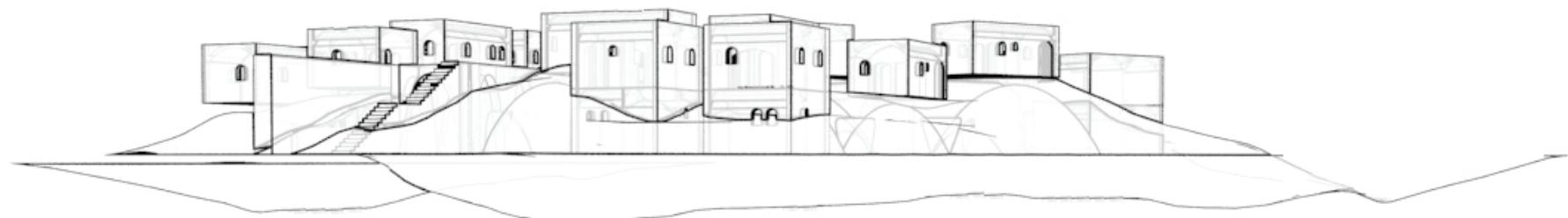


COMMUNAL HOUSING

ZAATARI REFUGEE CAMP, JORDAN



PRESENTATION CONTENT

ANALYSIS

*Identifying
the issues*

*Refugee
Solutions*

*Site
Analysis*

CONCEPT

*Communal
Housing
Concept*

EXECUTION

*Structural
Design*

*Construction
Process*

Computation

ANALYSIS

*Identifying
the issues*

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Process*

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BROKEN SOCIAL NETWORKS

"The consequences of family separation are significant, and in addition to financial burdens, expose refugees to serious protection risks, including harsh child labour, broken social networks, parenting challenges, and changes to familial roles. Furthermore, decades of research connect damaged social networks to poor physical and mental health."



POOR LIVING CONDITIONS FOR CHILDREN

One third of the children in the camp are not attending school. There are few safe places to play. Children end up playing in the streets adjacent to electrical wires and contaminated water.



INADEQUATE SAFETY & PRIVACY

*There is an abrupt transition from private to public zones.
A 2015 survey indicated 21% of residents do not feel safe leaving their house unattended.*



INFRASTRUCTURAL ISSUES

Poor infrastructure has led to stormwater and wastewater accumulating along roadsides and adjacent to dwellings.

ANALYSIS

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REARRANGING HOUSING CLUSTERS

Families group caravans and tents together to form private family units. Tarpaulins and tents are used to create private outdoor spaces.





SHARING TIME & RESOURCES

Families continue to follow their culture and traditions as much as possible. Many eat lunch together and chip in to prepare the meals.



INCORPORATION OF VEGETATION

Refugees have planted gardens and trees. Vegetation is a reminder of home and vegetable gardens provide additional sustenance.

ANALYSIS

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*Structural
Design*

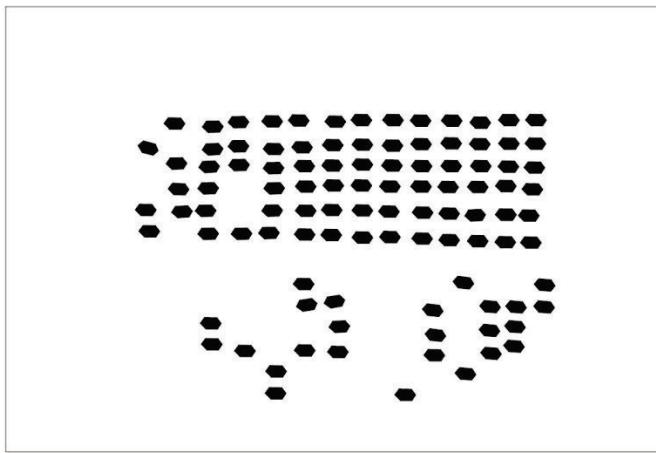
*Construction
Process*

Computation

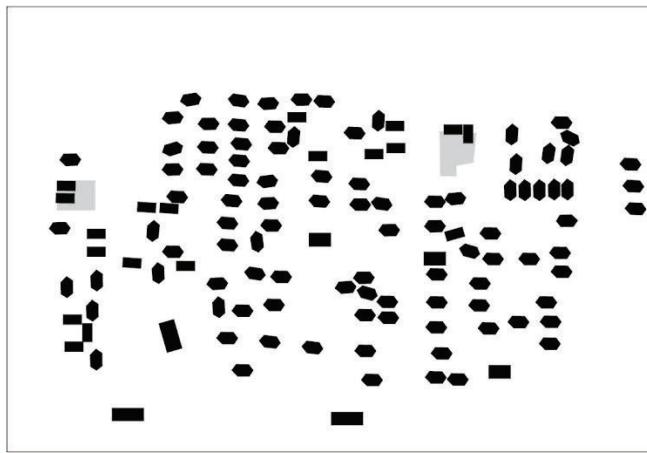
GROWTH OVER TIME: TEMPORARY TO PERMANENT

The camp has transitioned over time from tent structures to containers. The containers were then rearranged, establishing more permanent housing clusters.

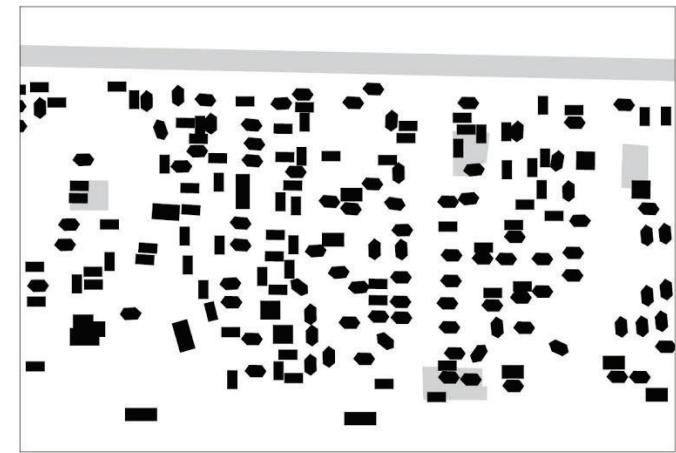
1 February 2013



2 September 2013



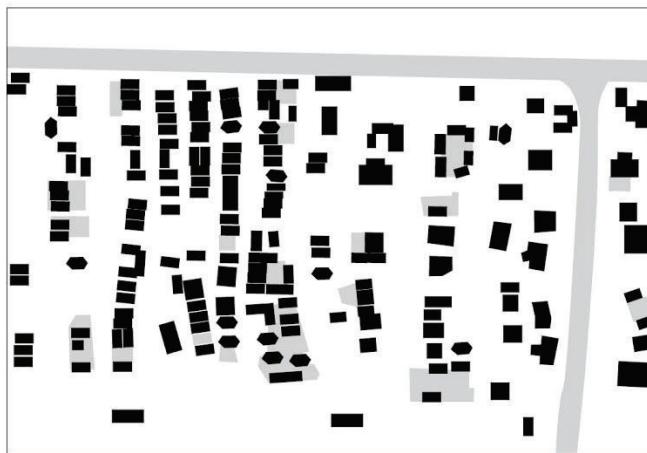
3 January 2014



4 July 2014



5 February 2016



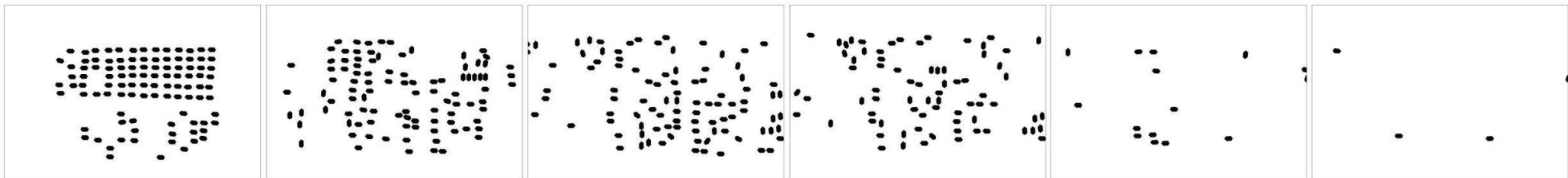
6 March 2017



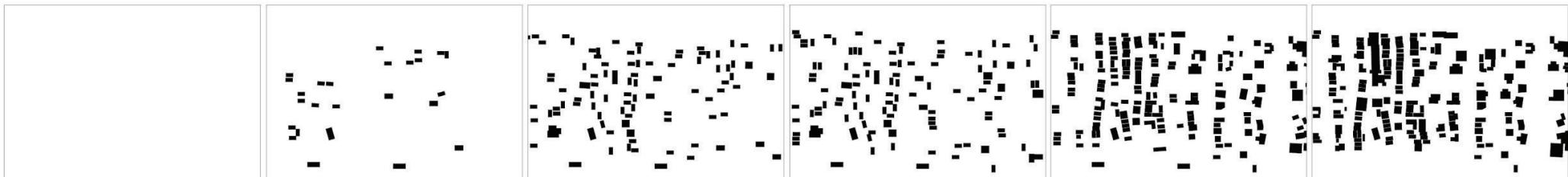
GROWTH OVER TIME: TEMPORARY TO PERMANENT

The diagrams below illustrate the reduction in tents and increase in containers, roads, and courtyards

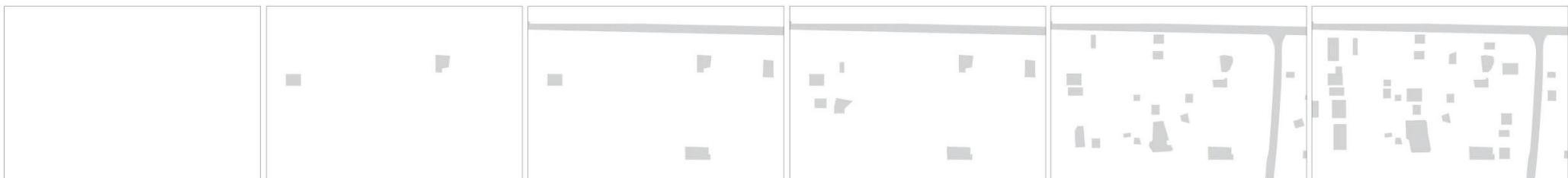
Tents



Containers

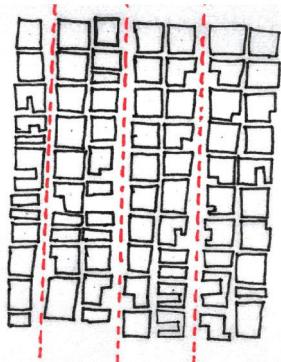


Roads and Courtyards

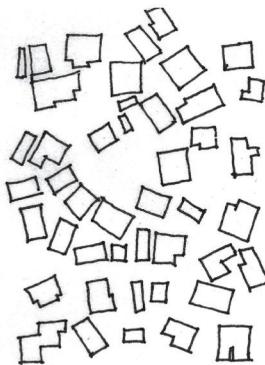


URBAN HOUSING CLUSTERS

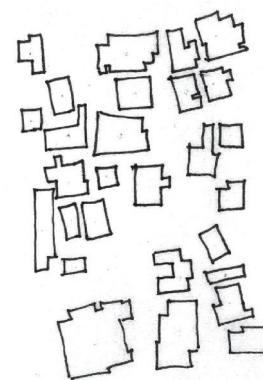
The following diagrams analyse different types of urban housing clusters to understand the organisation of an urban block. A variety of urban clusters have been observed in the refugee camp



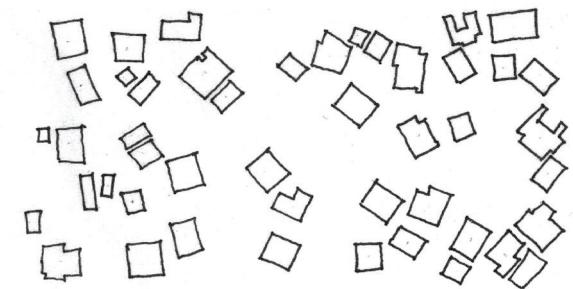
(a) regular grid



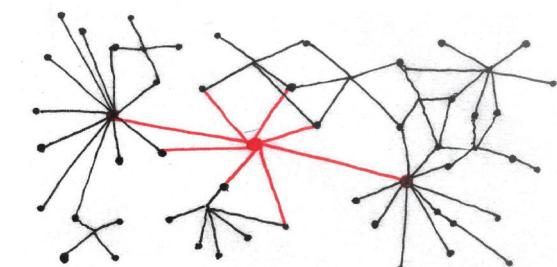
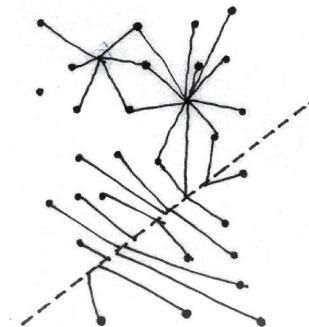
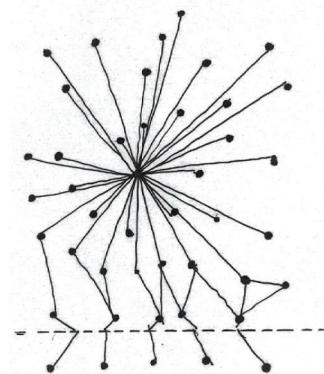
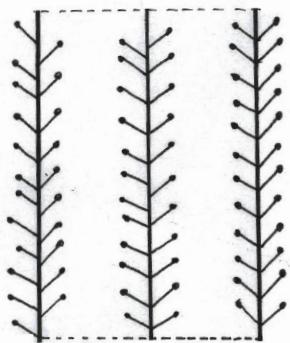
(b) central courtyard



(c) linear courtyard



(d) hierarchy of courtyards



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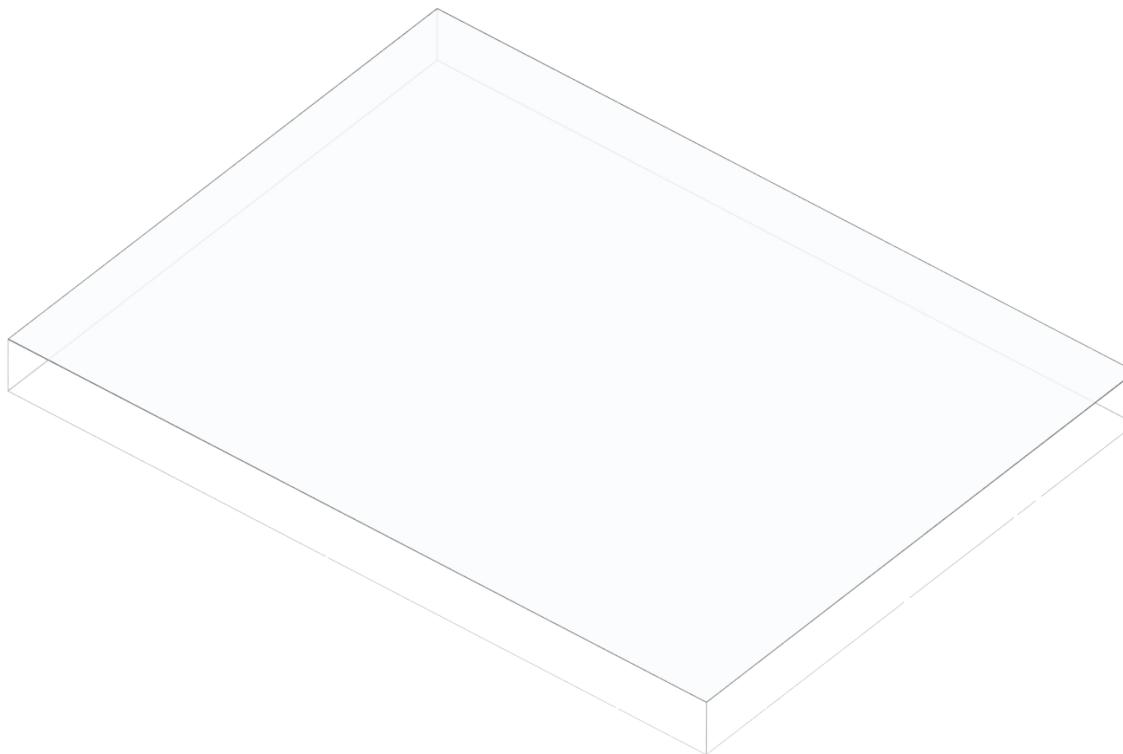
*Construction
Process*

Computation



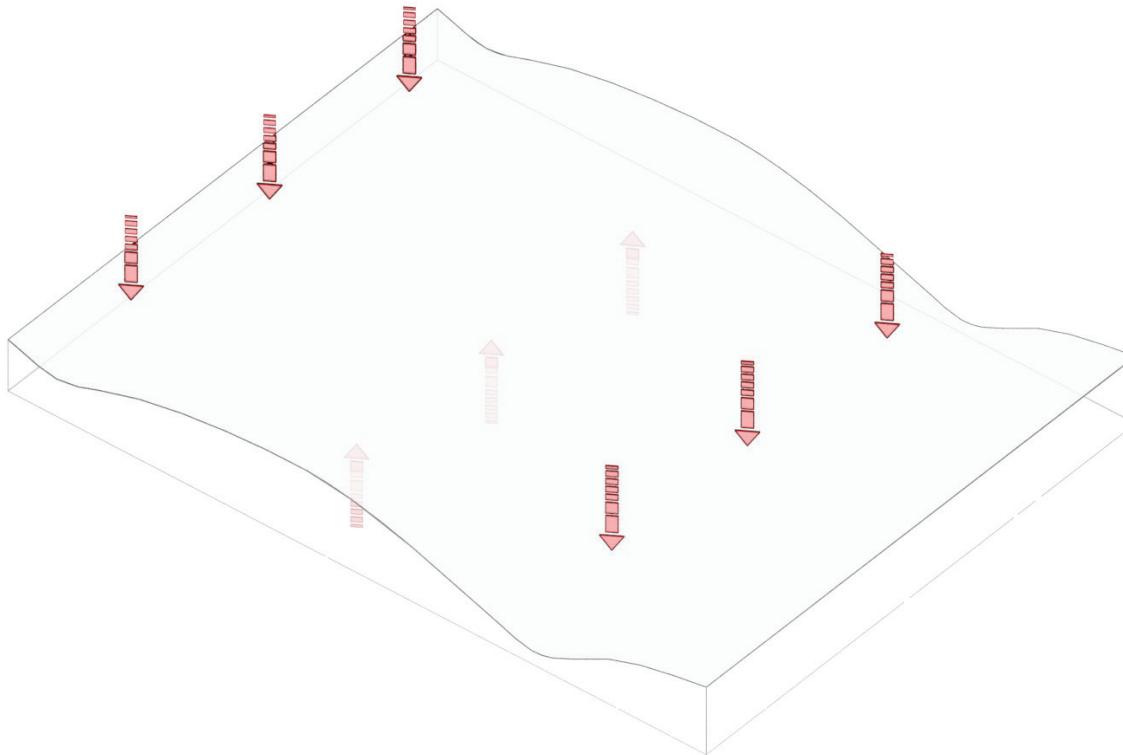
DISTRICT 7





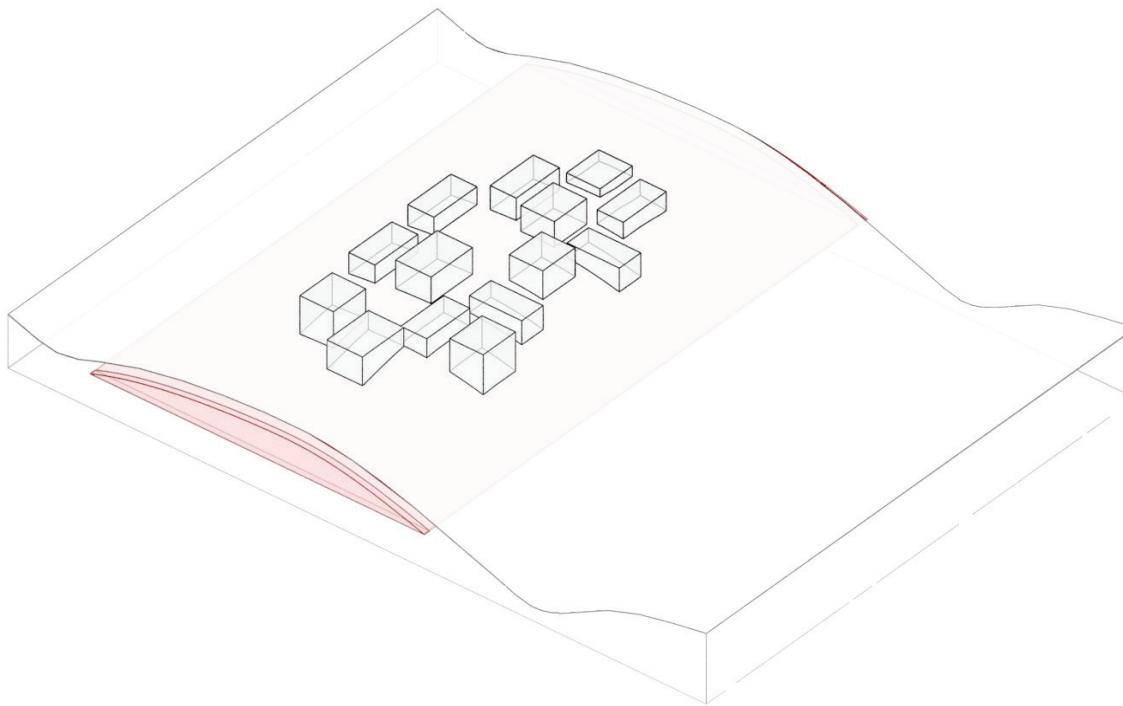
TOPOGRAPHY

The existing site has a minimal slope (negligible)



MORPHING

*The topography of the site has been morphed to create
retention ponds for water management on site*



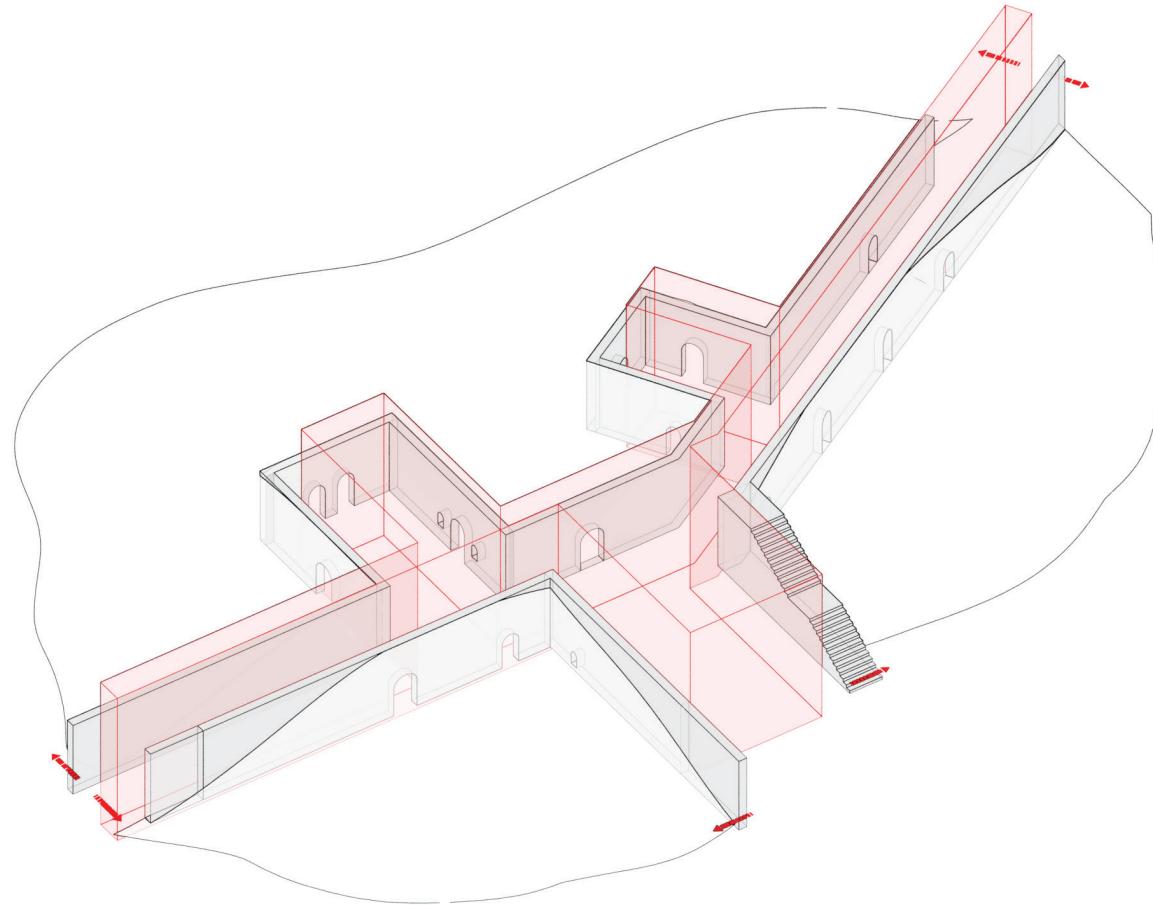
ADDING PROGRAM

*Dwellings are added on top of the morphed landscape.
Communal spaces are added below.*



