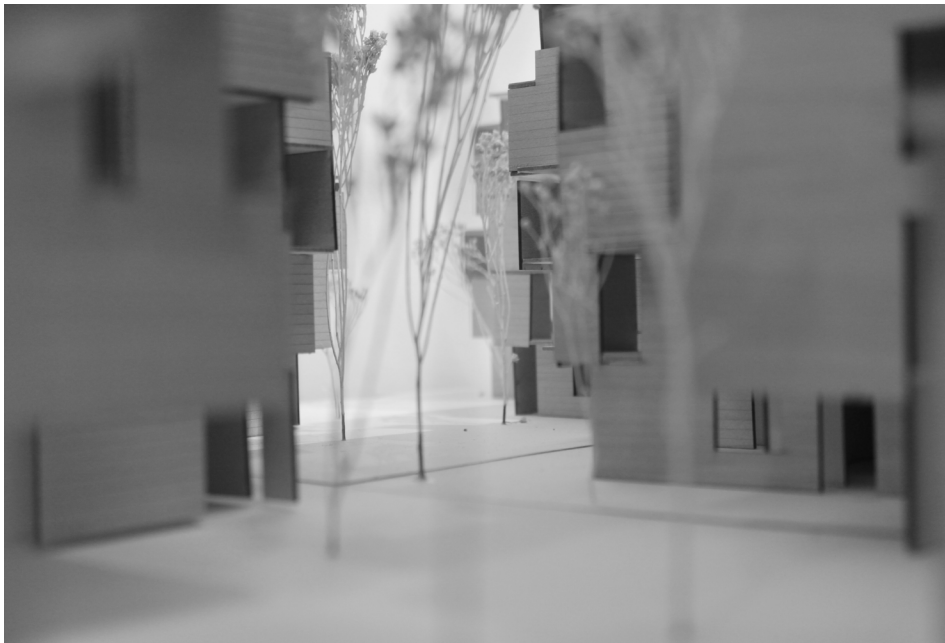
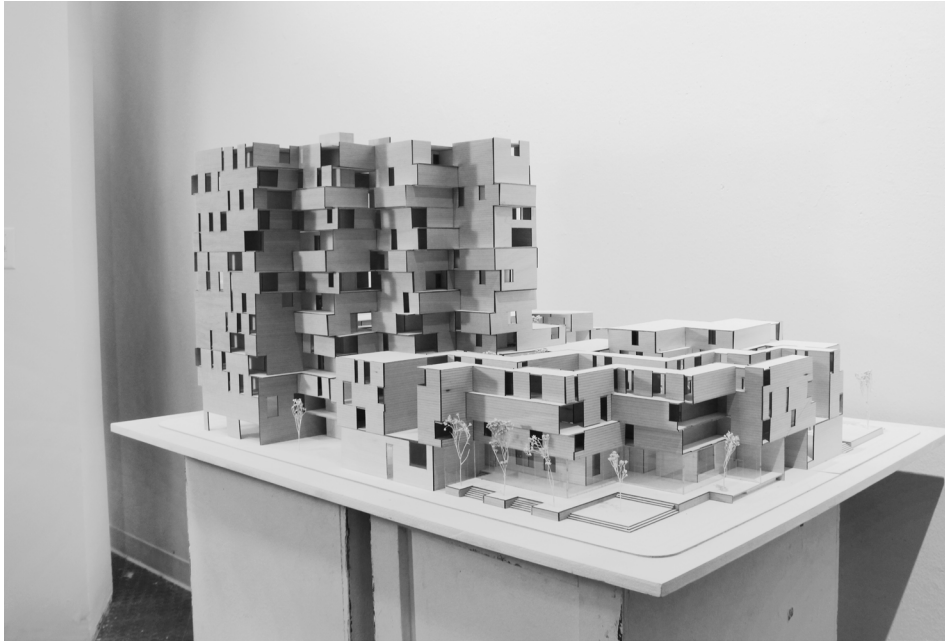
Figure 35  
Level 5 Plan