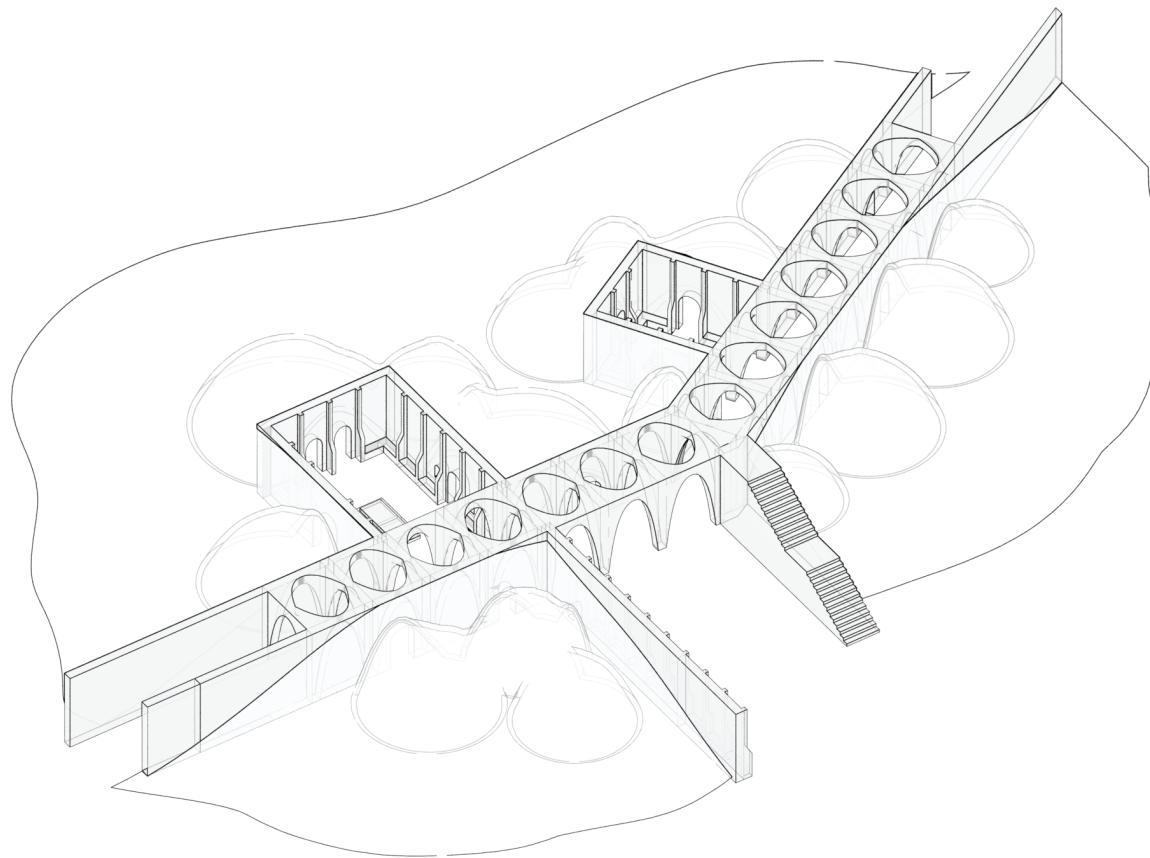






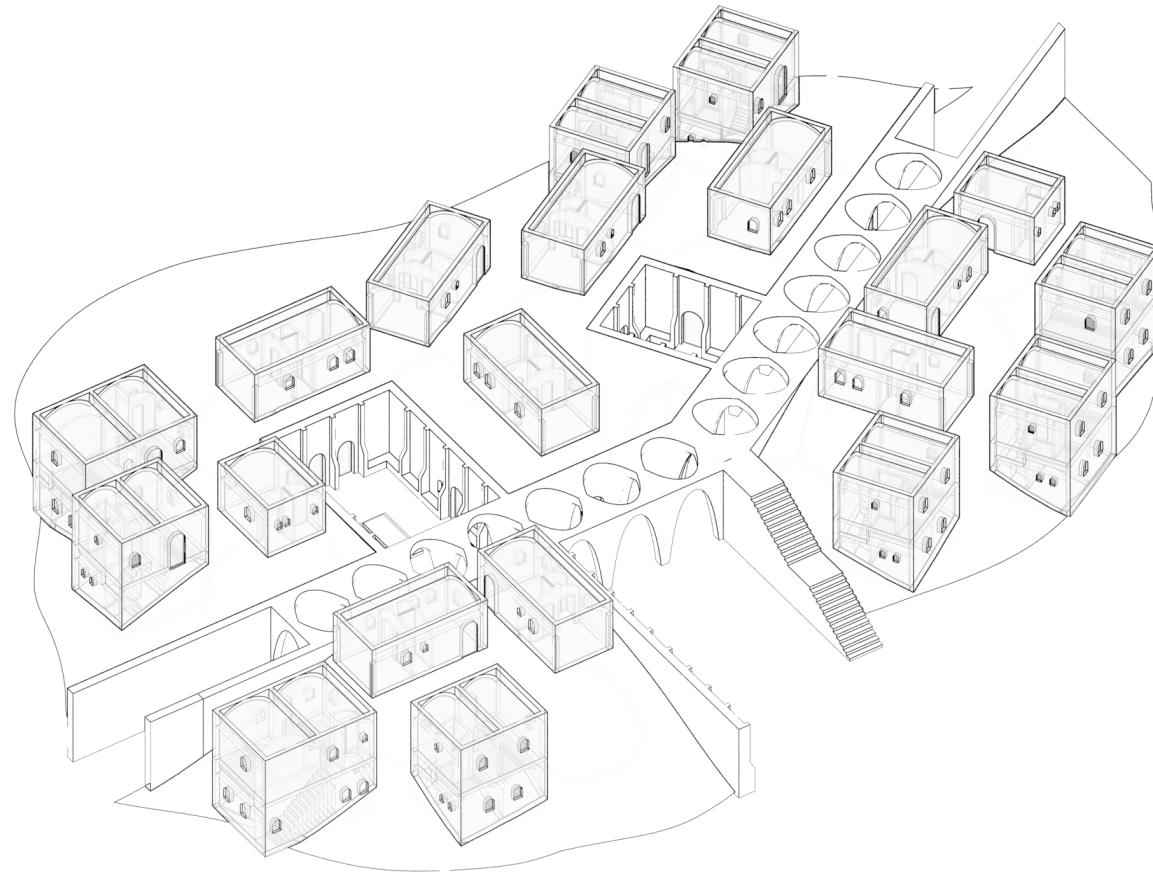
STREET AND COURTYARDS

The morphed landscape is split into two parts by adding a central street and three courtyards, improving the spatial quality



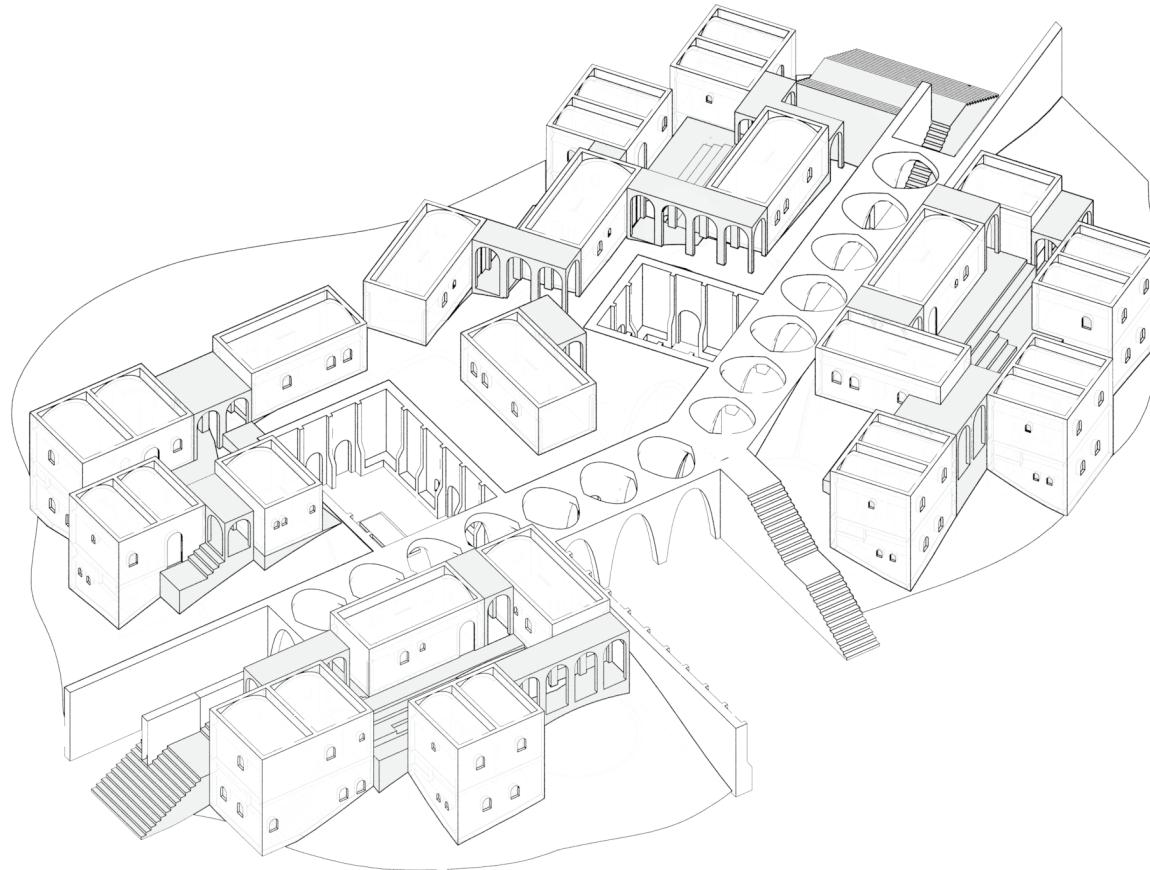
PROGRAM CONNECTIONS

The central street is lined with arches to support the walls of the communal programs as well as providing a connective spine tying the spaces together



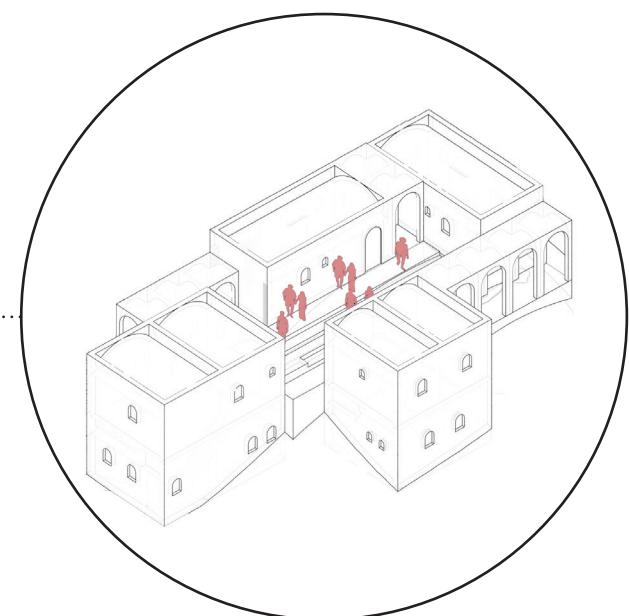
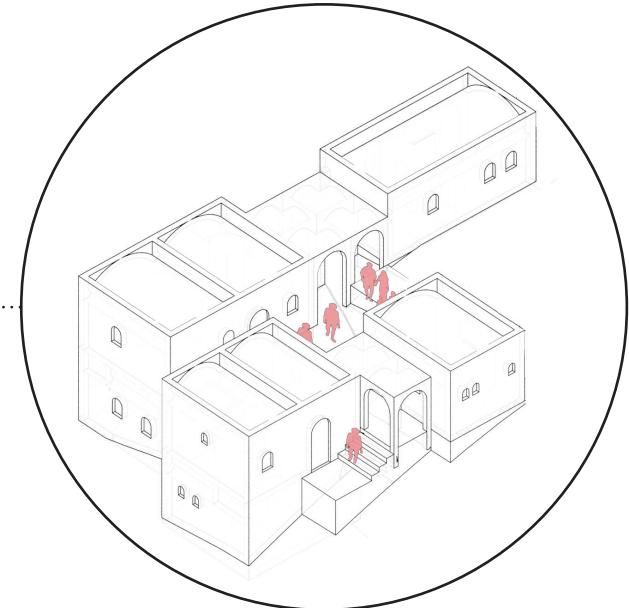
DWELLINGS

Dwellings are added on the first floor, overlooking and intertwining with the communal facilities below

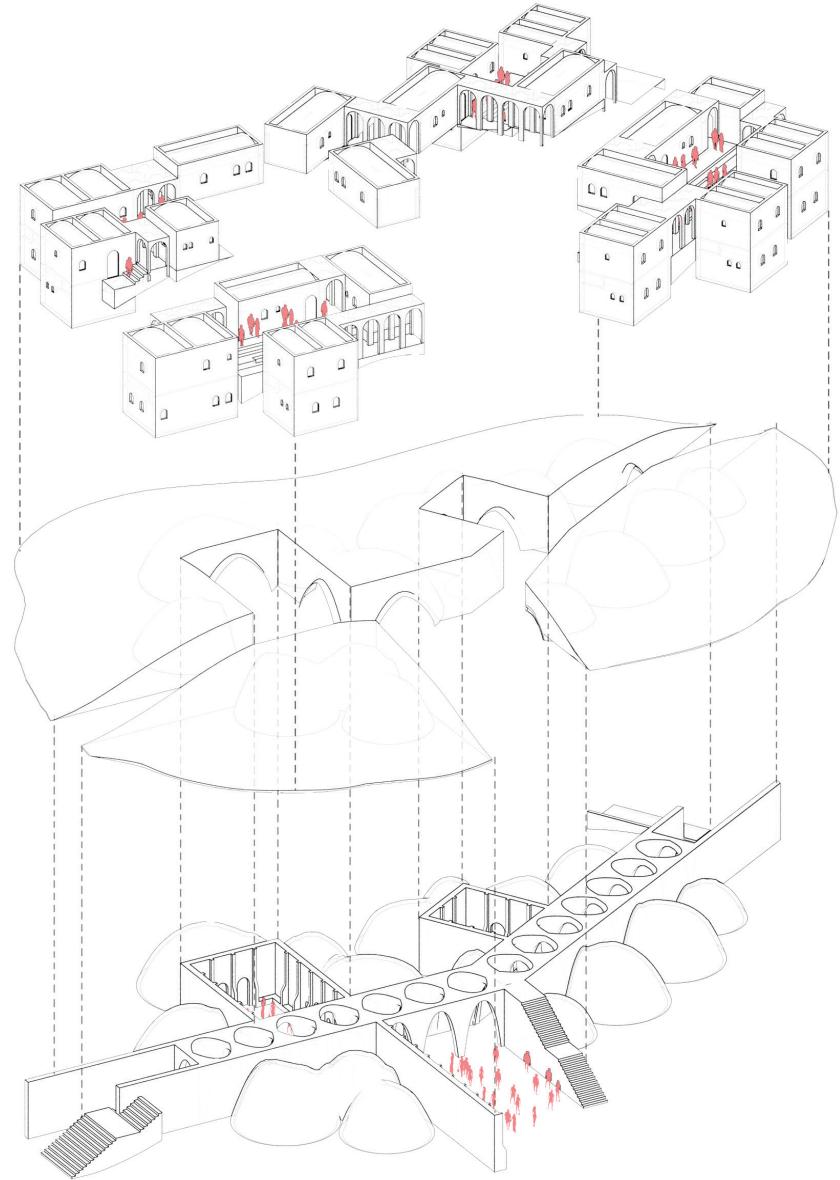


LIWANS

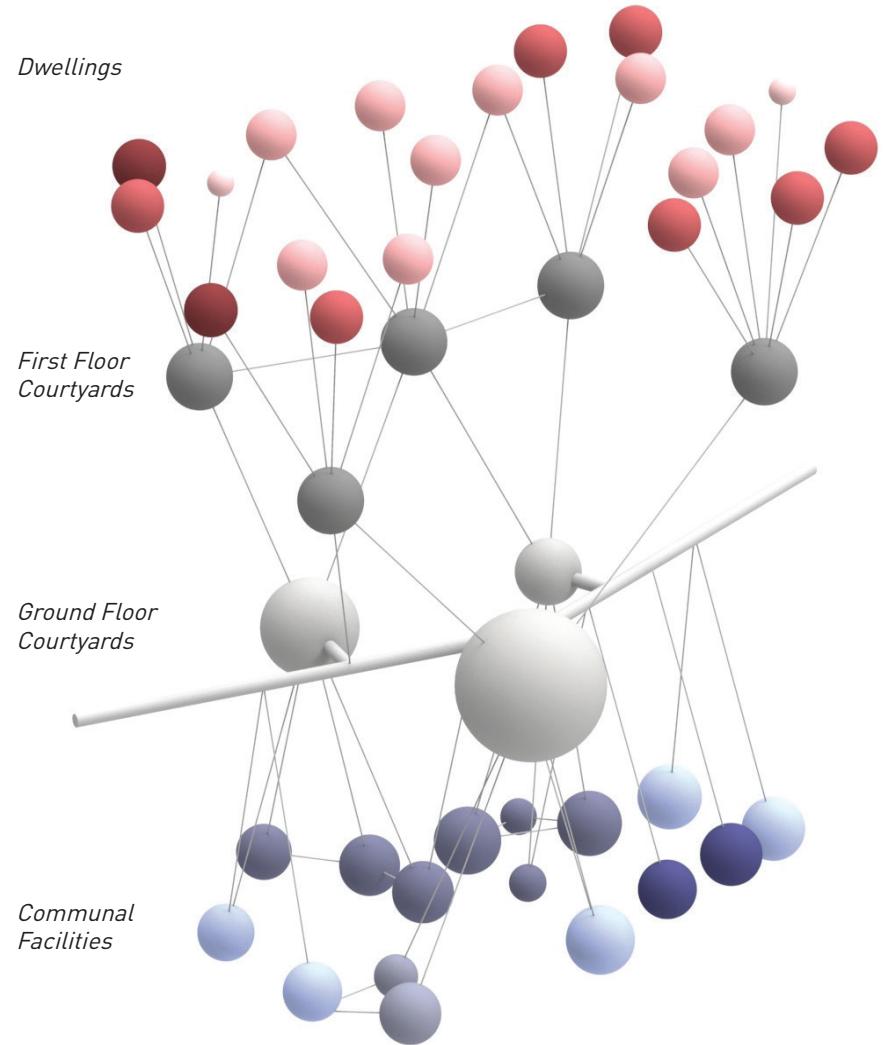
Shaded colonnades are added between dwelling units to provide communal spaces on the first floor



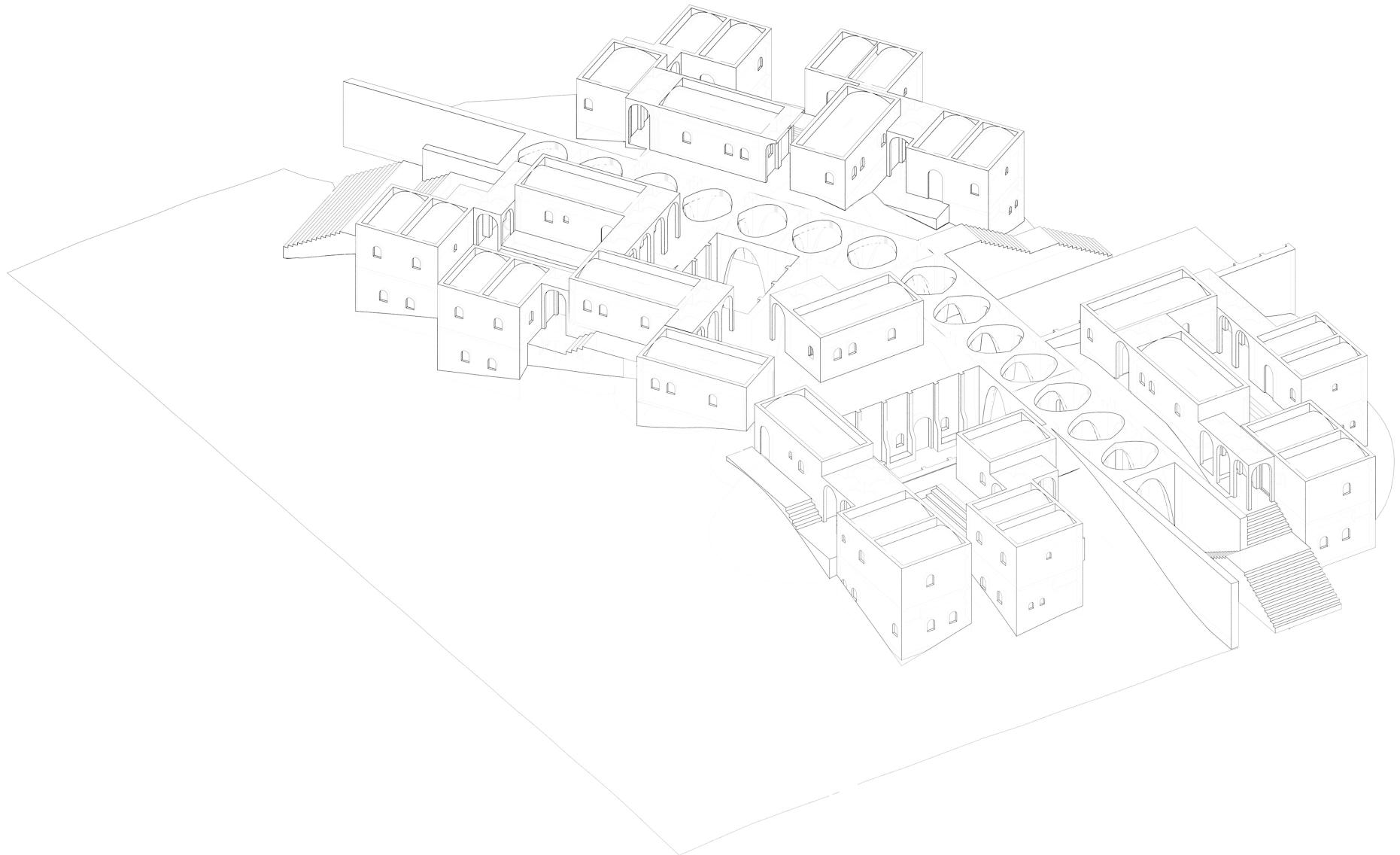
FIRST FLOOR COMMUNAL SPACES

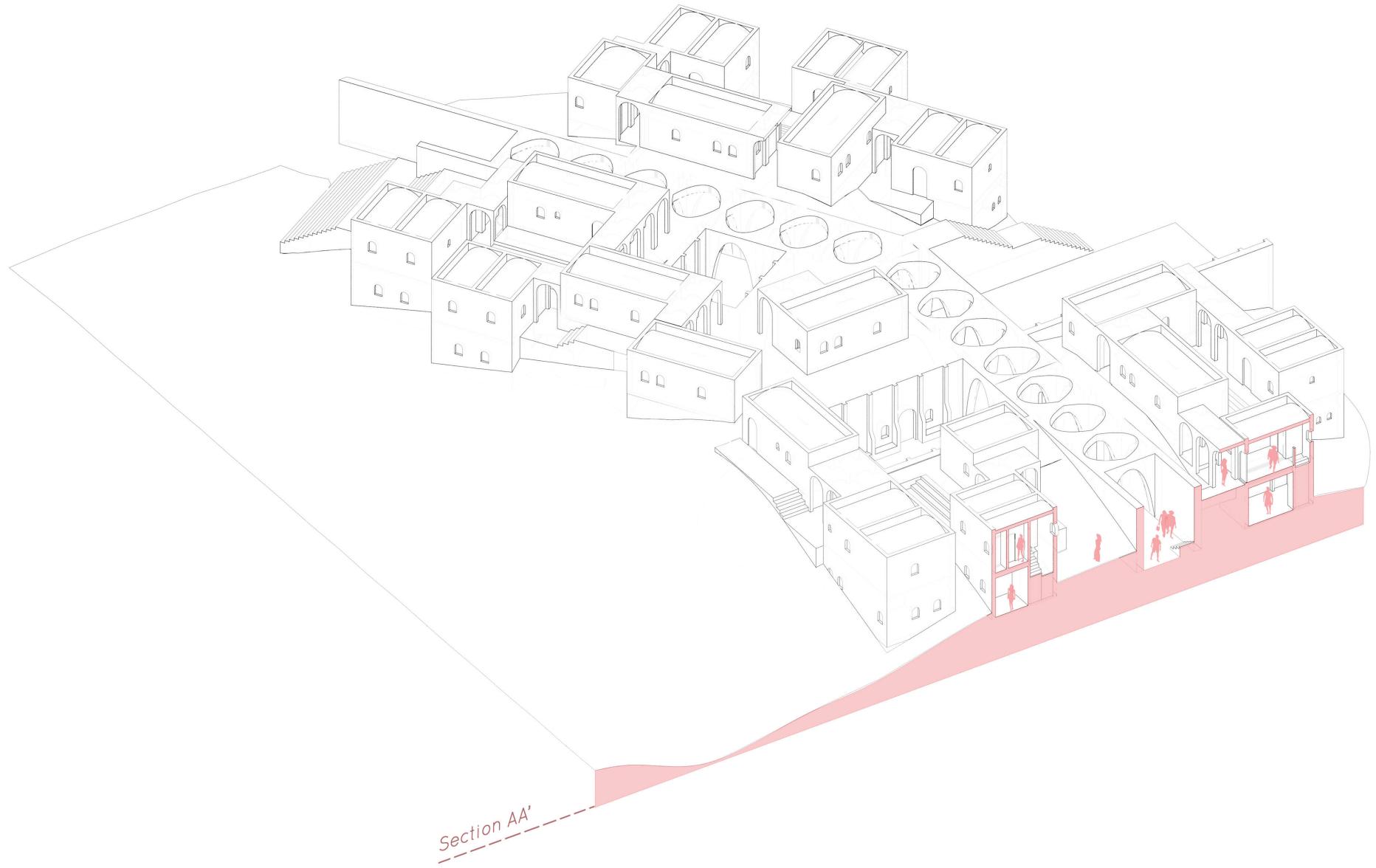


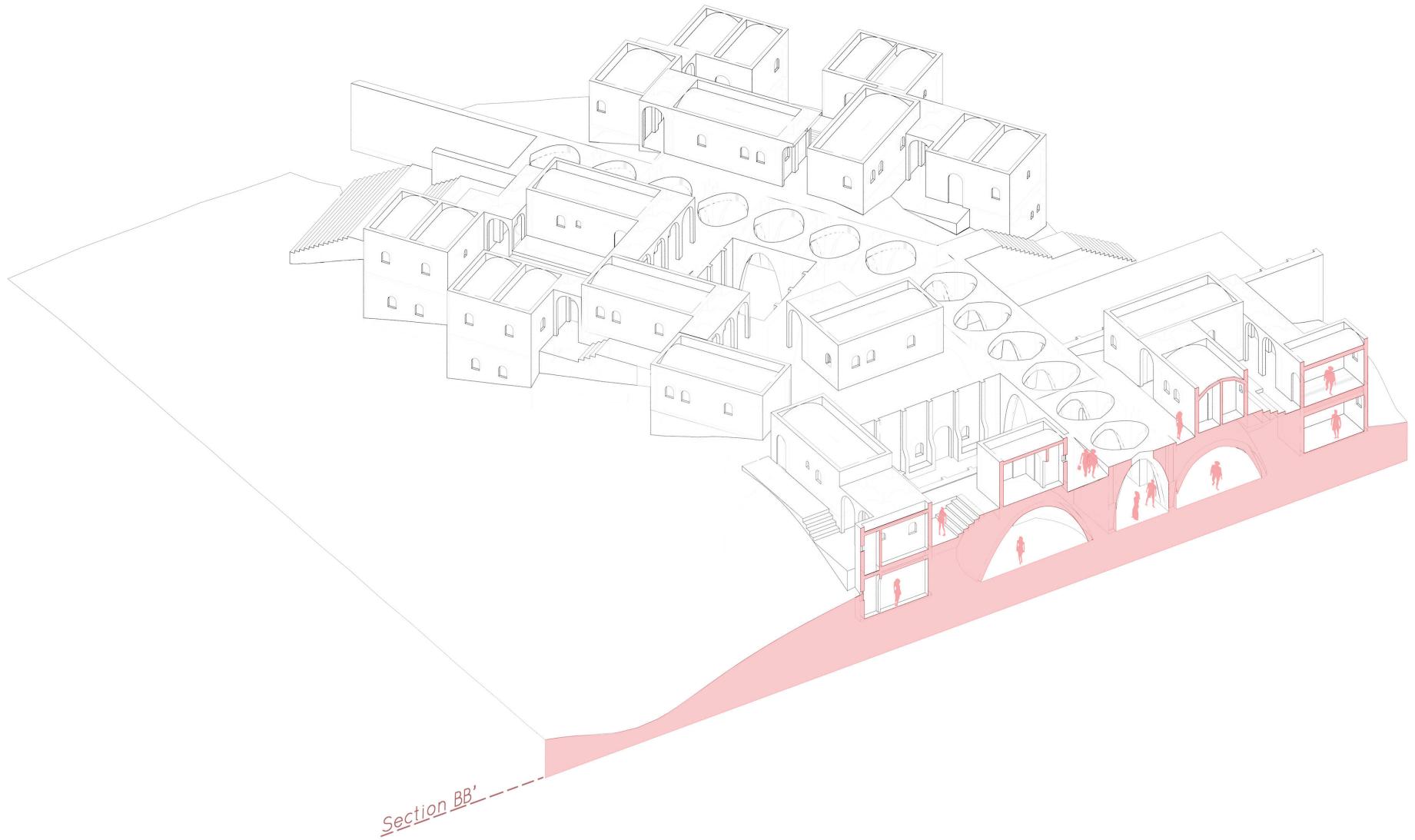
EXPLODED ISOMETRIC

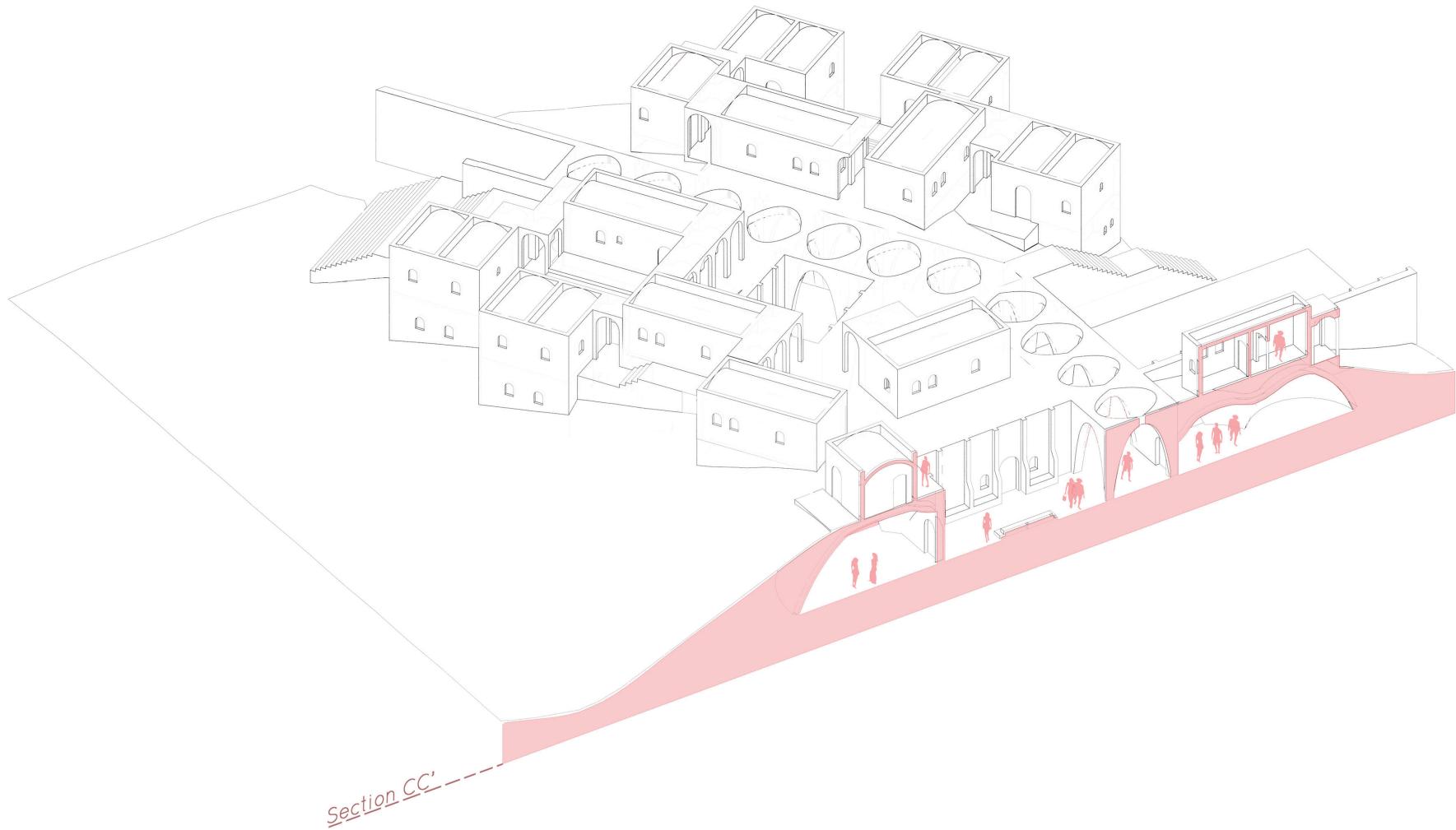


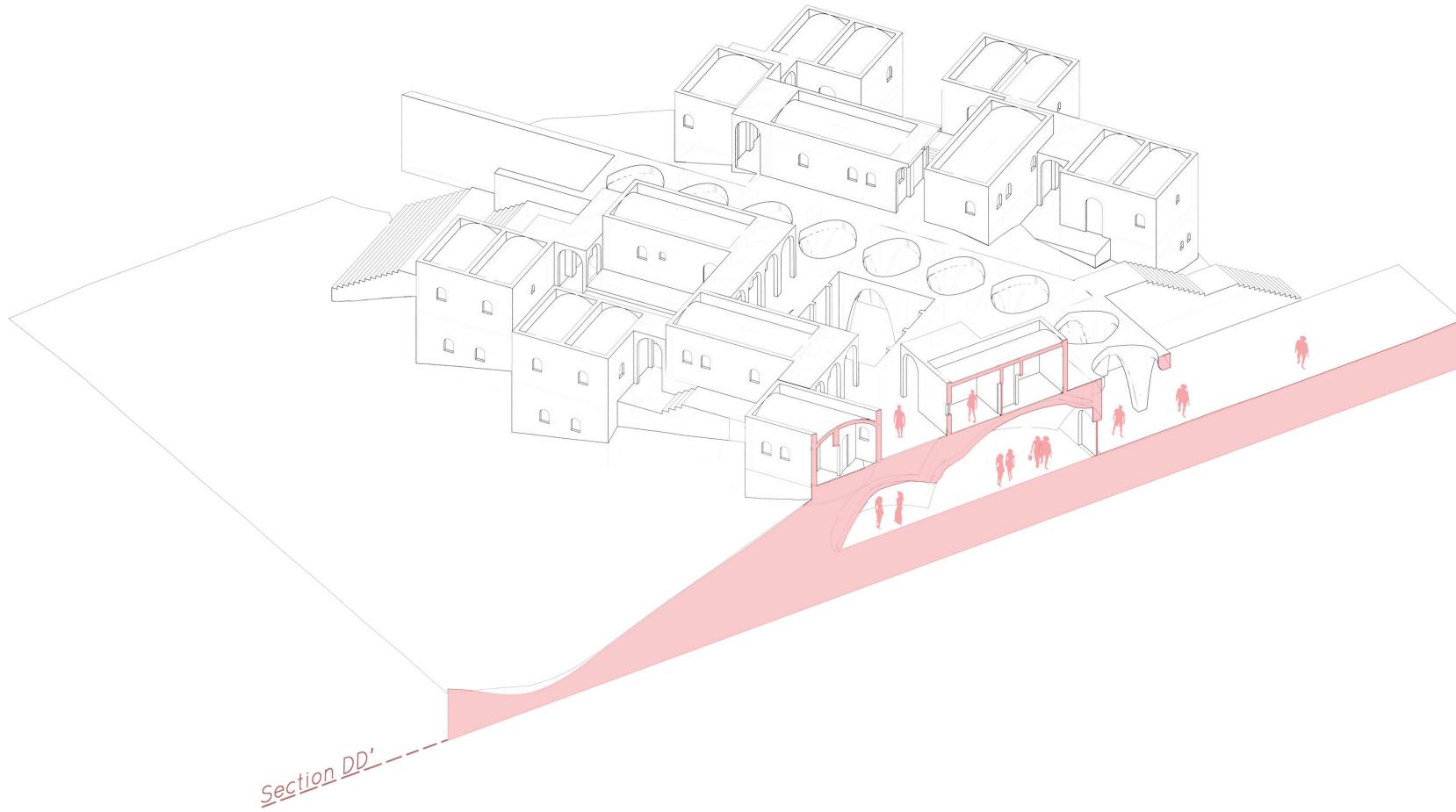
PROGRAM DISTRIBUTION

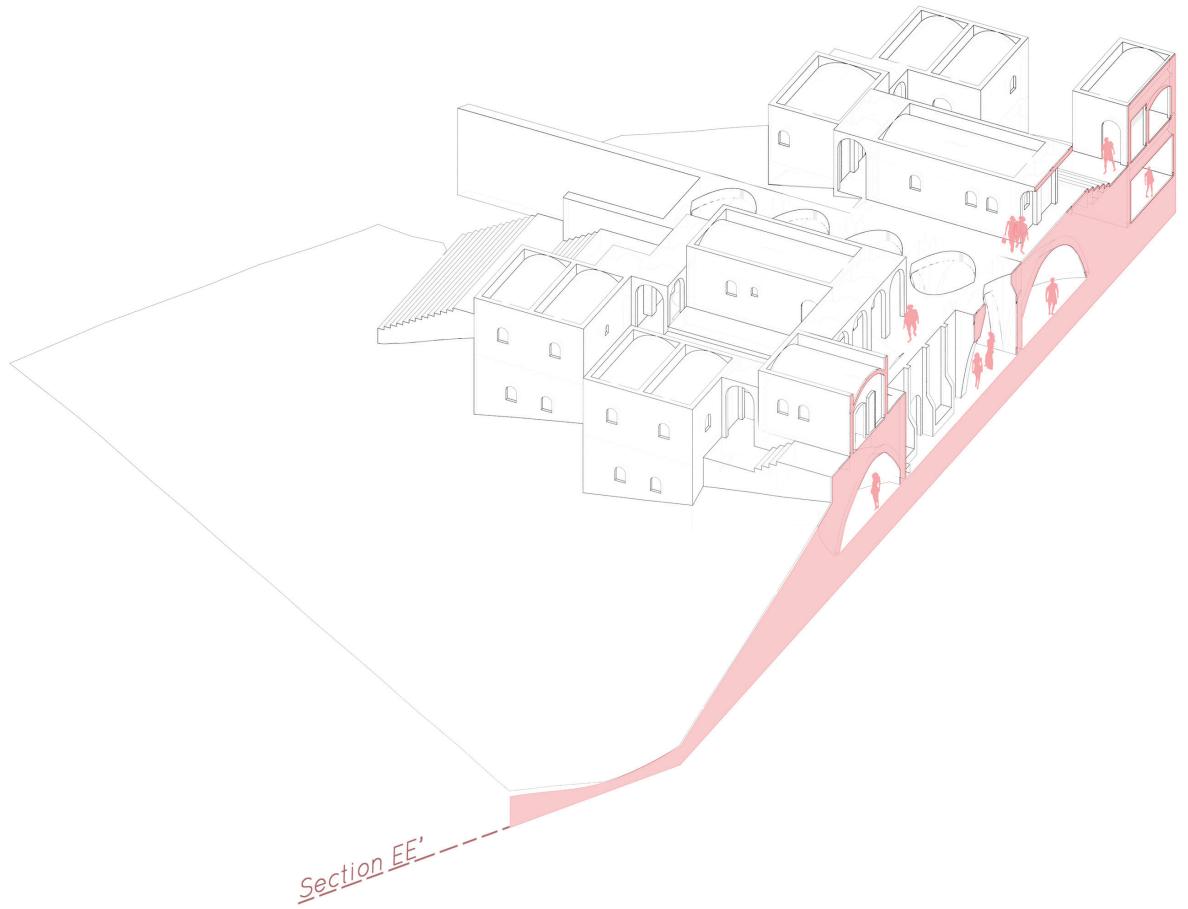


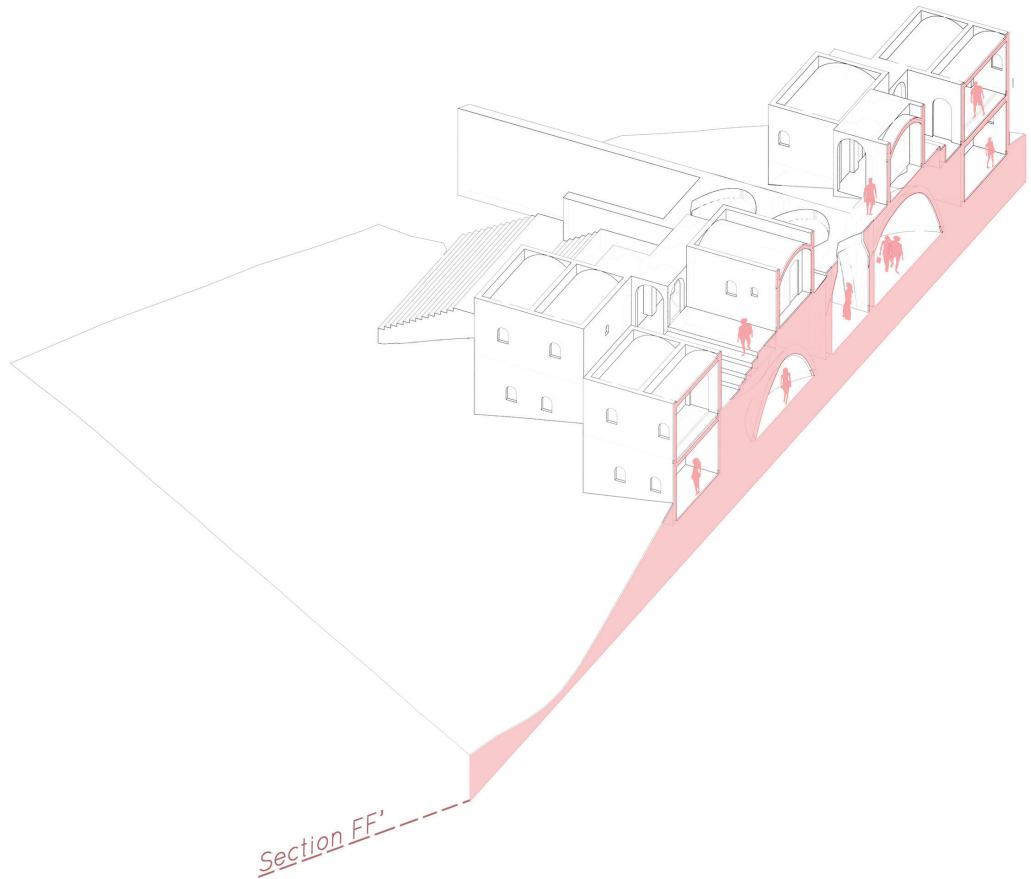


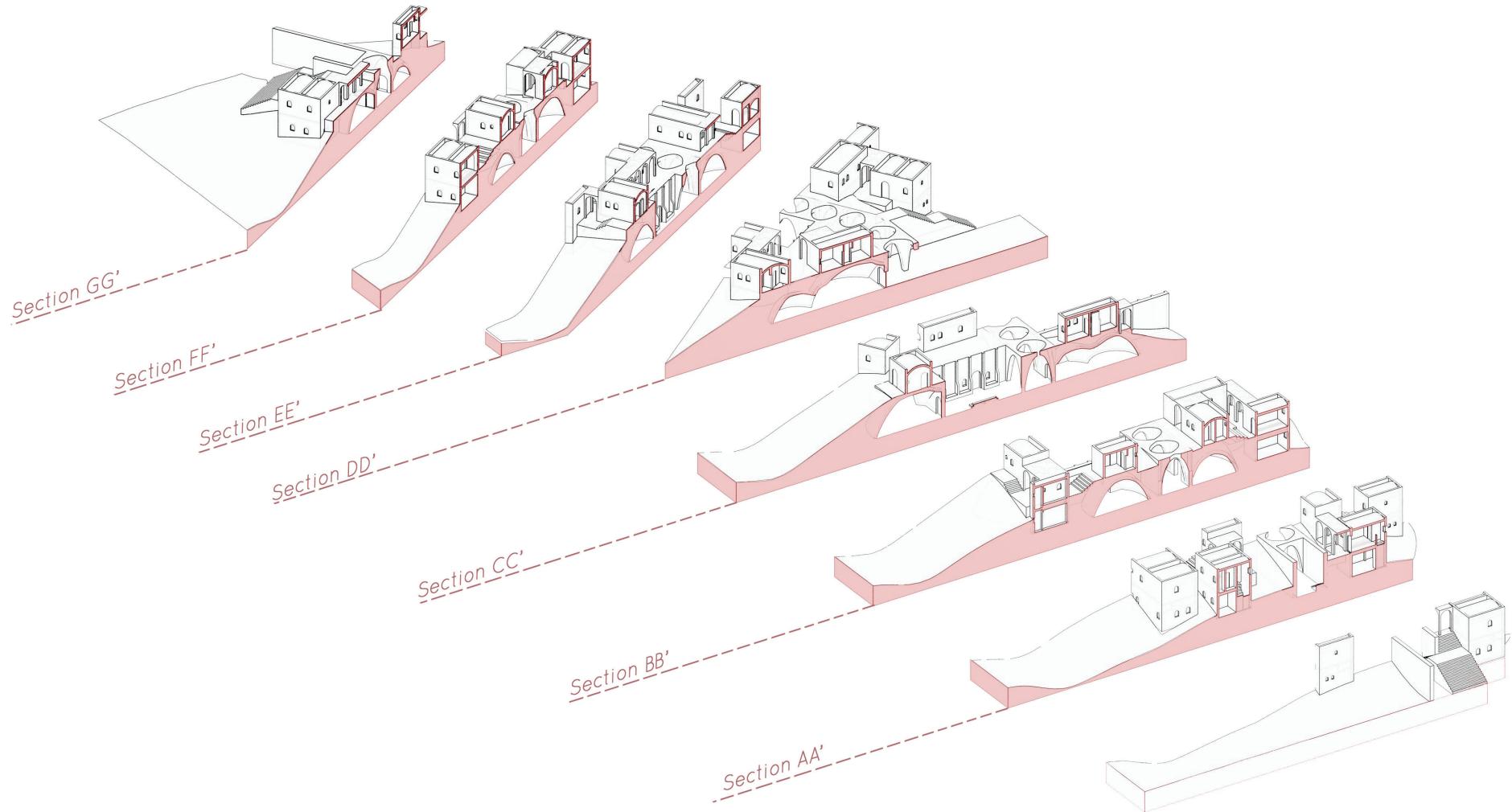












ANALYSIS

*Identifying
the issues*

*Refugee
Solutions*

*Site
Analysis*

CONCEPT

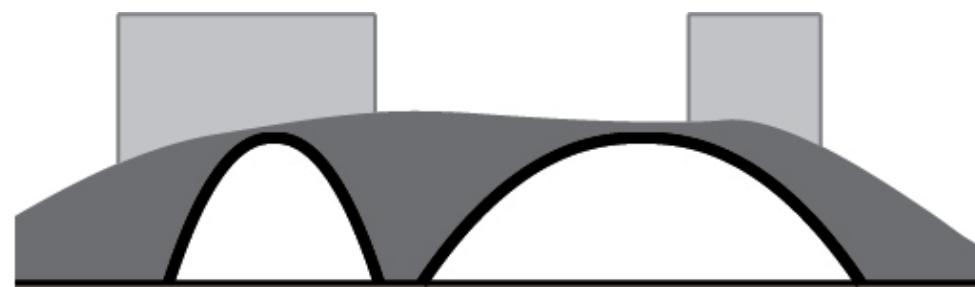
*Communal
Housing
Concept*

EXECUTION

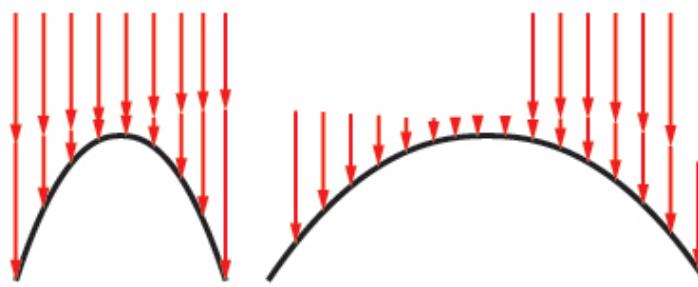
*Structural
Design*

*Construction
Processs*

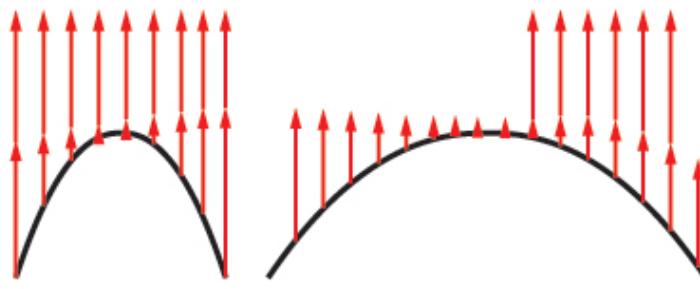
Computation



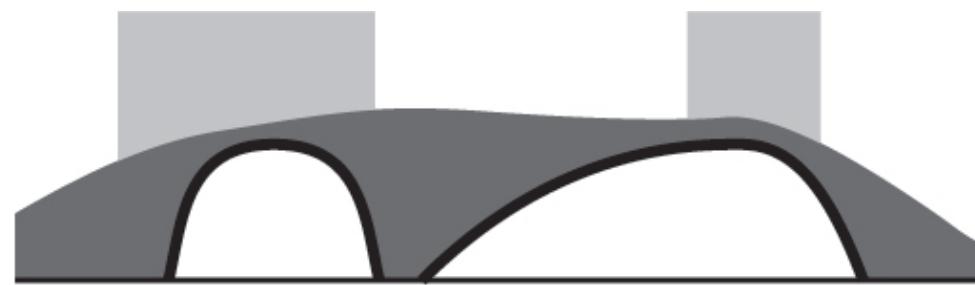
SCHEMATIC SECTION



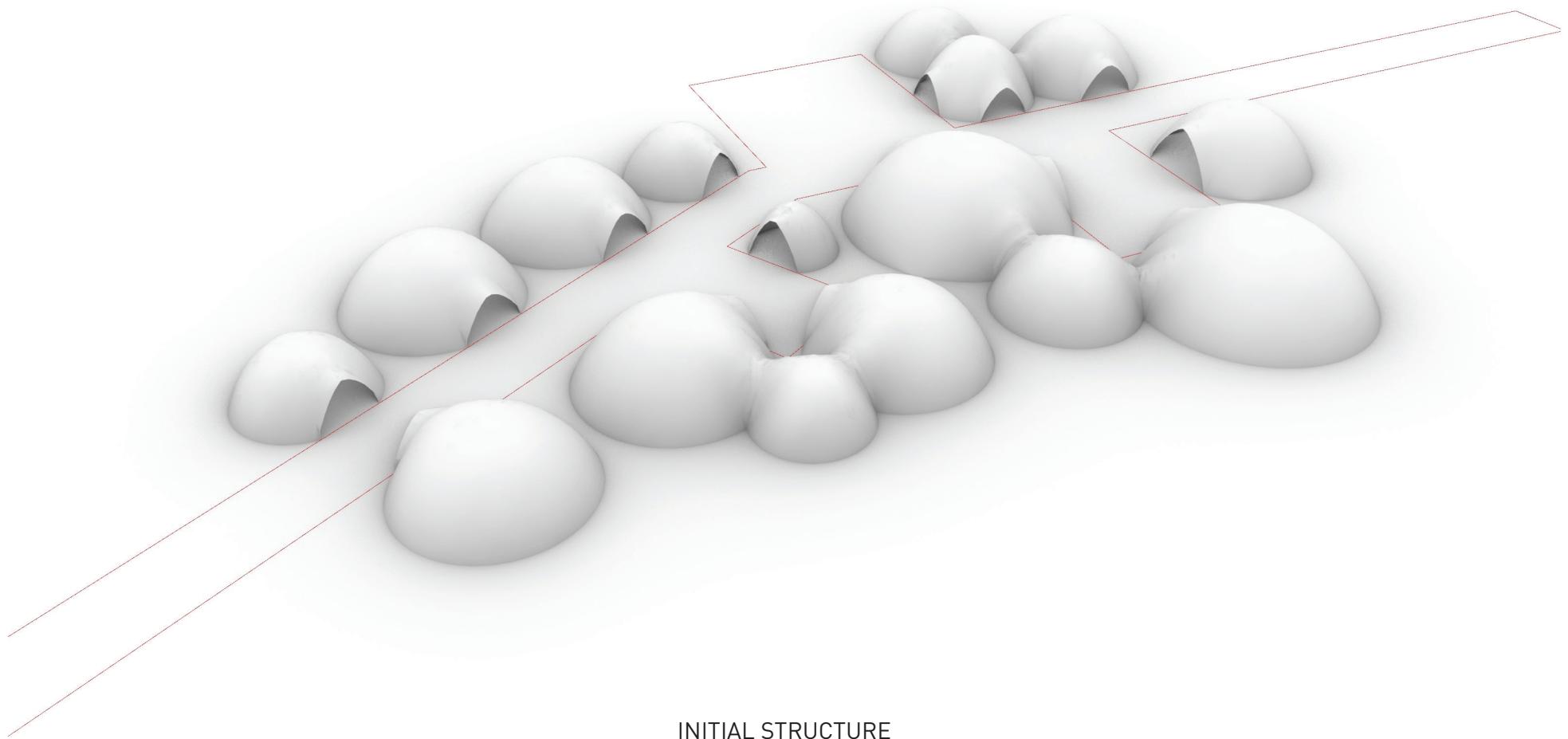
LOADS ACTING ON THE DOMES



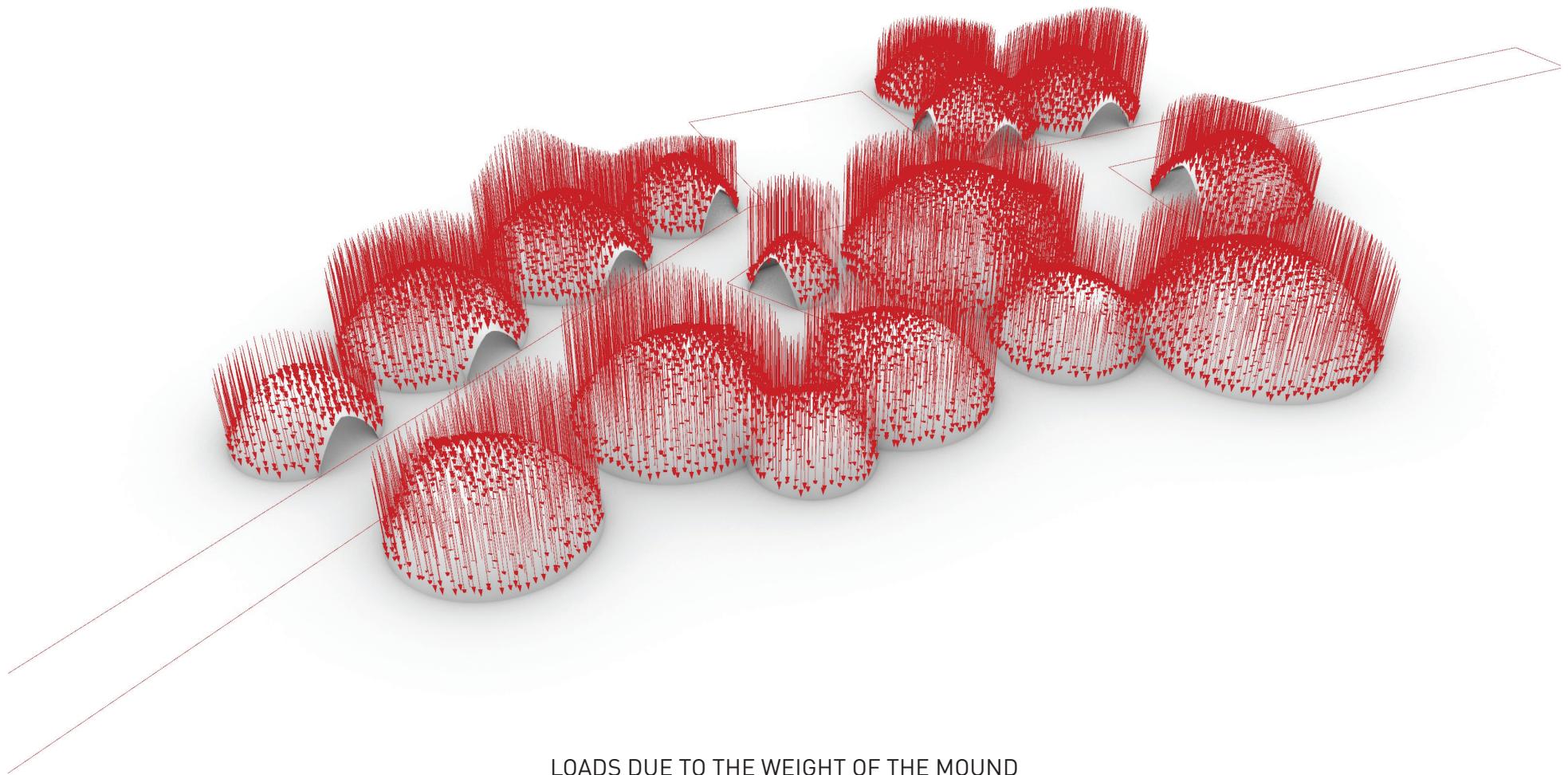