- 1 Outdoor Lobby
- 2 Outdoor Space
- 3 Lounge
- 4 Laundry Room

- B Building
- 501 3bd/1b
  - 502 2bd/1b
  - 503 3bd/1b
  - 504 3bd/1.5b
  - 505 4bd/2b
  - 506 4bd/1b

- C Building
- 501 3 bd/ 1 b







Final Model, Scale 1/4"=1'-0"

## APPENDIX

### Rental Revenue Calculations

Household Size	Harris County AMI*	30% of AMI**	Rent/month	
1	\$48,600	\$14,580	\$1,215	
2	\$55,500	\$16,650	\$1,388	
3	\$62,400	\$18,720	\$1,560	
4	\$69,300	\$20,790	\$1,733	
5	\$74,900	\$22,470	\$1,873	

\* Harris County AMI taken from HUD 2015 Income Limits.  
 \*\* According to Federal standards , housing is "affordable" when housing expense is 30% of income.

### Residential Revenue

Type	Bedrms	Bathroom	# of Units	Unit Size	Unit Rent	Rent PSF	Annual Rent
Apt: Efficiency	0	1	5	320	\$1,215	3.80	\$72,900
Apt: 1-Bedroom Unit	1	1	10	550	\$1,388	2.52	\$166,500
Apt: 2-Bedroom Unit	2	1	20	750	\$1,560	2.08	\$374,400
Apt: 3-Bedroom Unit	3	1	30	900	\$1,733	1.93	\$623,700
Apt: 4-Bedroom Unit	4	1.5	25	1100	\$1,873	1.70	\$561,750
		Total	90	76600	\$149,938		\$1,799,250
		Average		851.11	\$1,666		

### Commercial Revenue

Type			Unit Size	Unit Rent	Rent PSF	Annual Rent
Leasable Space		4	1000	20000	20	\$1,200,000

Full Project Underwriting

Total Square Feet	197,168				Expense			
Total Units	90	64.86	units / acre		Salaries	108,000	0.55	1,200
Avg Unit Size	851				Marketing & Leasing	15,750	0.08	175
Land Size	1.39	30.00	per sf		General & Administrative	20,250	0.10	225
					Repairs & Maintenance	76,500	0.39	850
		Total	\$ / SF	\$ / Unit	Utilities	85,500	0.43	950
Land Costs		\$1,813,200	\$9.20	\$20,147	Controllable Expenses	306,000	1.55	3,400
Hard Costs		20,505,472	104.00	227,839	Management Fee 3.00%	88,081	0.45	979
Construction Soft Costs		5,126,368	26.00	56,960	Property Insurance	47,320	0.24	526
Marketing Soft Costs		19,717	0.10	219	Property Taxes 2.57%	670,603	3.40	7,451
Total Cost - Land, Hard & Soft		27,464,757	139.30	305,164	Non-controllable	806,005	4.09	8,956
Developer's Fee 3.0%		823,943	4.18	9,155	<hr/>			
Financing Costs 5.0%		1,553,185	7.88	17,258	Total Expenses	1,112,005	5.64	12,356
Underground Parking 185		2,775,000						
<hr/>					Net Operating Income (NOI)	1,824,034	9.25	20,267
Total Project Cost		32,616,884	165.43	362,410	Replacement Reserve	13,500	0.07	150
					NOI After RR	1,810,534	9.18	20,117
Income								
Current Rents \$1.96					Untrended Project Return	5.47%		
Current Rent/Unit \$19,991.67								
Commercial Space Annual Income \$1,200,000					Return on Cost	5.55%		
Rents (2% growth - 2 yr stabilization) \$2.00 per sf								
Other Income (internet) \$0.06 per sf								
Vacancy 5.00%								
<hr/>								
Total Income		2,936,039	14.89	32,623				