INVERTED LOADS



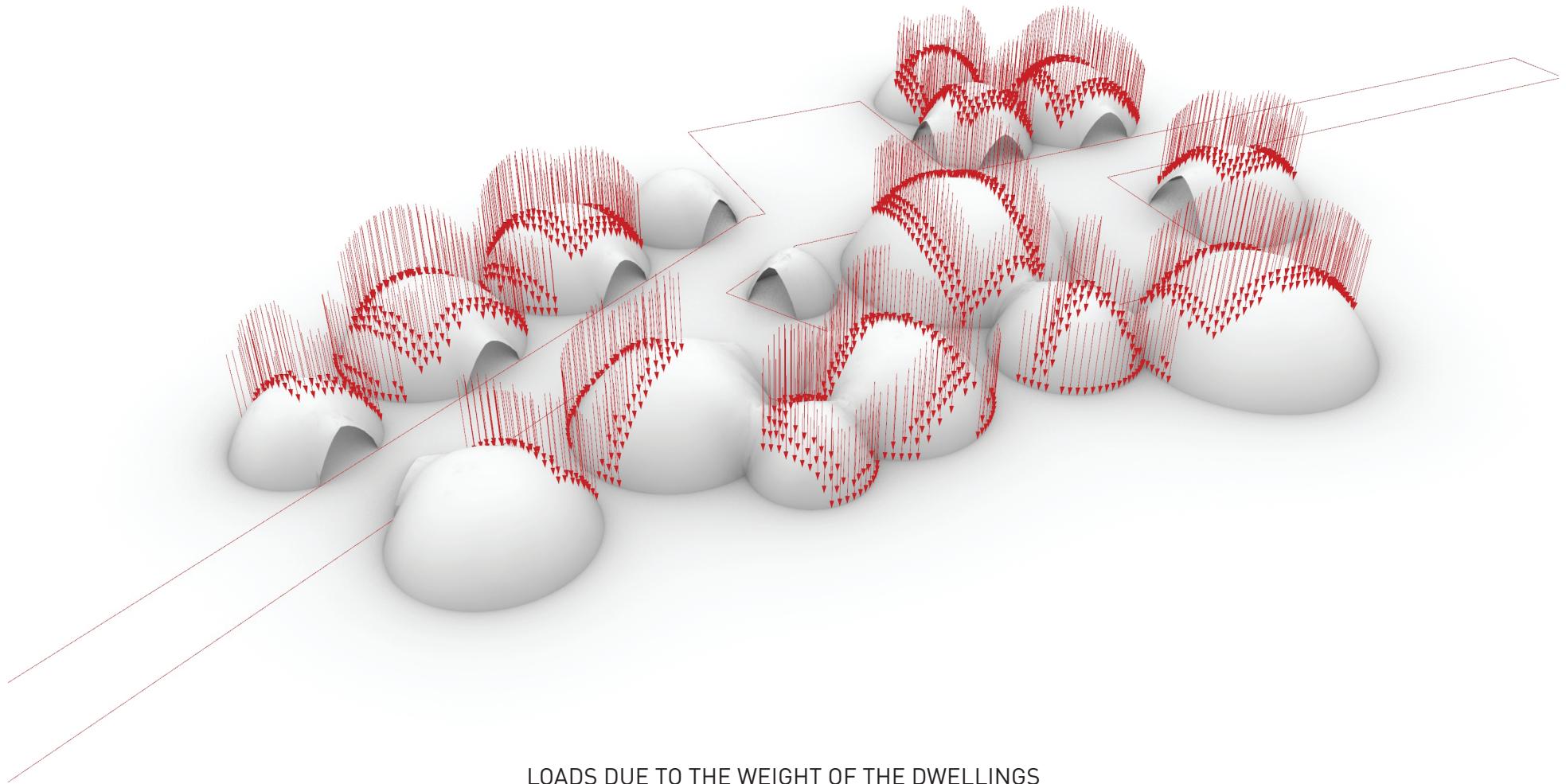
OPTIMISED STRUCTURE



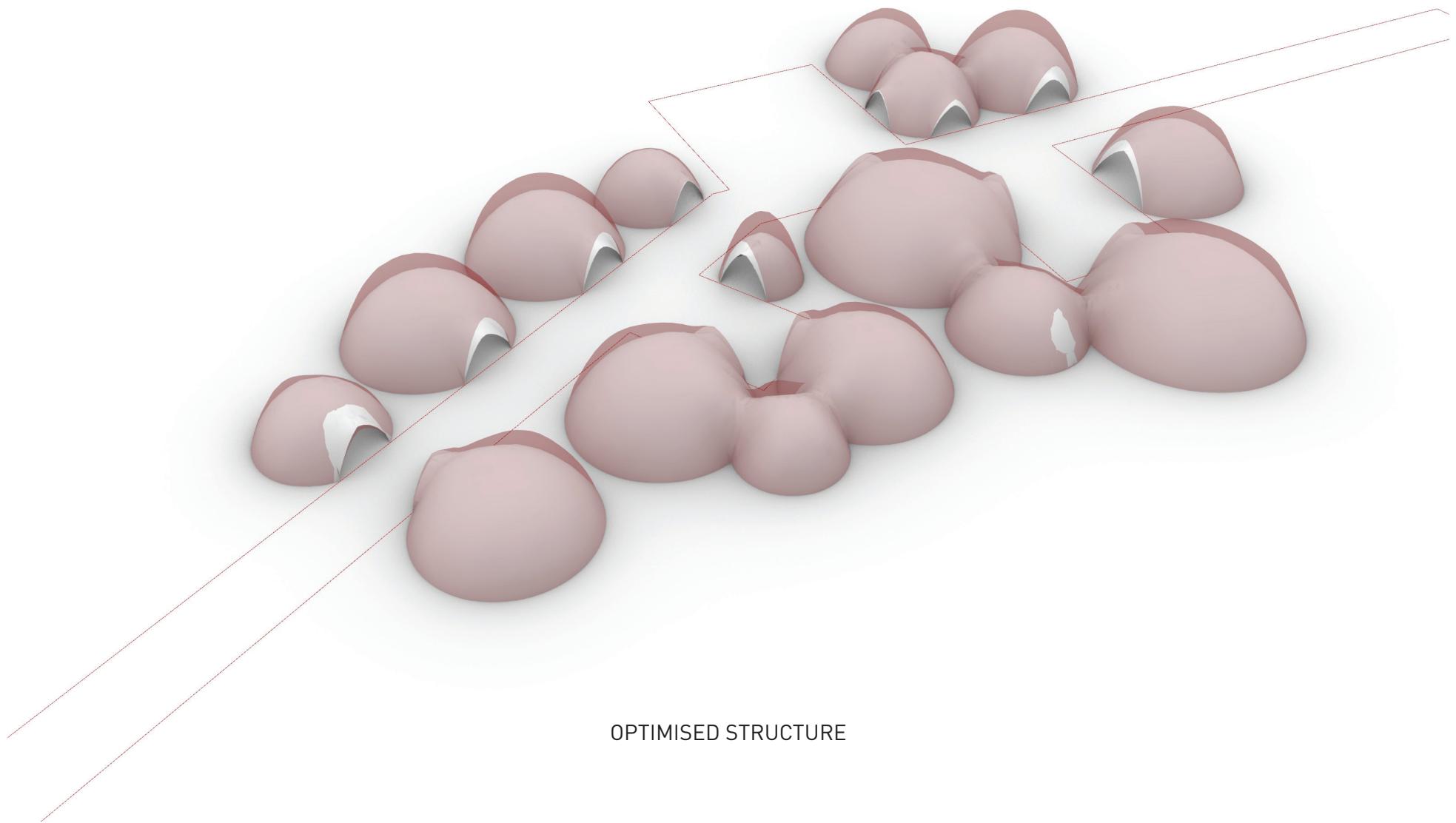
INITIAL STRUCTURE



LOADS DUE TO THE WEIGHT OF THE MOUND



LOADS DUE TO THE WEIGHT OF THE DWELLINGS



OPTIMISED STRUCTURE

FINITE ELEMENT ANALYSIS

Mechanical Properties

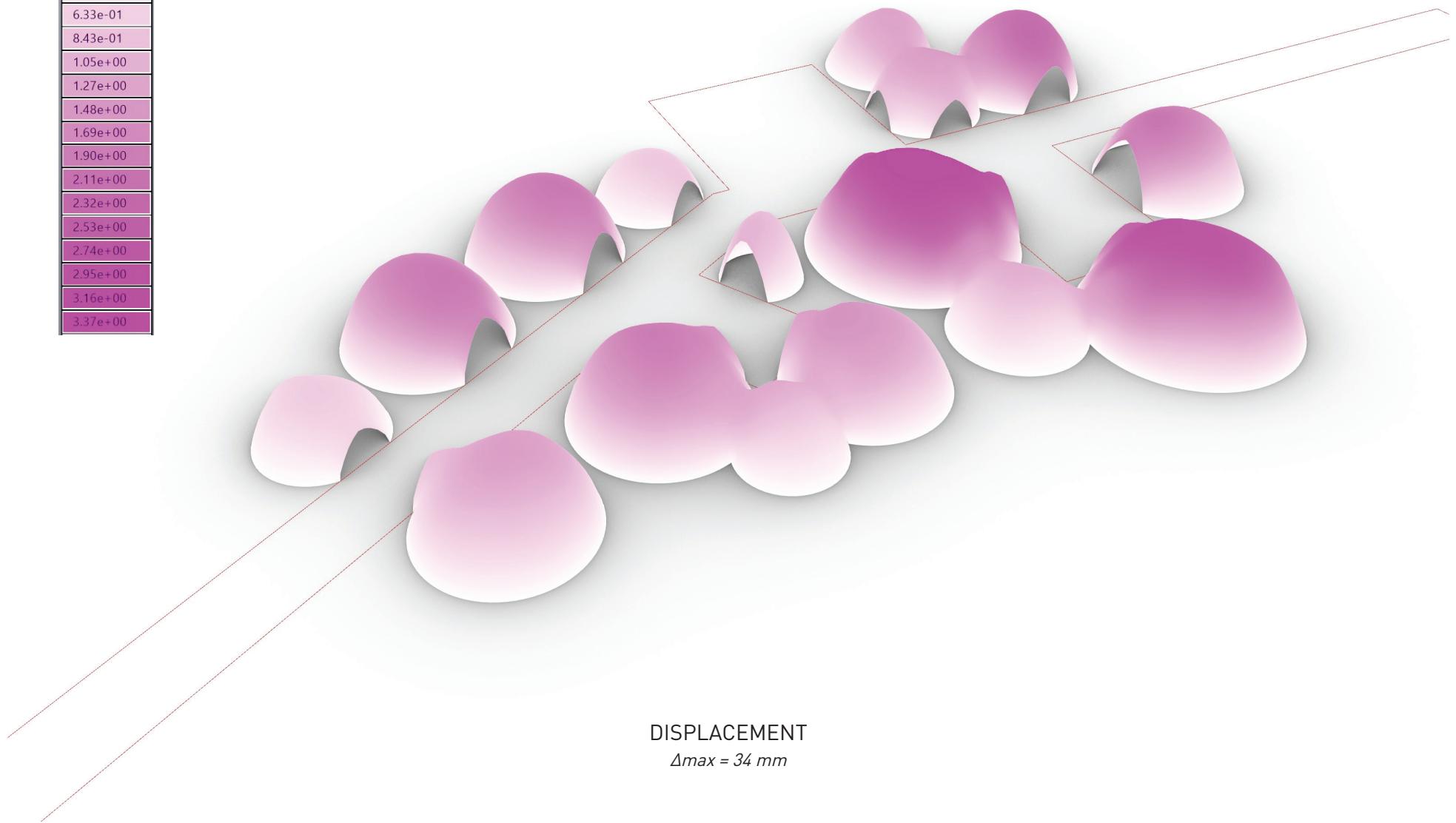
<i>Young's Modulus</i>	100 MPa
<i>Compressive Strength</i>	2.0 MPa
<i>Tensile Strength</i>	0.1 MPa

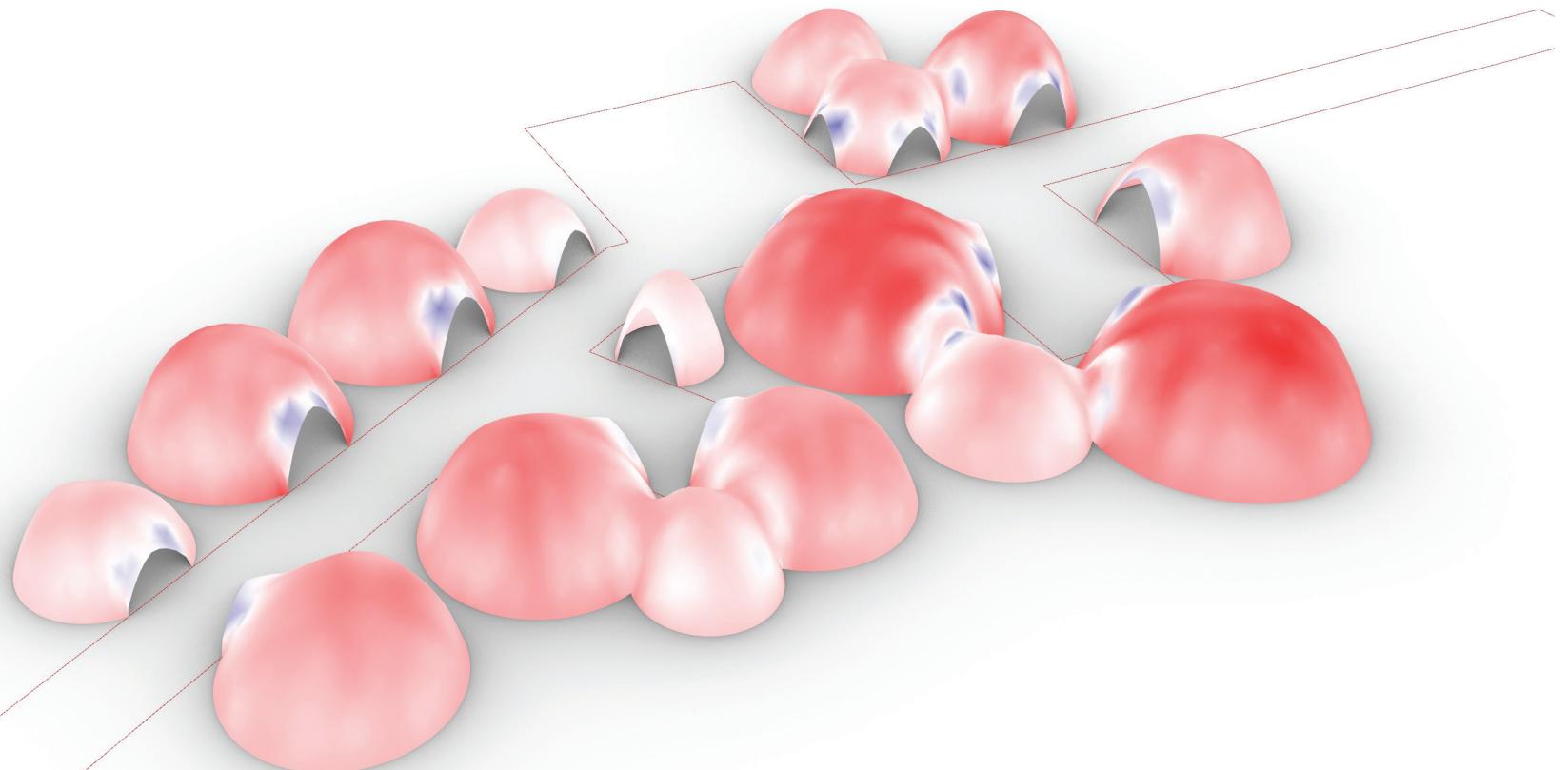
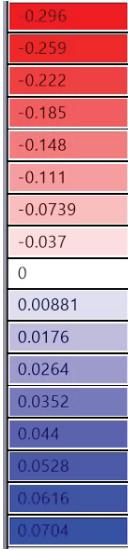
Loads

<i>Dead Load</i>	
<i>Live Load</i>	1 kN/m^2

<i>Thickness</i>	330 mm
------------------	------------------

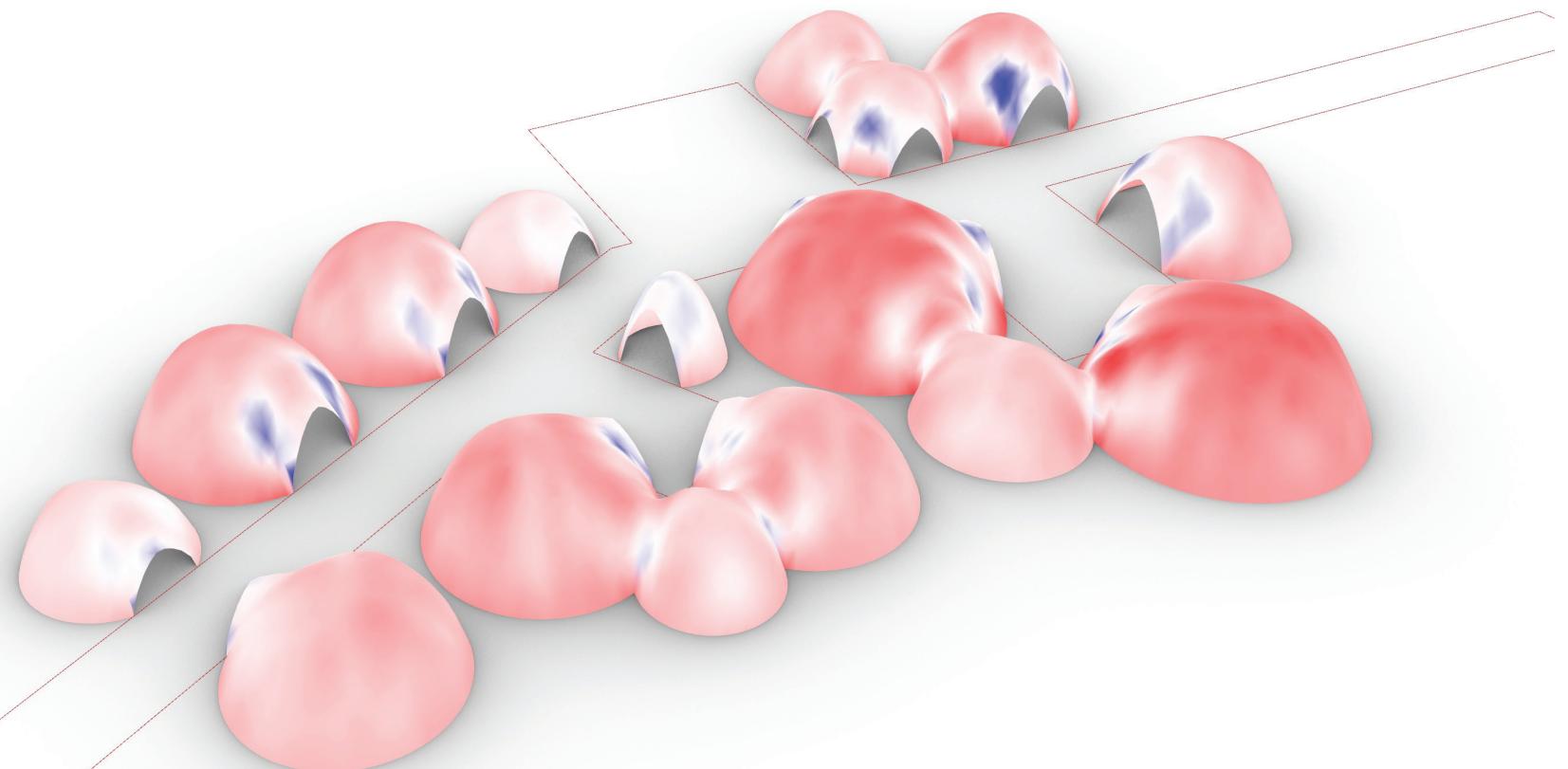
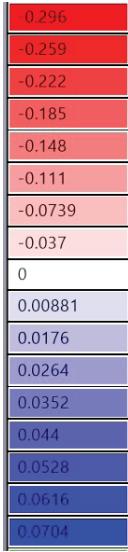
0.00e+00
2.11e-01
4.22e-01
6.33e-01
8.43e-01
1.05e+00
1.27e+00
1.48e+00
1.69e+00
1.90e+00
2.11e+00
2.32e+00
2.53e+00
2.74e+00
2.95e+00
3.16e+00
3.37e+00





PRINCIPAL STRESSES 1, LAYER 1

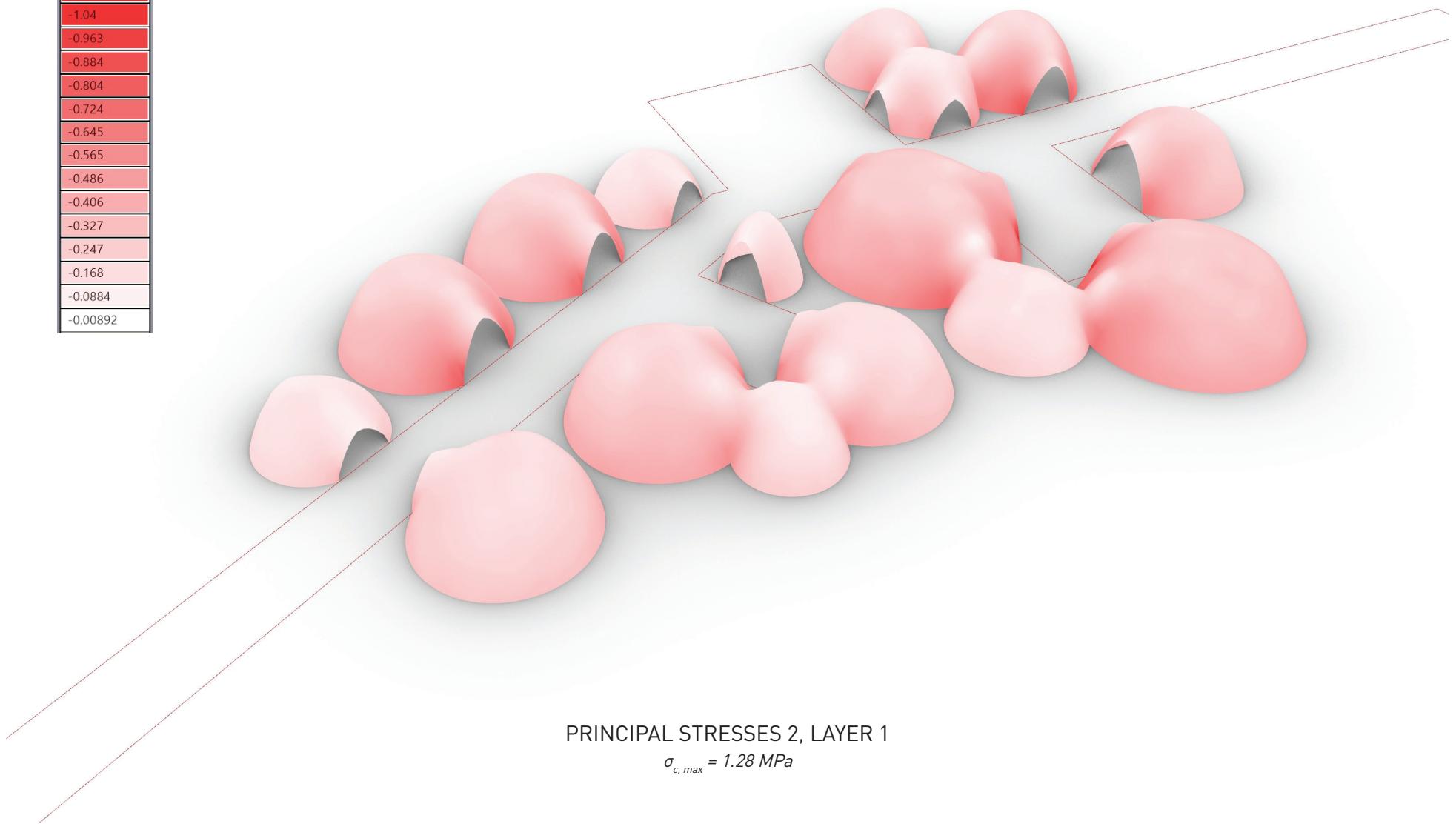
$$\sigma_{t, \max} = 0.07 \text{ MPa}$$



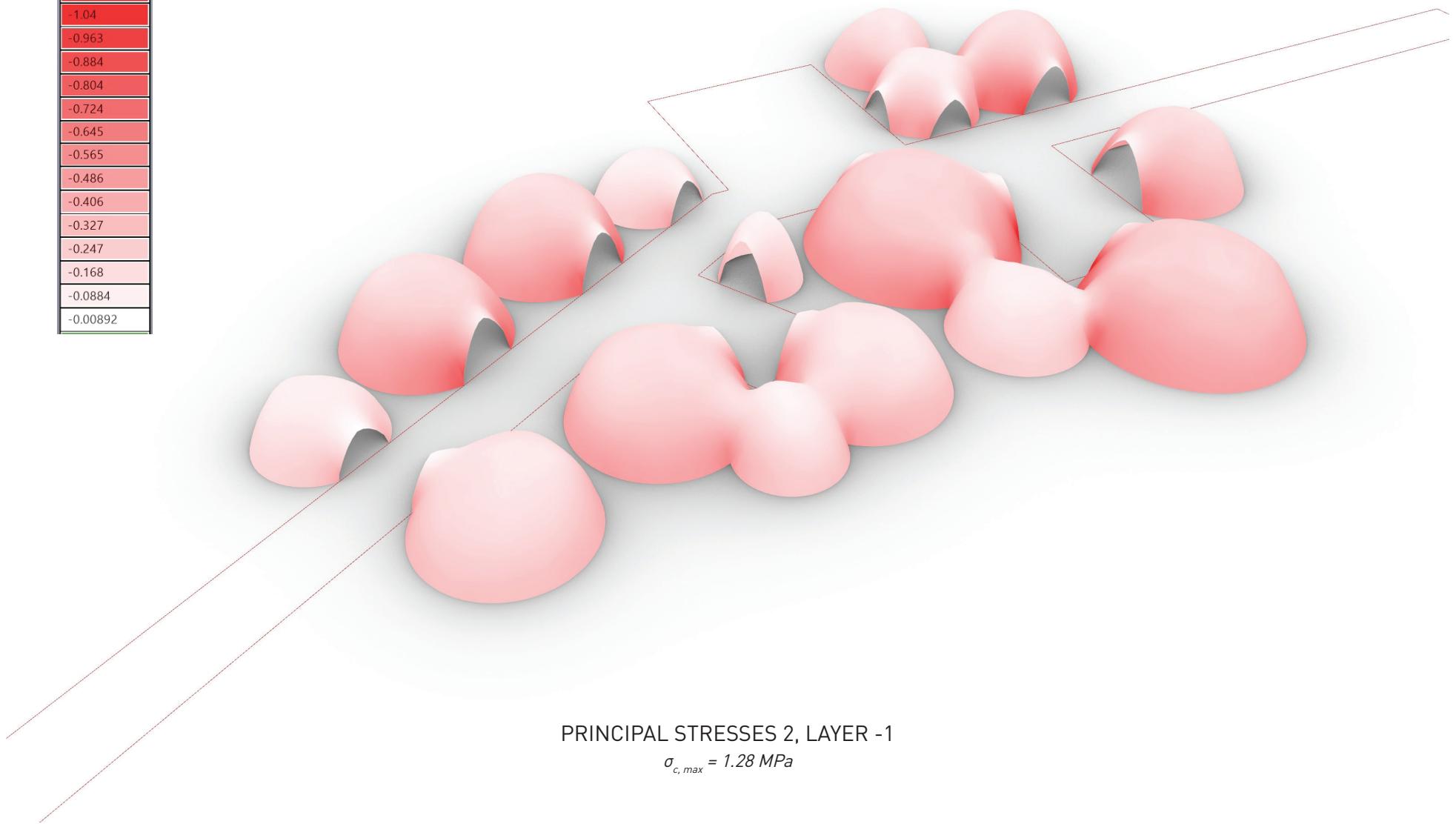
PRINCIPAL STRESSES 1, LAYER -1

$$\sigma_{t, \max} = 0.07 \text{ MPa}$$

1.28
-1.2
-1.12
-1.04
-0.963
-0.884
-0.804
-0.724
-0.645
-0.565
-0.486
-0.406
-0.327
-0.247
-0.168
-0.0884
-0.00892



1.28
-1.2
-1.12
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-0.724
-0.645
-0.565
-0.486
-0.406
-0.327
-0.247
-0.168
-0.0884
-0.00892



FINITE ELEMENT ANALYSIS

	<i>Initial Structure</i>	<i>Optimised Structure</i>	
<i>Maximum Displacement</i>	35 mm	34 mm	97%
<i>Maximum Compressive Stress</i>	1.69 MPa	1.28 MPa	76%
<i>Maximum Tensile Stress</i>	0.23 MPa	0.07 MPa	30%

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CONCEPT

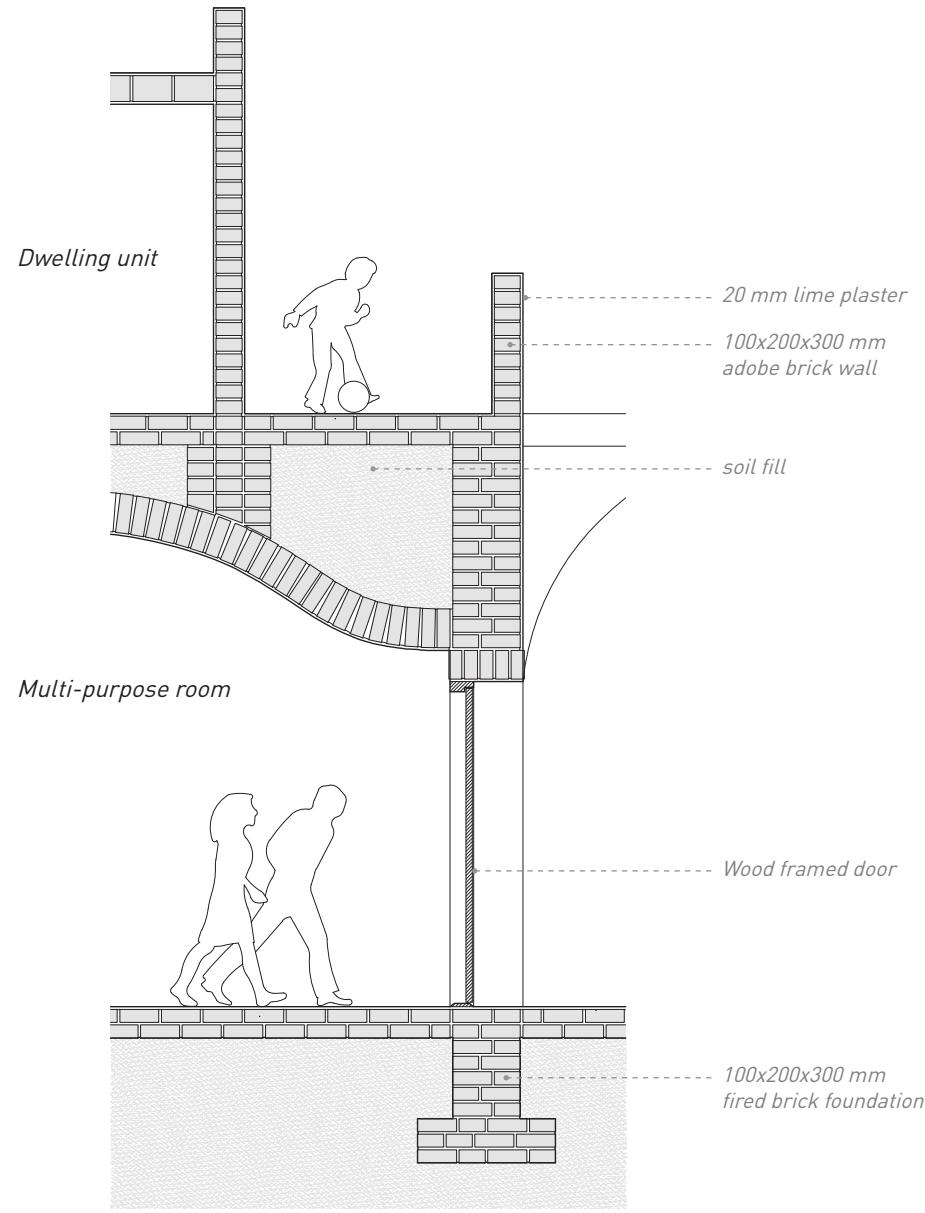
*Communal
Housing
Concept*

EXECUTION

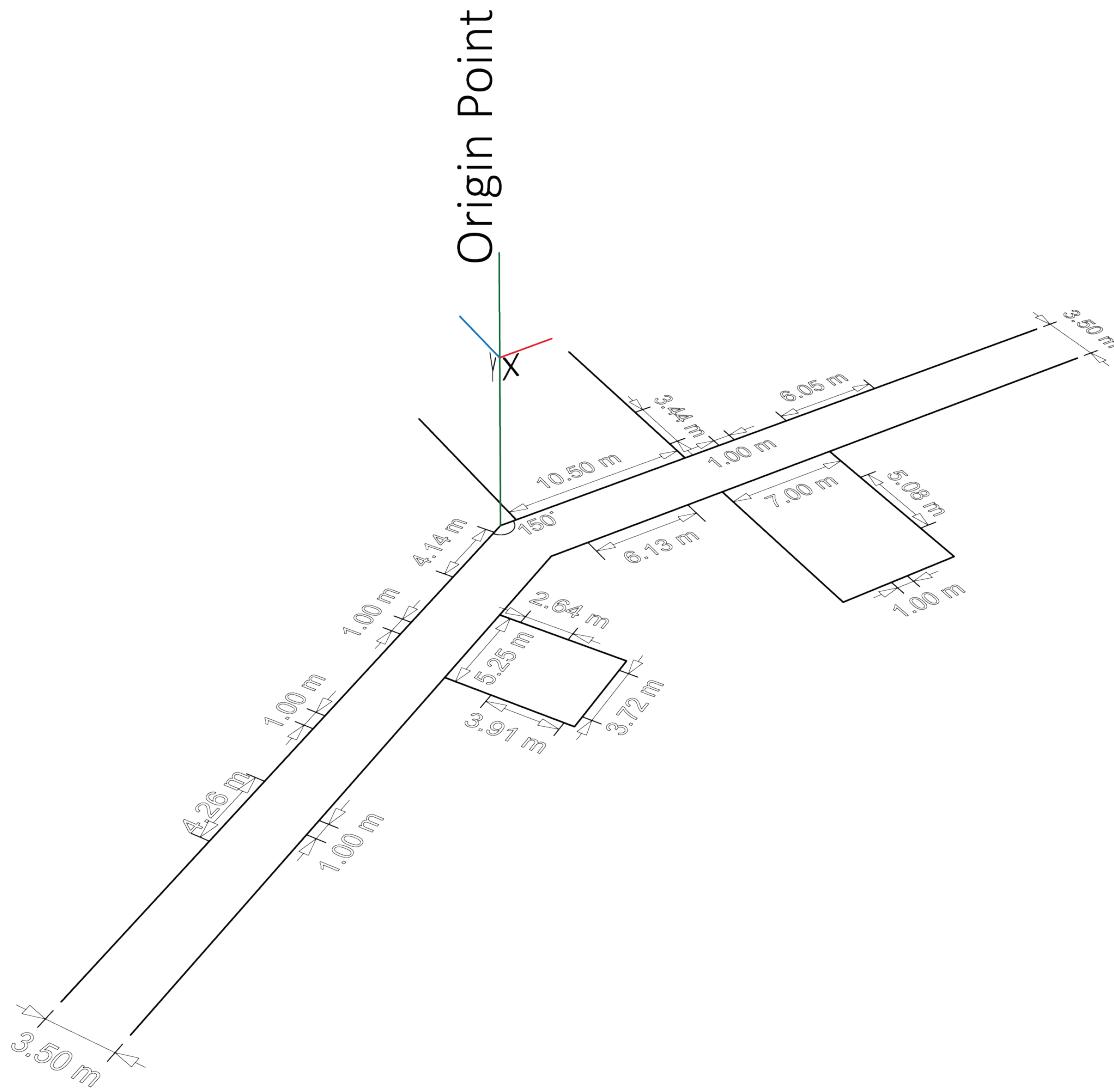
*Structural
Design*

*Construction
Processs*

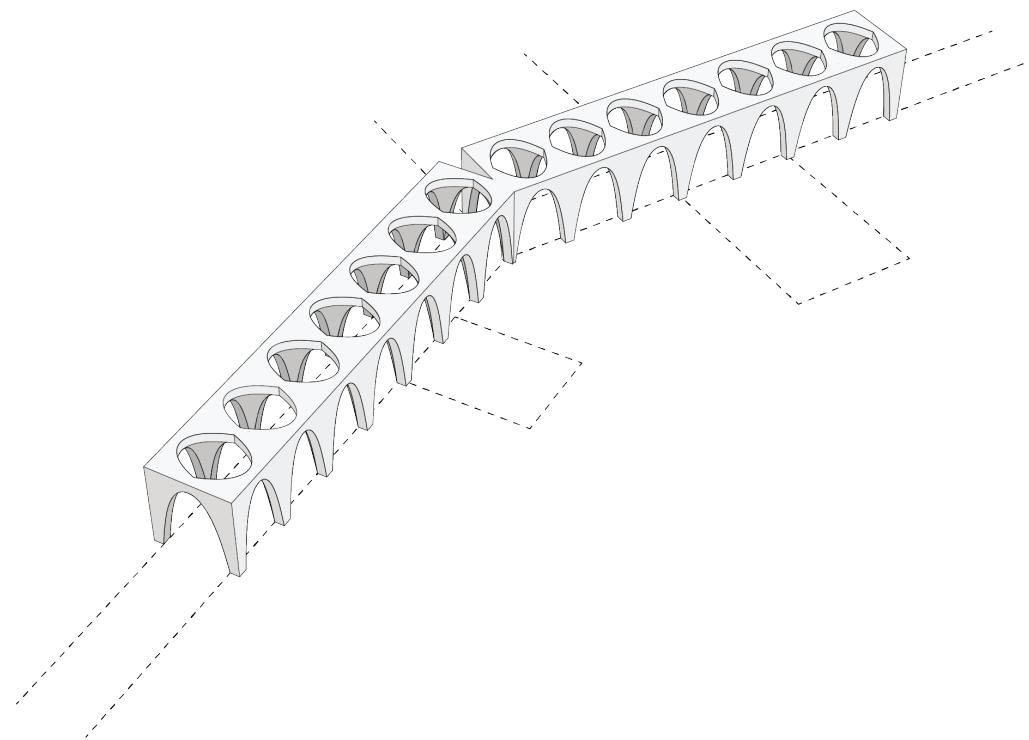
Computation



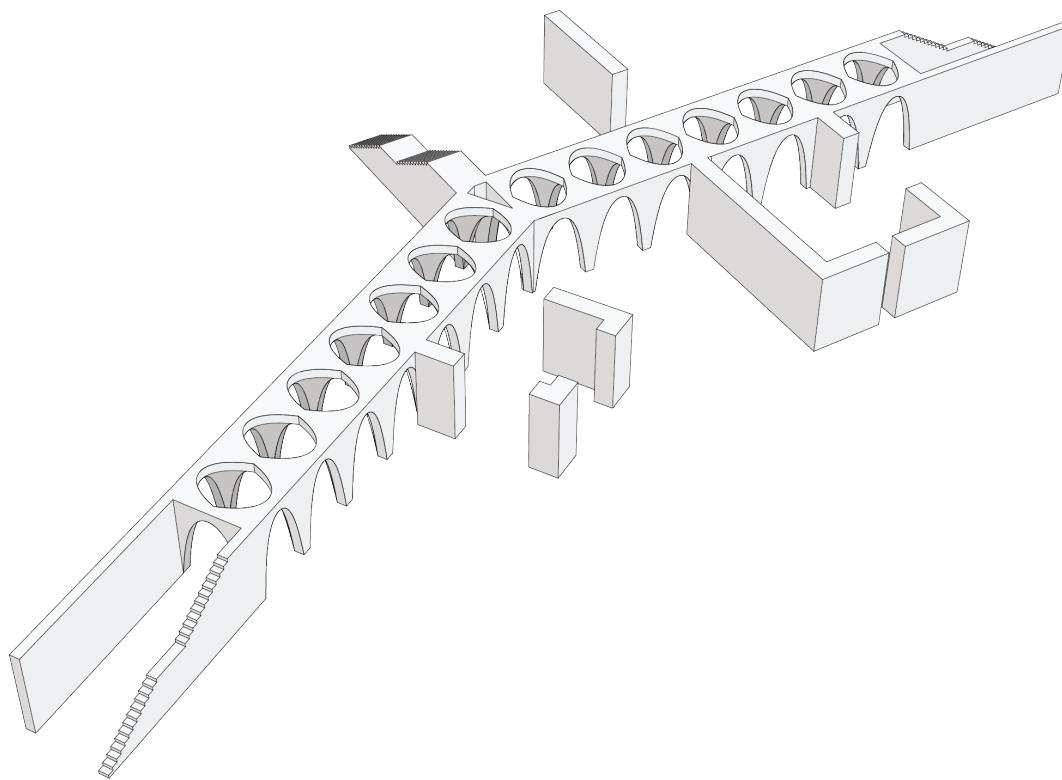
WALL SECTION



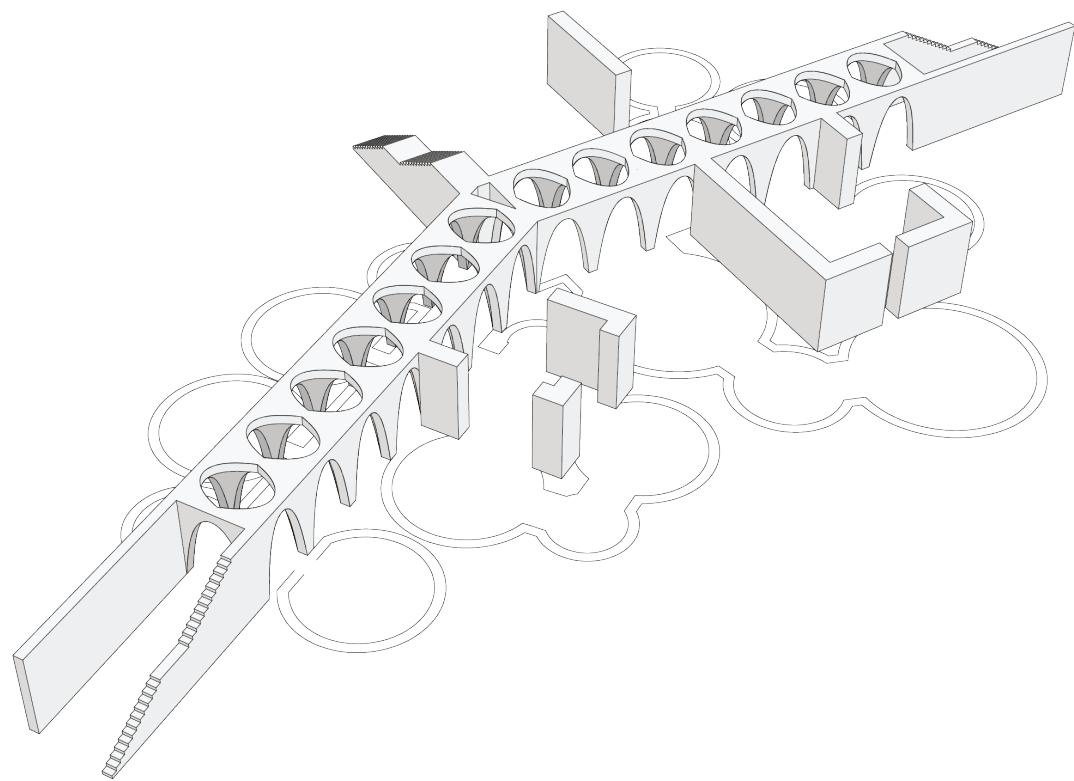
MARK STREET WALLS



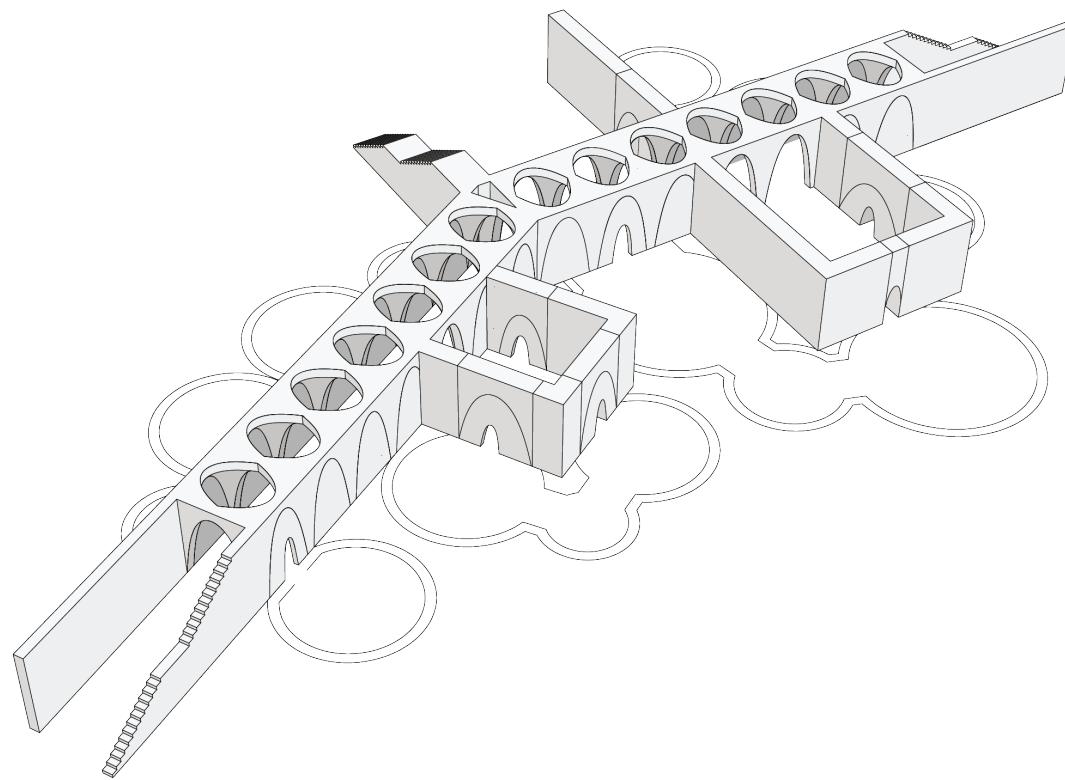
CONSTRUCT ARCHES



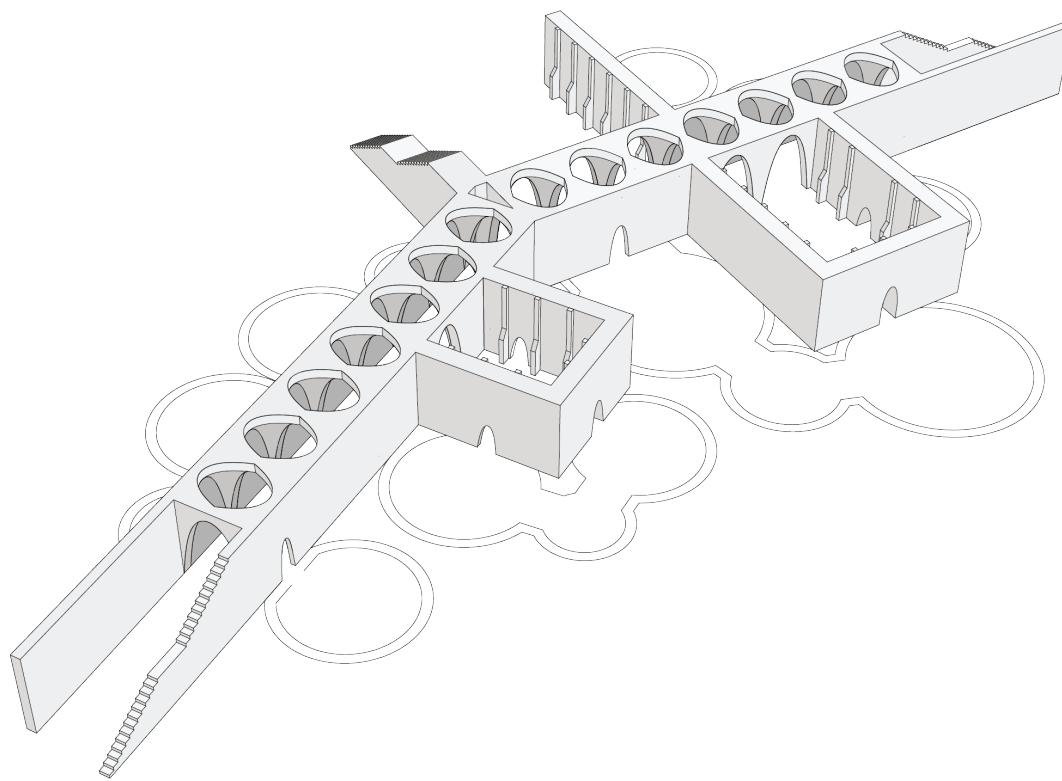
CONSTRUCT STREET WALLS AND STAIRS



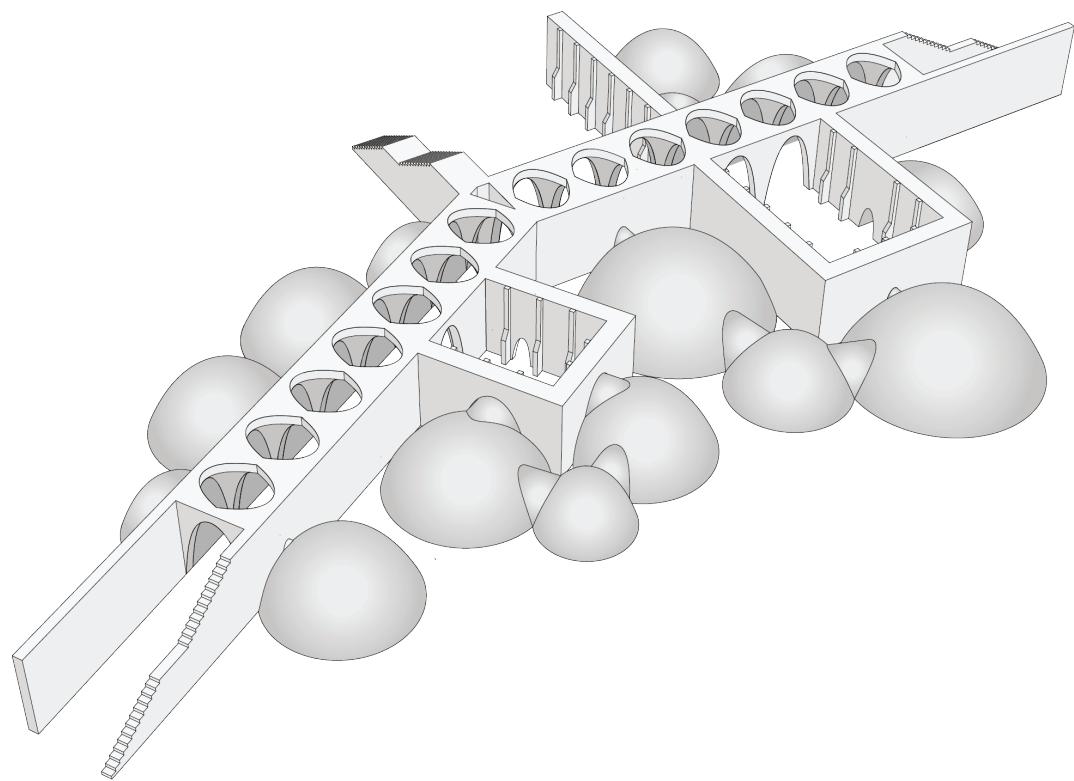
MARK DOME WALLS



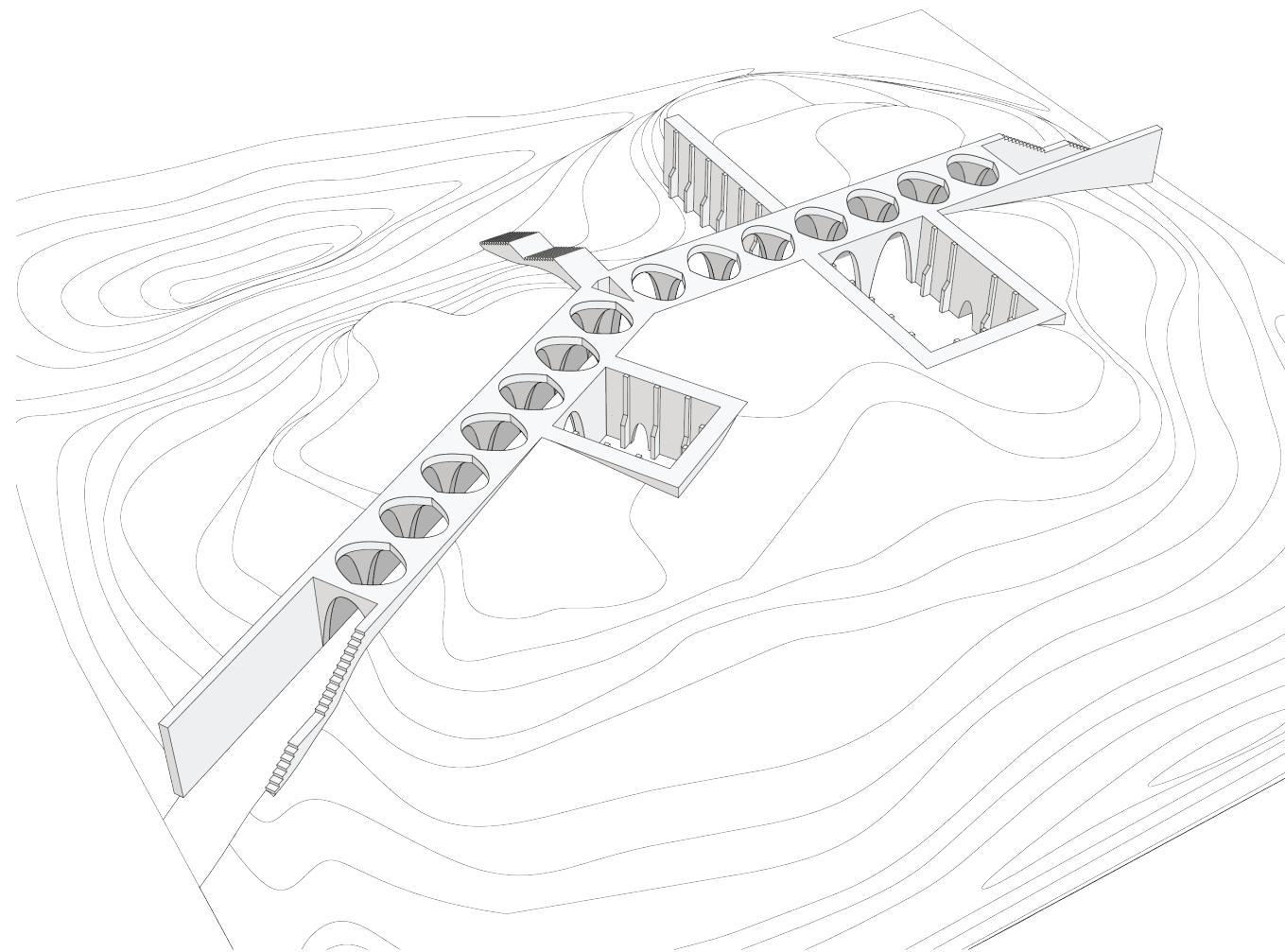
INFILL OPENINGS BETWEEN DOMES AND STREET



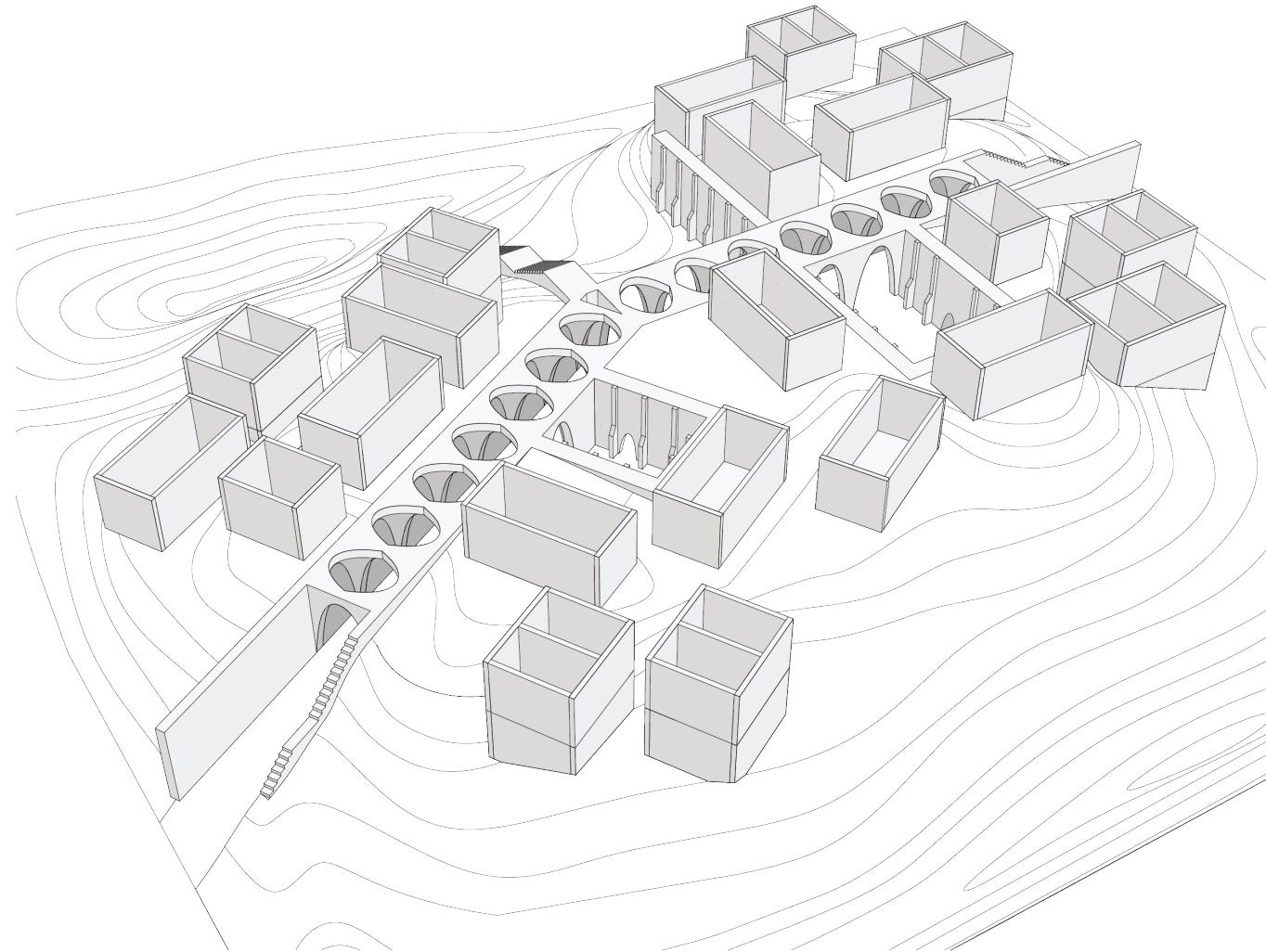
CONSTRUCT BUTTRESSES



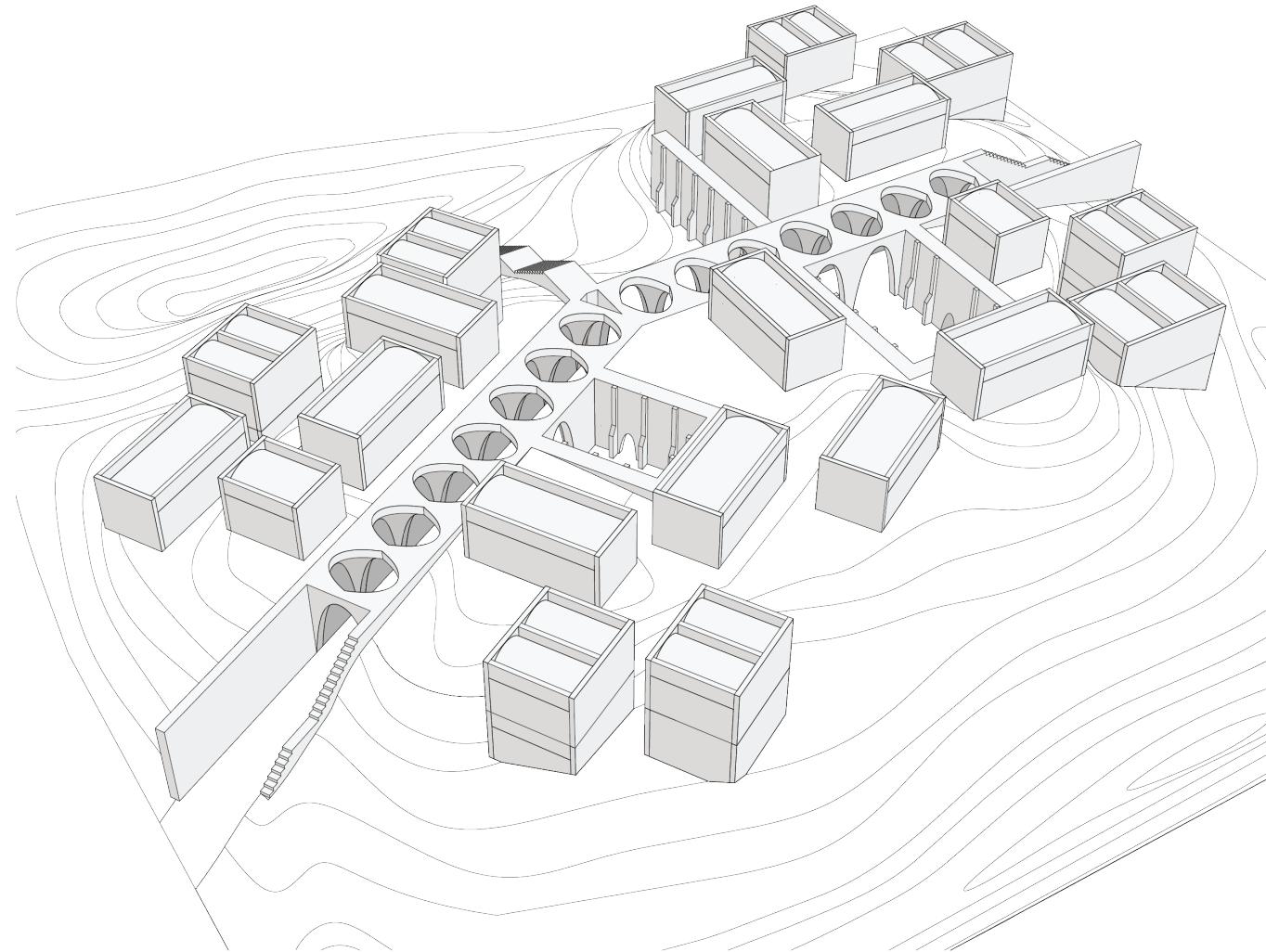
CONSTRUCT DOMES



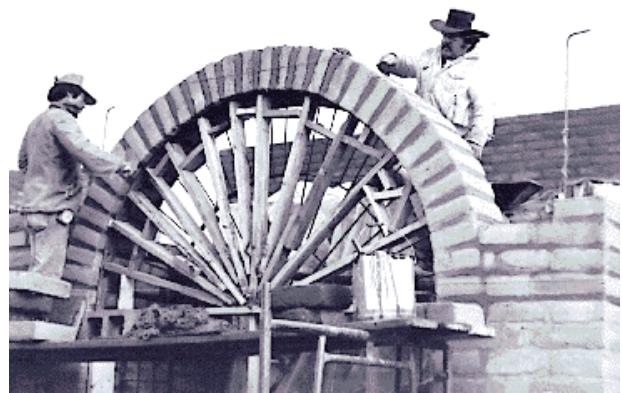
INFILL AND RAISE LANDSCAPE WITH SOIL



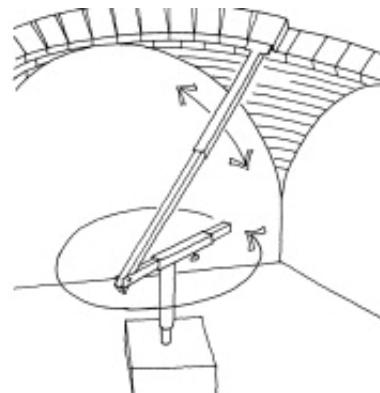
CONSTRUCT DWELLING WALLS



CONSTRUCT DWELLING ROOFS

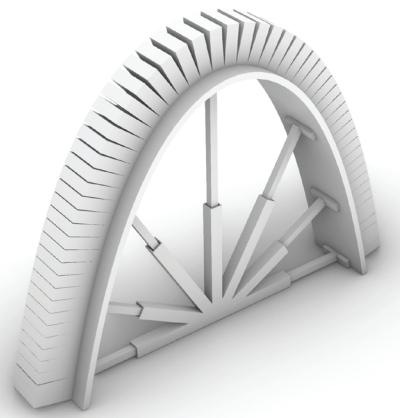


Vault Construction Formwork



Dome Construction Device

CONSTRUCTION PRECEDENTS

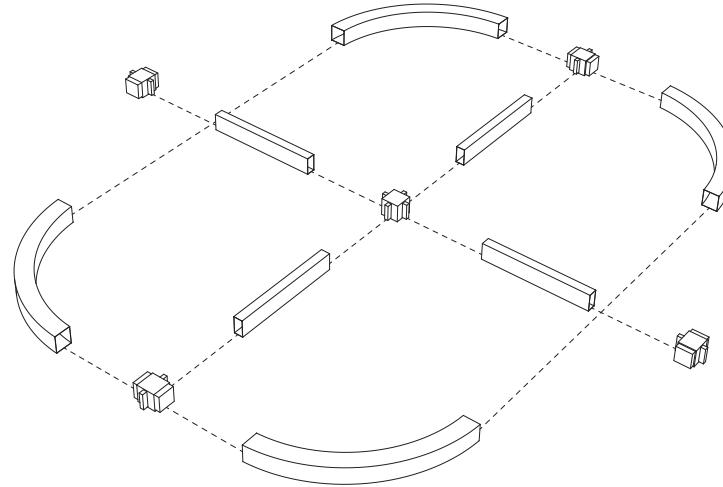


Vault Construction Formwork

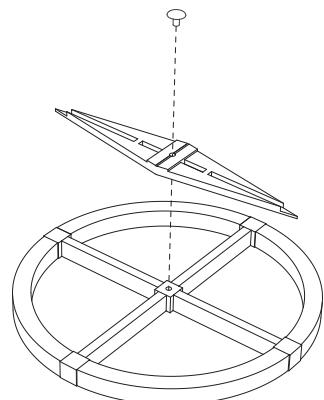


Dome Construction Device

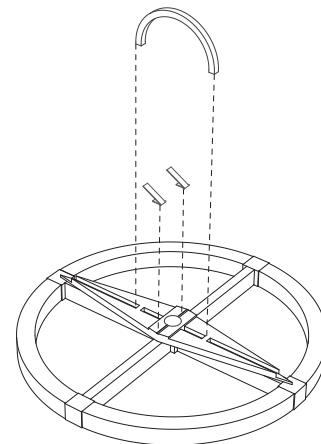
PROPOSED CONSTRUCTION DEVICES



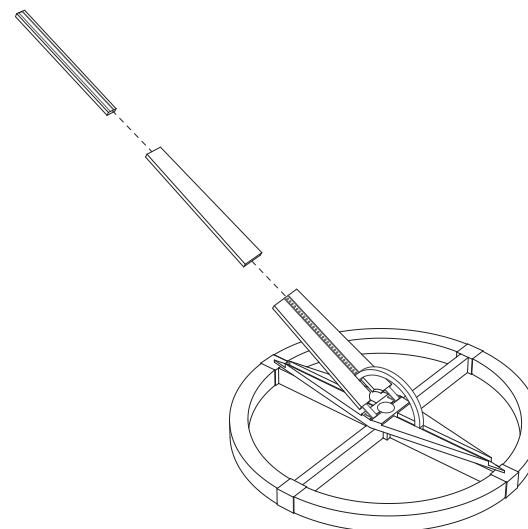
Constructing the Base



Placing Horizontal Compass

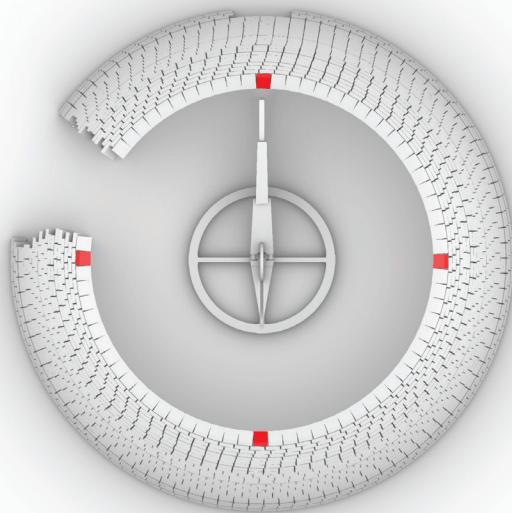


Placing Vertical Compass

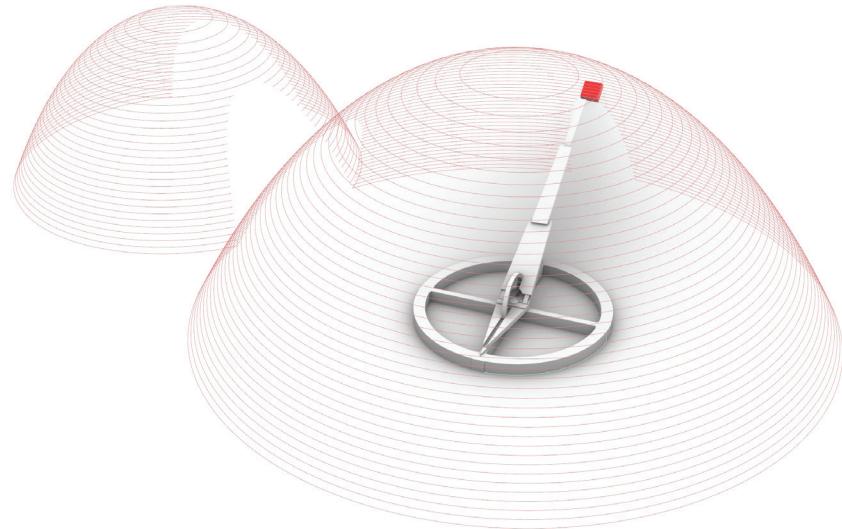


Placing Adjustable Arm

DOME CONSTRUCTION DEVICE



Starting Placement Bricks



Computationally Generated Brick Info: *Horizontal Angle*
Vertical Angle
Distance from the Center

DOME CONSTRUCTION

ANALYSIS

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*Site
Analysis*

CONCEPT

*Communal
Housing
Concept*

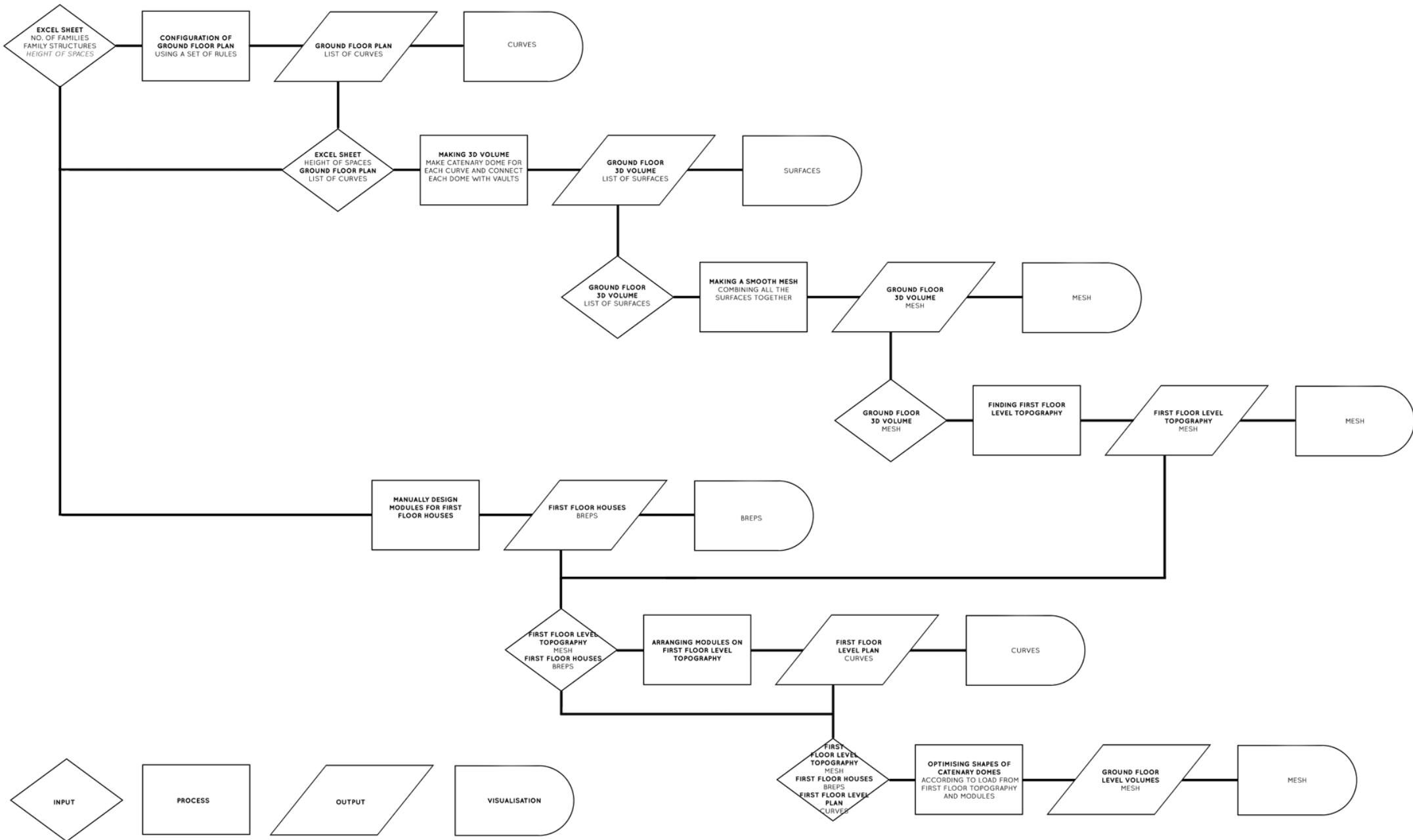
EXECUTION

*Structural
Design*

*Construction
Processss*

Computation

COMPUTATION FLOWCHART



COMMUNAL HOUSING PLAN GENERATOR

MODIFY THE NUMBERS IN BLUE CELLS BELOW

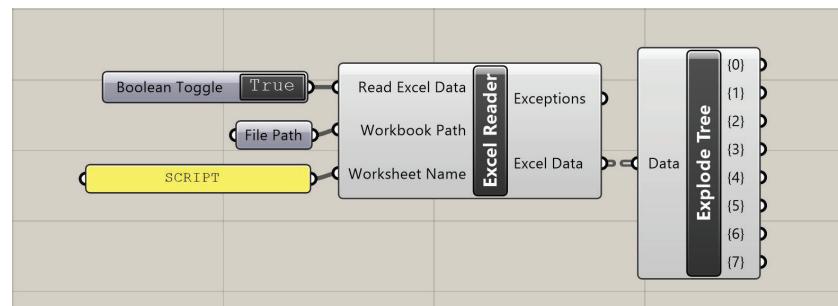
FAMILY	ADULTS	CHILDREN	
1	2	2	
2	1	2	
3	2	3	
4	1	4	
5	2	4	
6	1	3	
7	1	5	
8	2	1	
9	1	2	
10	2	1	
11	1	0	
12	2	3	
13	2	0	
14	1	1	
15	1	1	
16	2	0	
17	2	3	
18	0	0	
19	0	0	
20	0	0	
TOTAL	26	35	61

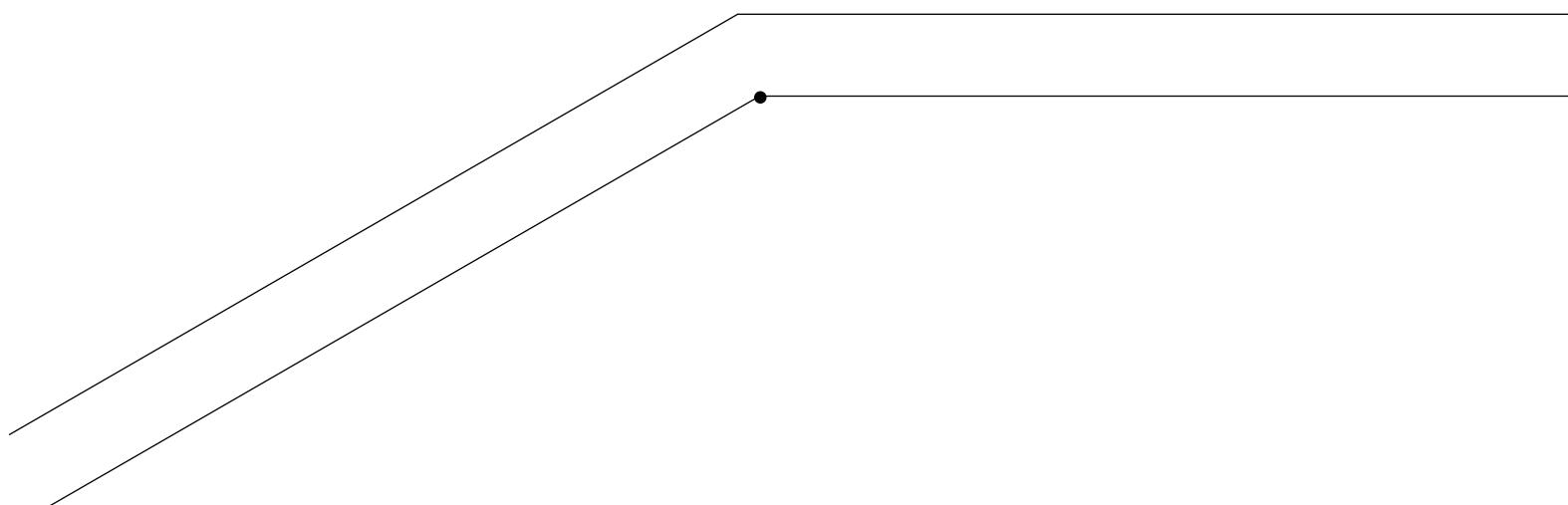


M1	M2	M3	M4
<i>Family 11</i> 	<i>Family 8</i> 	<i>Family 1</i> 	<i>Family 3</i>
<i>Family 13</i> 	<i>Family 10</i> 	<i>Family 2</i> 	<i>Family 4</i>
<i>Family 16</i> 	<i>Family 14</i> 	<i>Family 6</i> 	<i>Family 5</i>
<i>Family 15</i> 	<i>Family 9</i> 	<i>Family 7</i> 	<i>Family 12</i>
			<i>Family 17</i>

COMMUNAL HOUSING PLAN GENERATOR

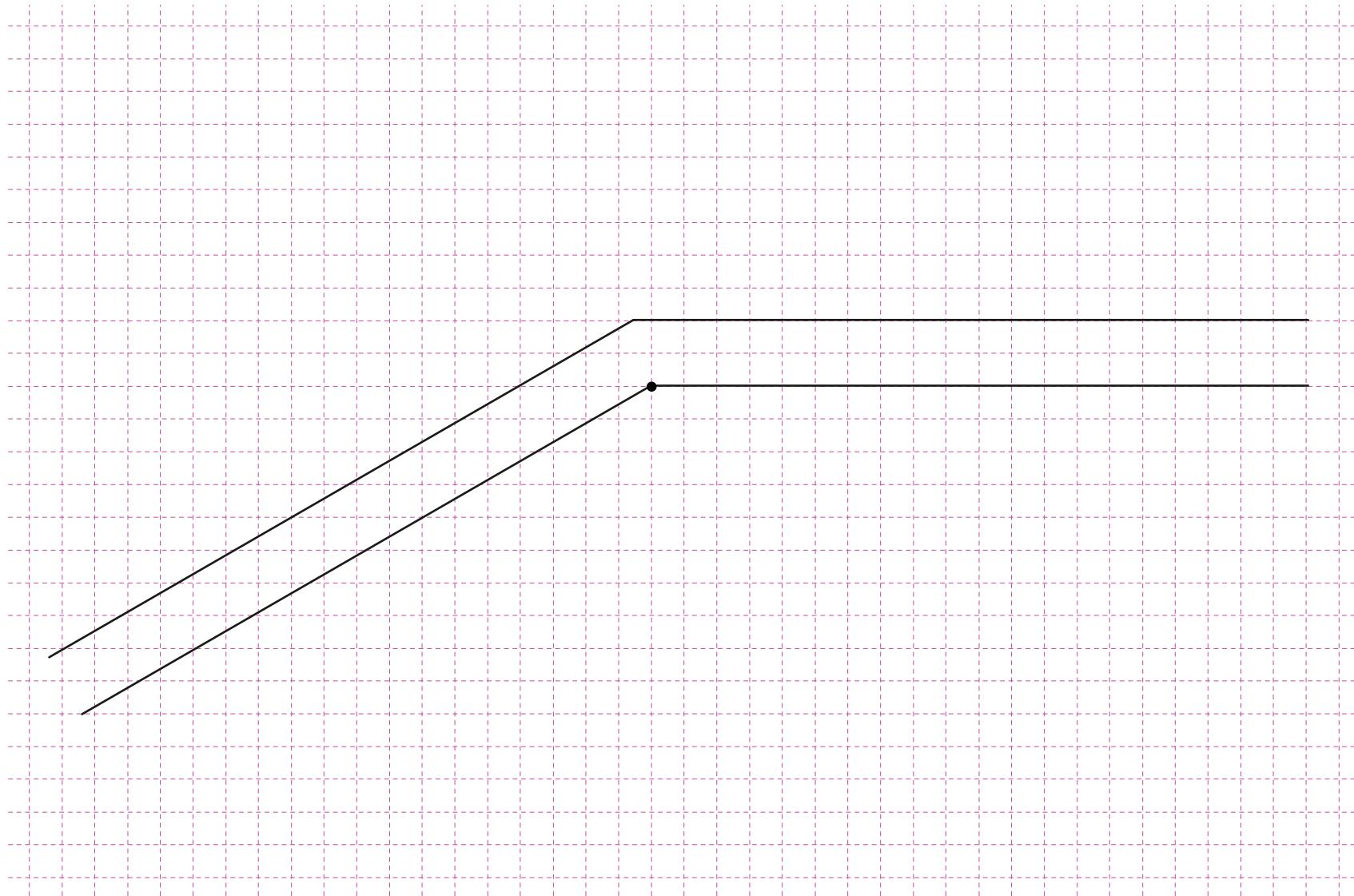
FAMILY	ADULTS	CHILDREN	HOUSING MODULE REQUIRED	COMMUNAL PROGRAM	m ² PER PERSON	m ² REQUIRED	HEIGHT (m)
1	2	2	3	Courtyard (large)	1.75	106.75	
2	1	2	3	Iwan (large)	0.49	29.89	3.6
3	2	3	4	Work Room	0.33	20.13	3
4	1	4	4	Building Storage	0.35	21.35	3
5	2	4	4	Iwan (small)	0.23	14.03	3
6	1	3	3	Courtyard (medium)	0.9	54.9	
7	1	5	4	Dining (large)	0.99	60.39	4.2
8	2	1	3	Kitchen (large)	0.92	56.12	4.2
9	1	2	3	Kitchen (large) Storage	0.32	19.52	3
10	2	1	3	Iwan (medium)	0.49	29.89	3
11	1	0	1	Courtyard (small)	0.5	30.5	
12	2	3	4	Dining (small)	0.54	32.94	3.6
13	2	0	2	Kitchen (small)	0.46	28.06	3.6
14	1	1	2	Kitchen (small) Storage	0.16	9.76	3
15	1	1	2	Iwan (small)	0.23	14.03	3
16	2	0	2	Male Showers	0.49	29.89	3.6
17	2	3	4	Female Showers	0.49	29.89	3.6
18	0	0	0	Building Utility Room	0.45	27.45	3.6
19	0	0	0	Clothes Washing Area	0.1	6.1	3
20	0	0	0				
TOTAL	26	35					
		61					





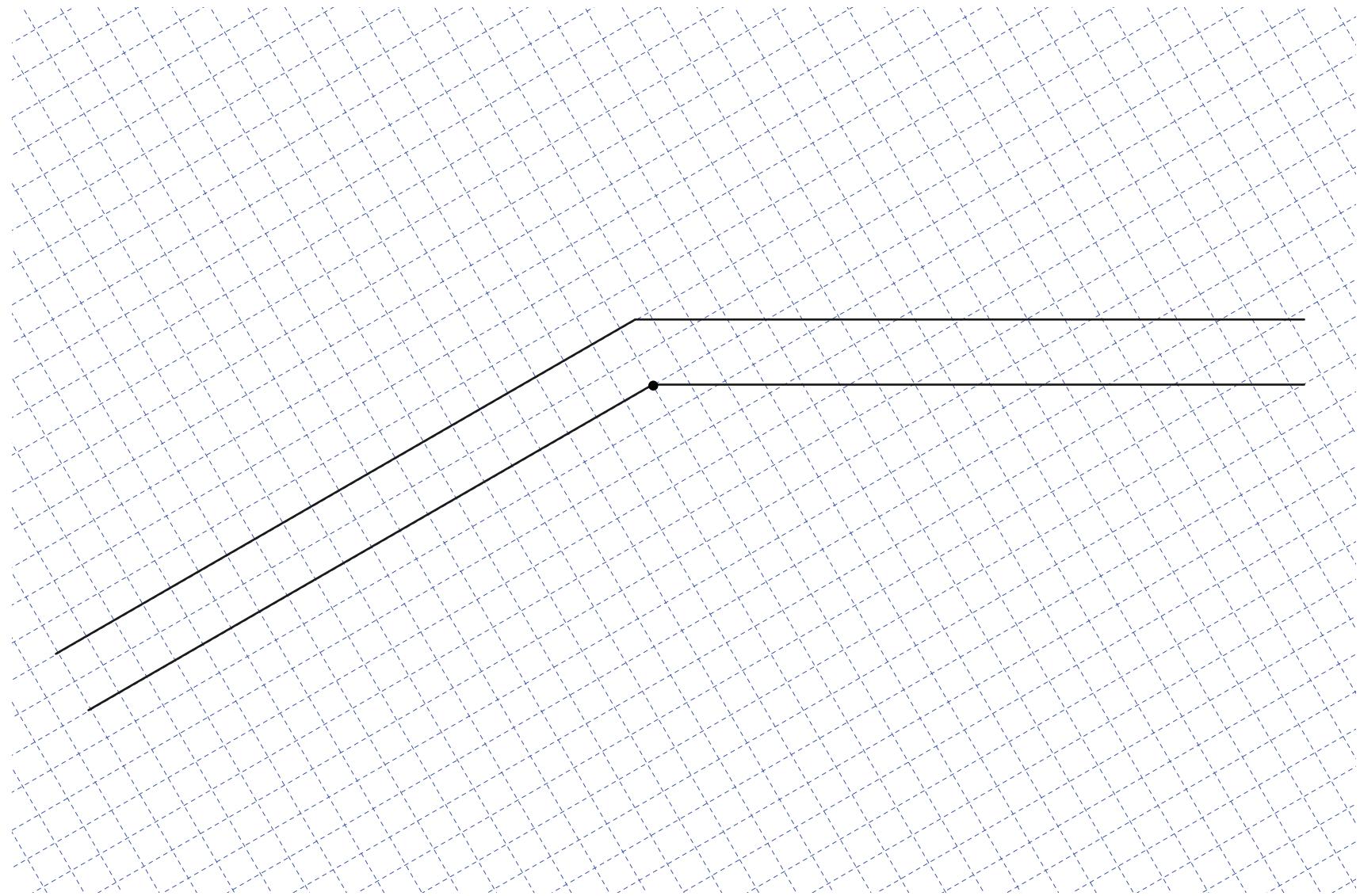
ORIGIN POINT & STREET

*The origin point is defined and the street is outlined with
one axis at 0 degrees and another at 30 degrees*



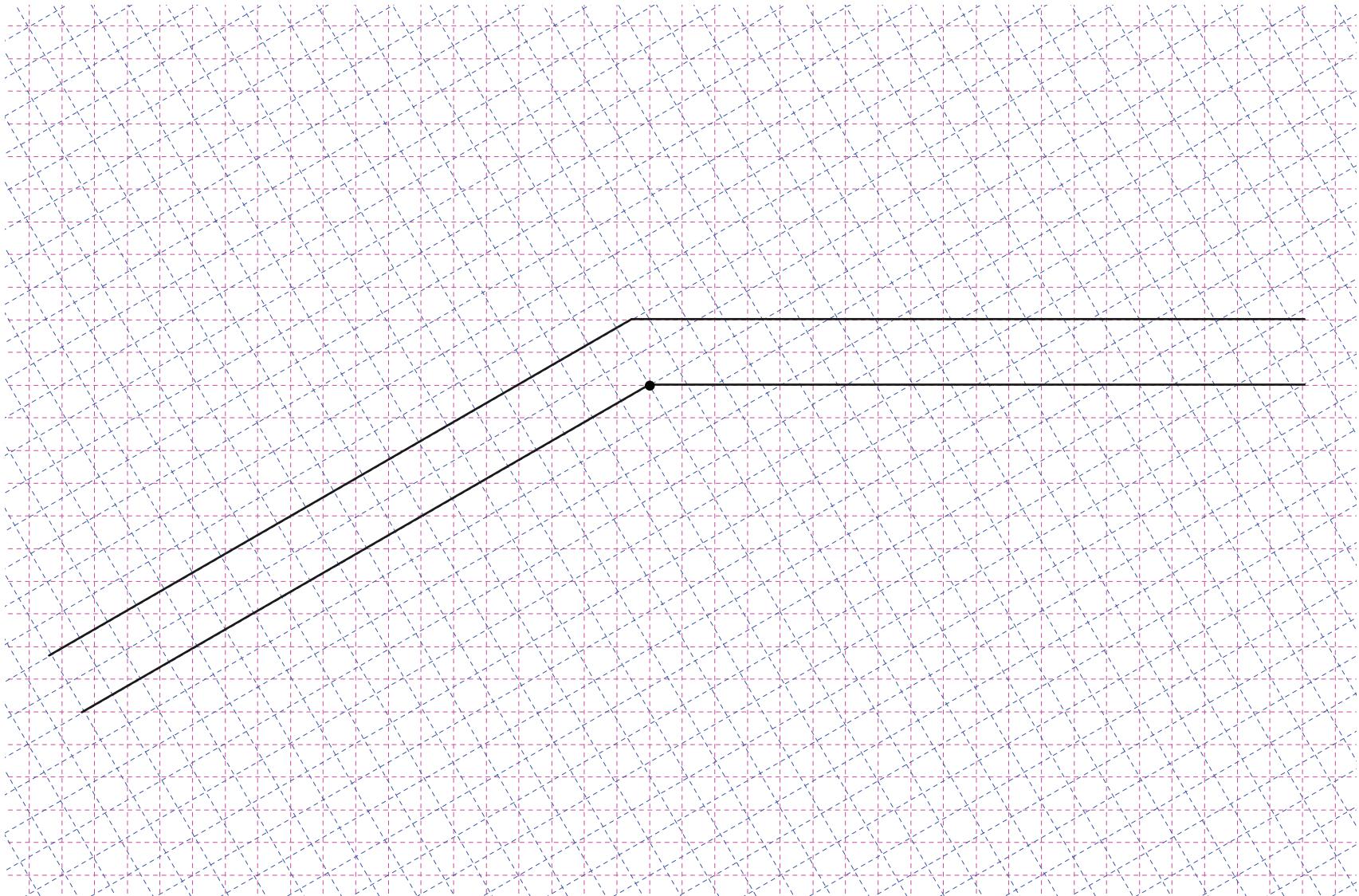
GRID 1

A grid is overlaid aligning to the right side of the street



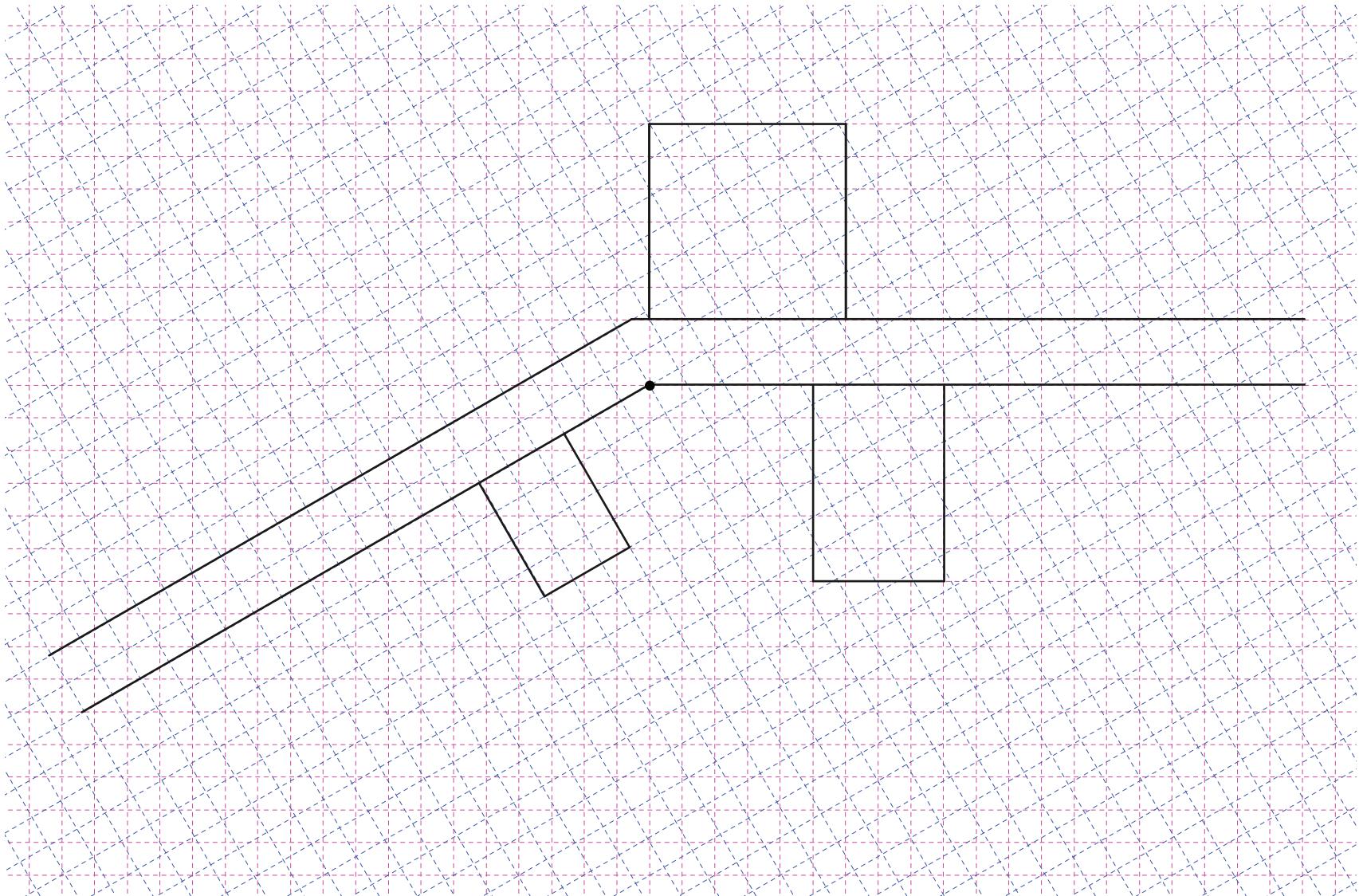
GRID 2

A grid is overlaid aligning to the left side of the street



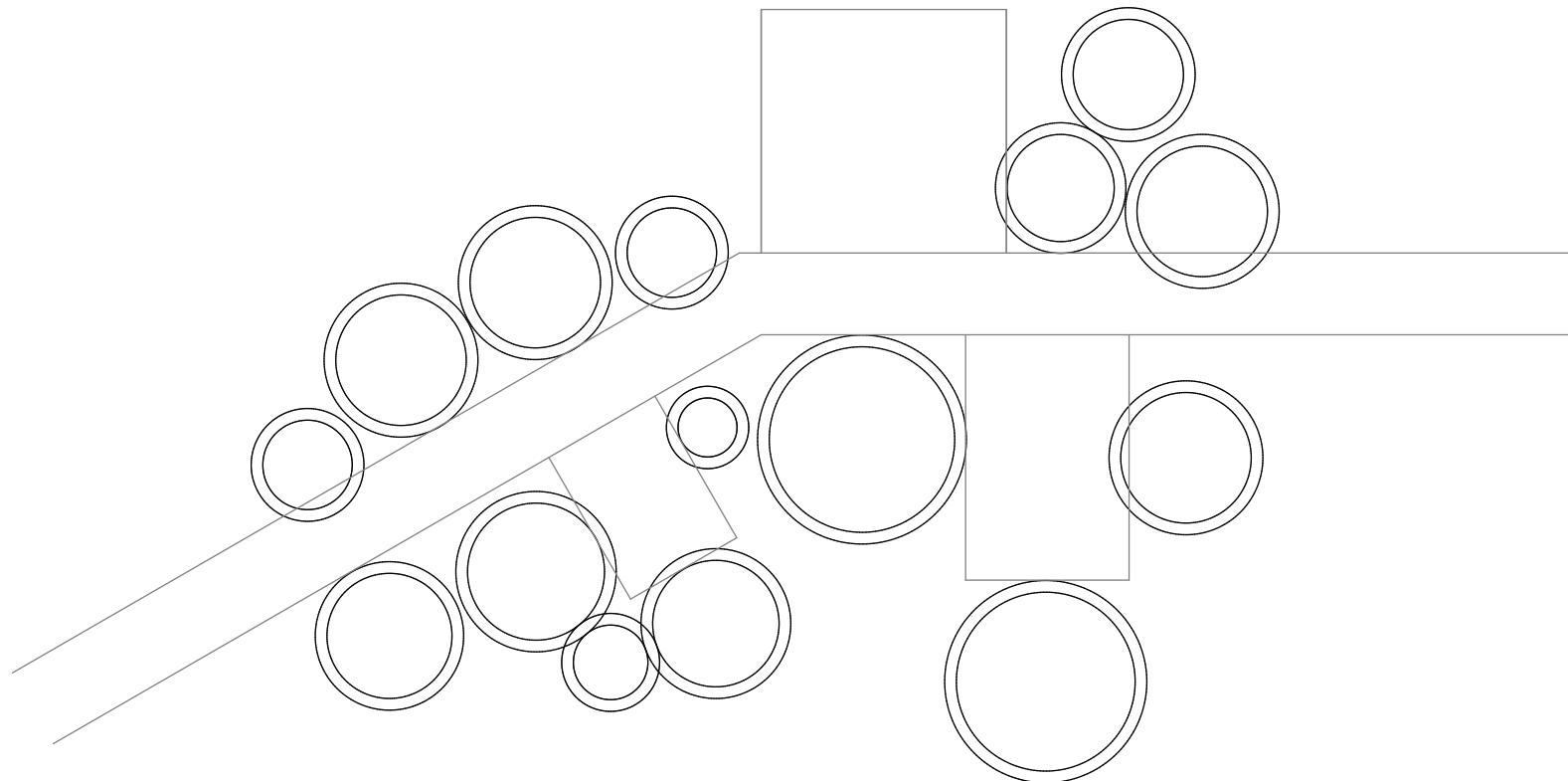
GRIDS 1 & 2

Both grids are used to align elements along the street



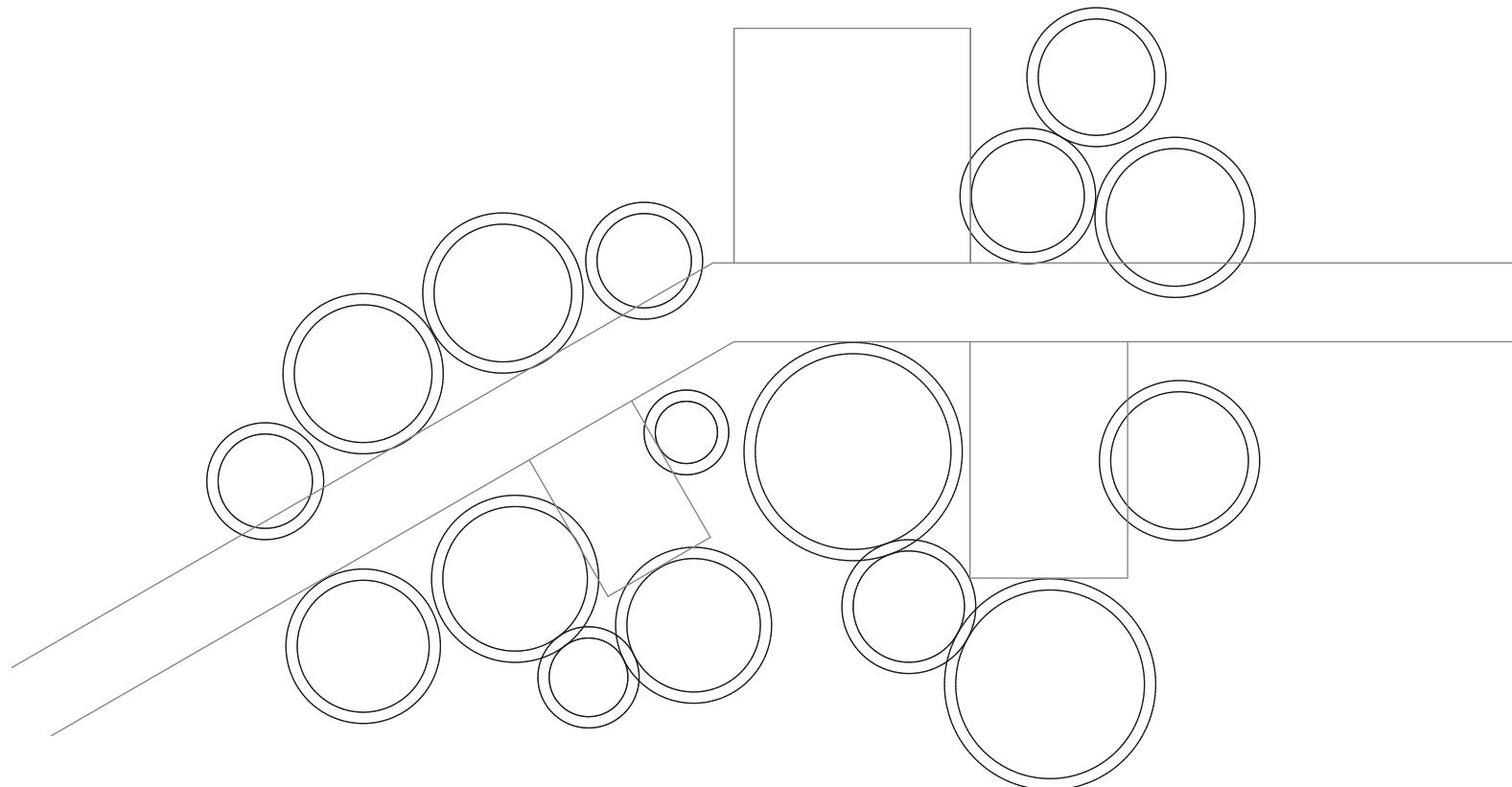
GROUND FLOOR COURTYARDS

Courtyards of three sizes are placed along the street in fixed locations



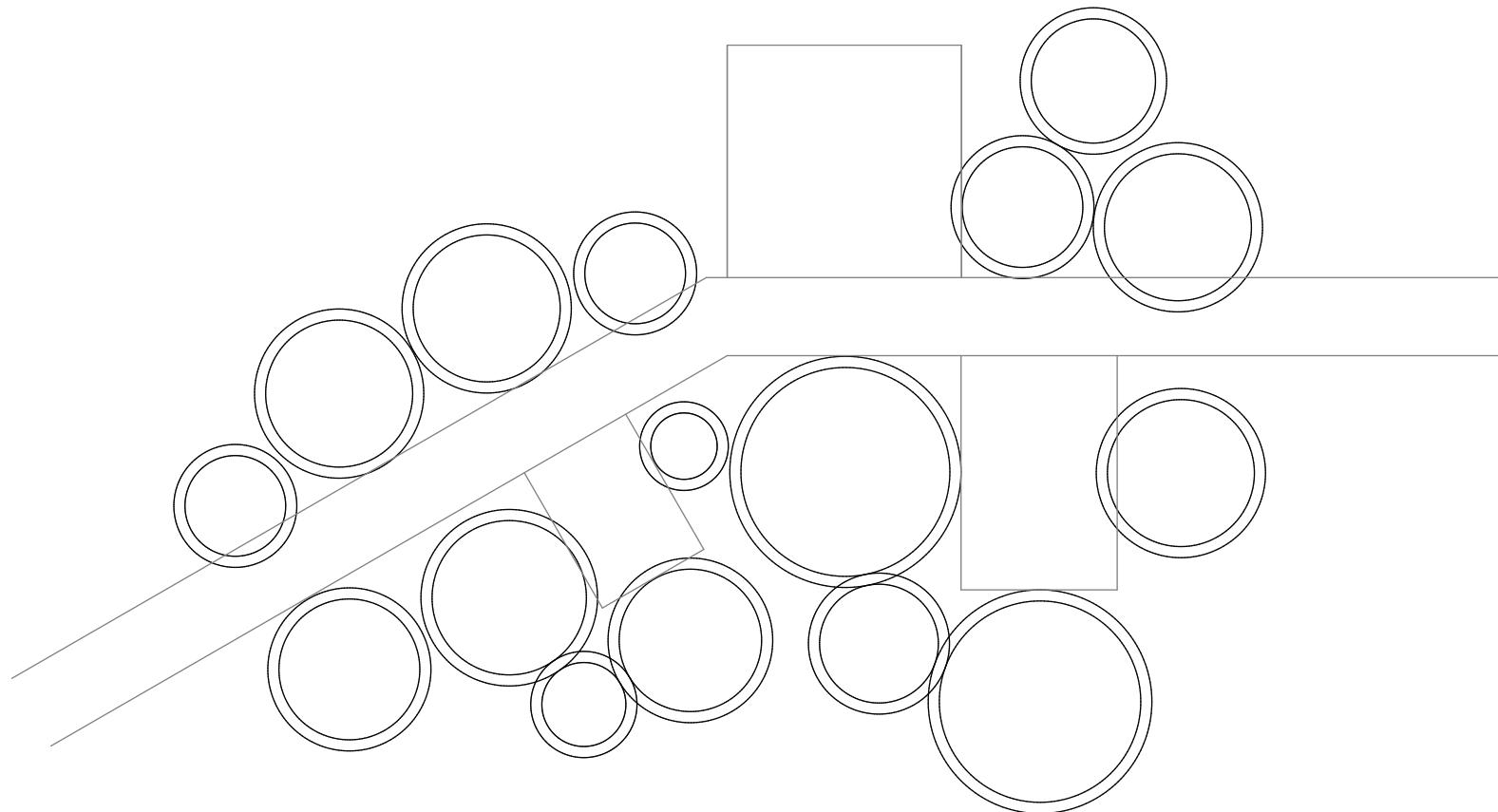
GROUND FLOOR PROGRAM: 50 RESIDENTS

The program on the ground floor has fixed relationships. The size of the space increases with the number of residents.



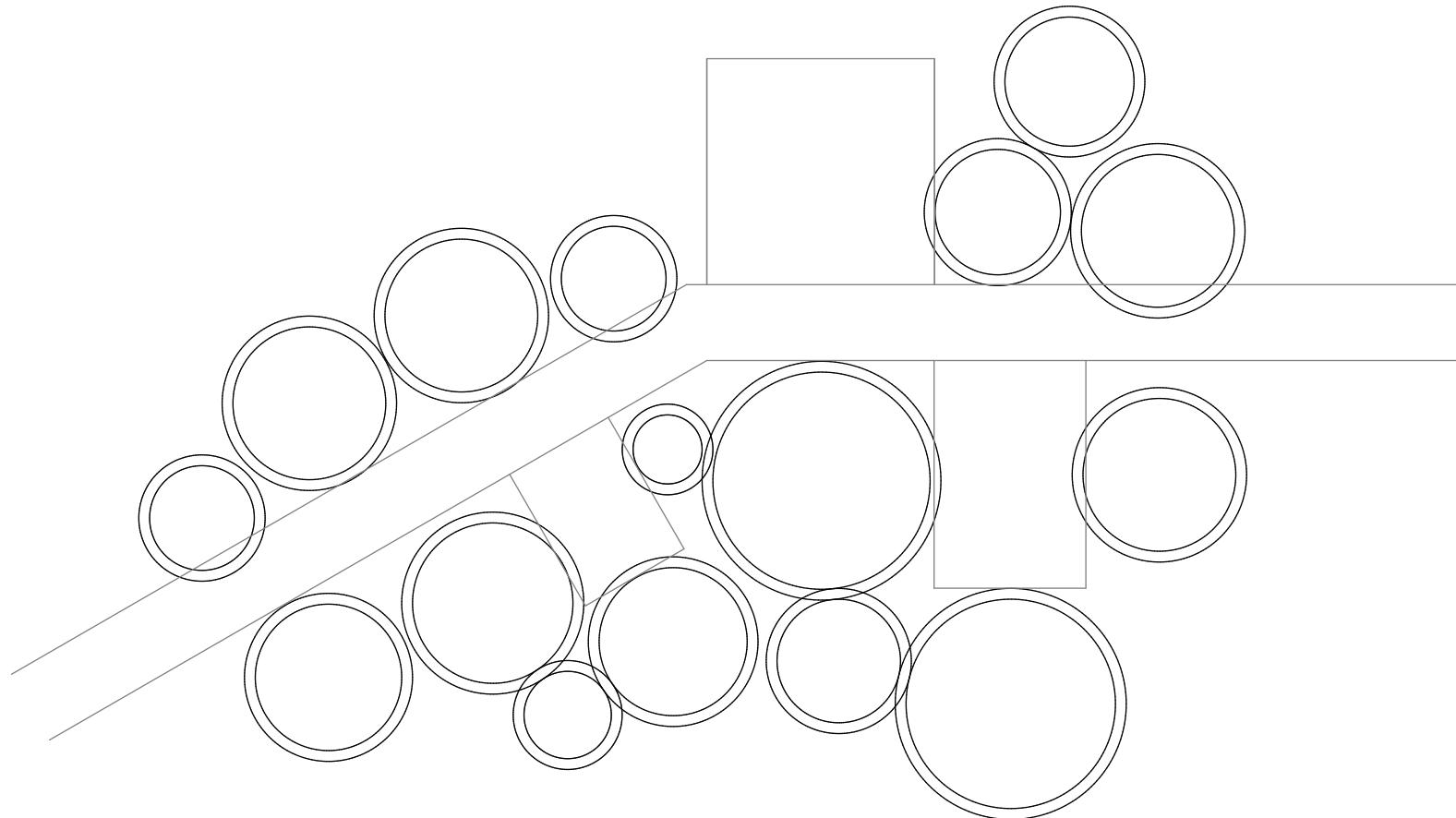
GROUND FLOOR PROGRAM: 60 RESIDENTS

The program on the ground floor has fixed relationships. The size of the space increases with the number of residents.



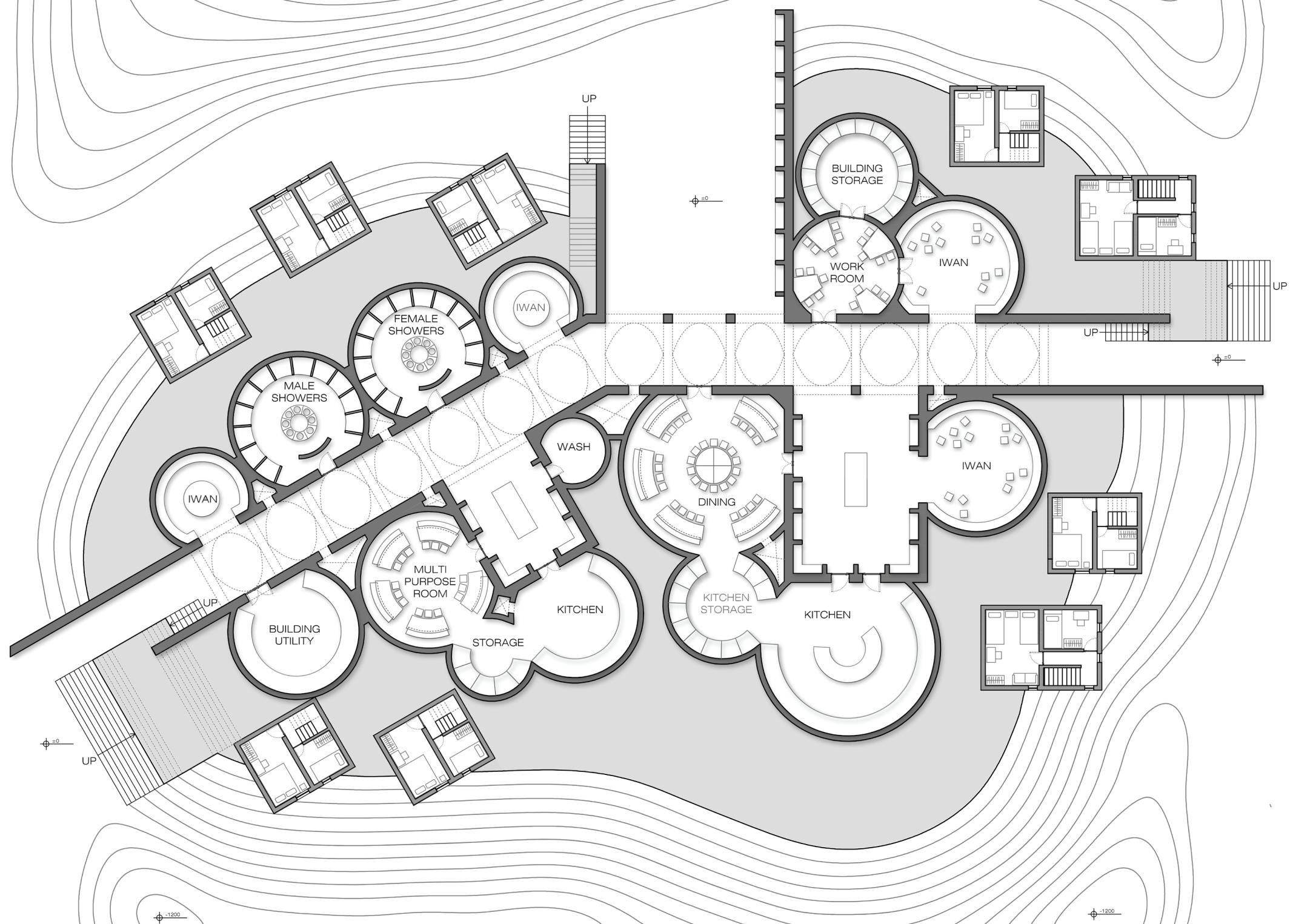
GROUND FLOOR PROGRAM: 70 RESIDENTS

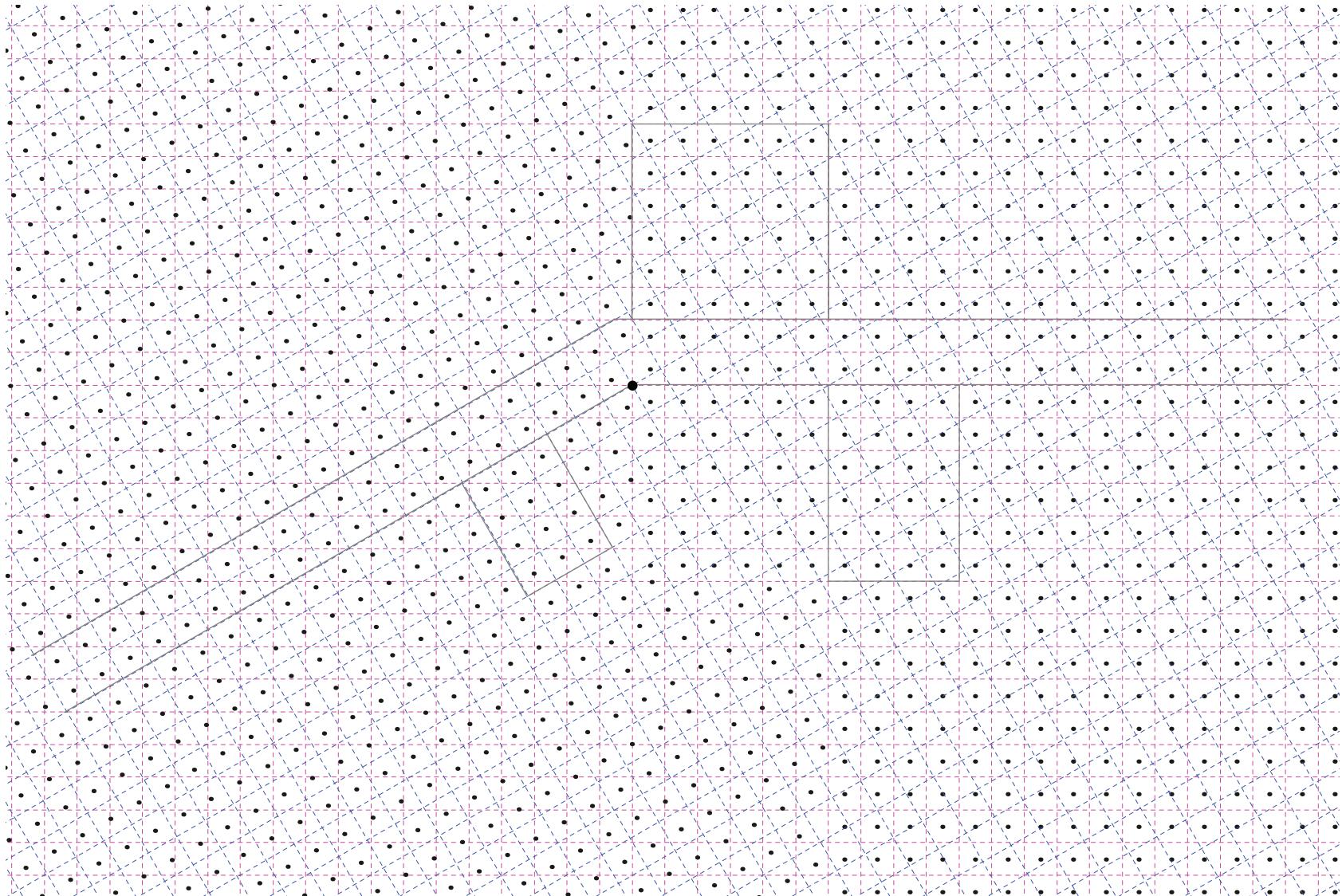
The program on the ground floor has fixed relationships. The size of the space increases with the number of residents.



GROUND FLOOR PROGRAM: 80 RESIDENTS

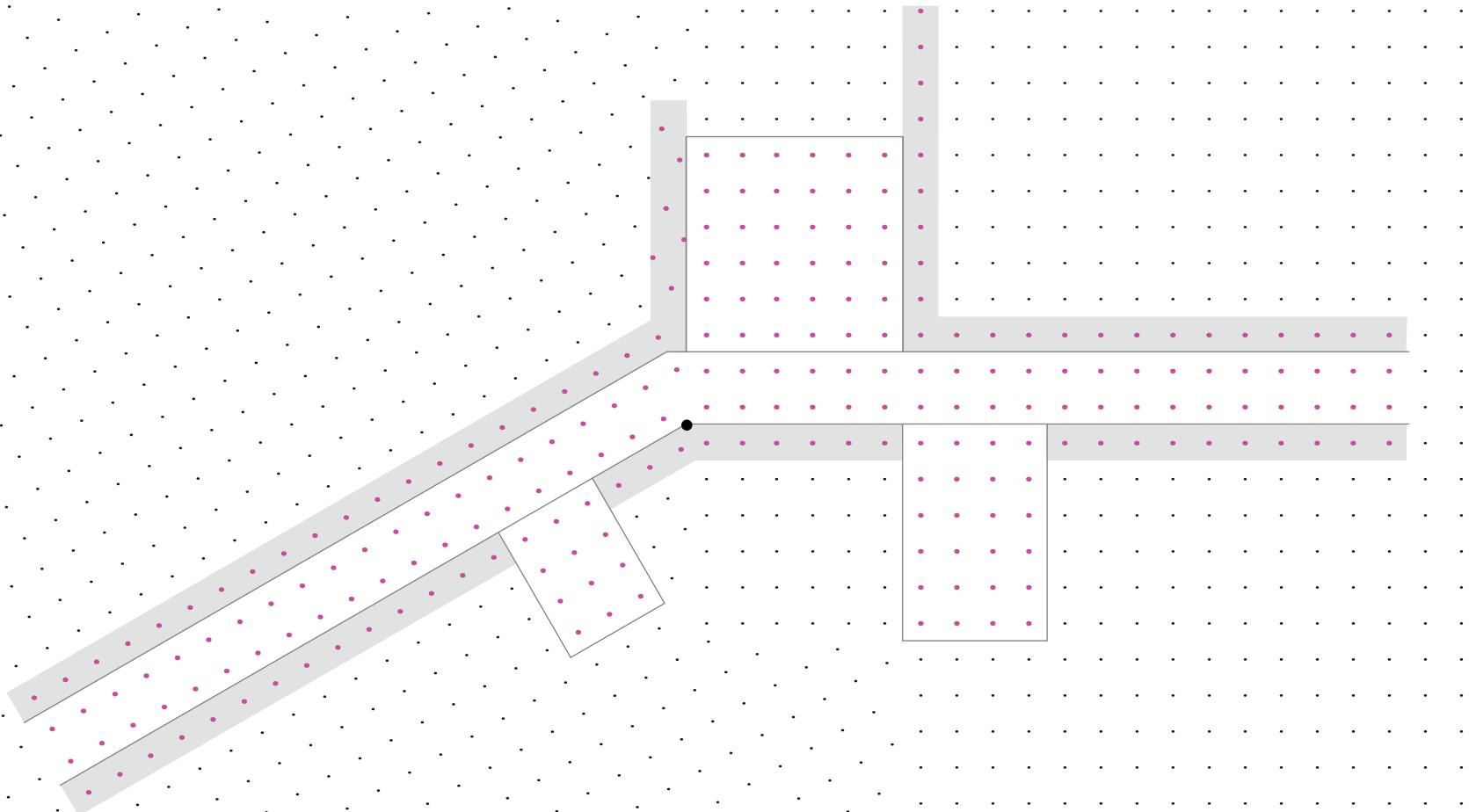
The program on the ground floor has fixed relationships. The size of the space increases with the number of residents.





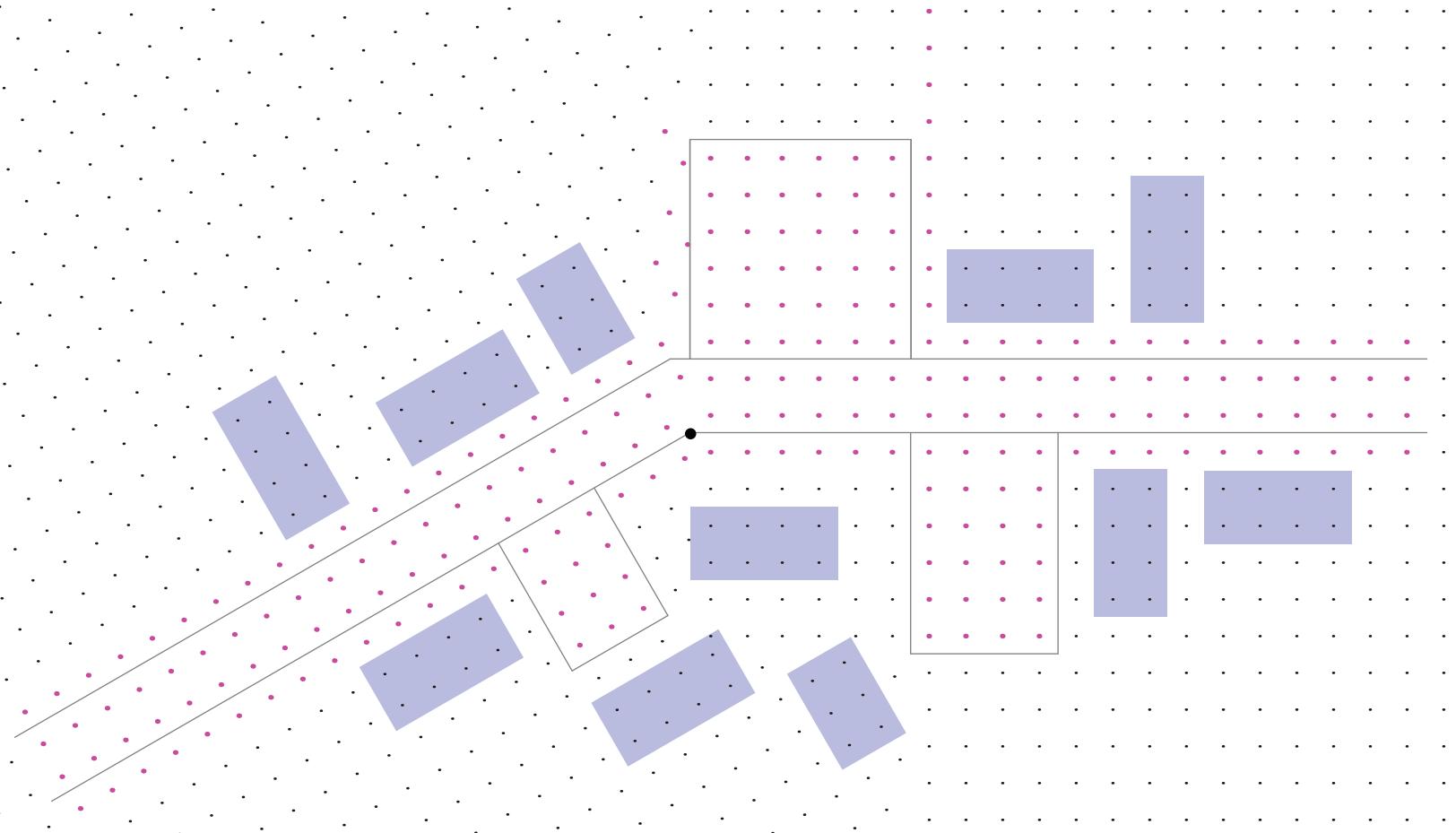
DOT GRID

A dot grid dual to the square grid is used for placing the dwellings on the first floor.



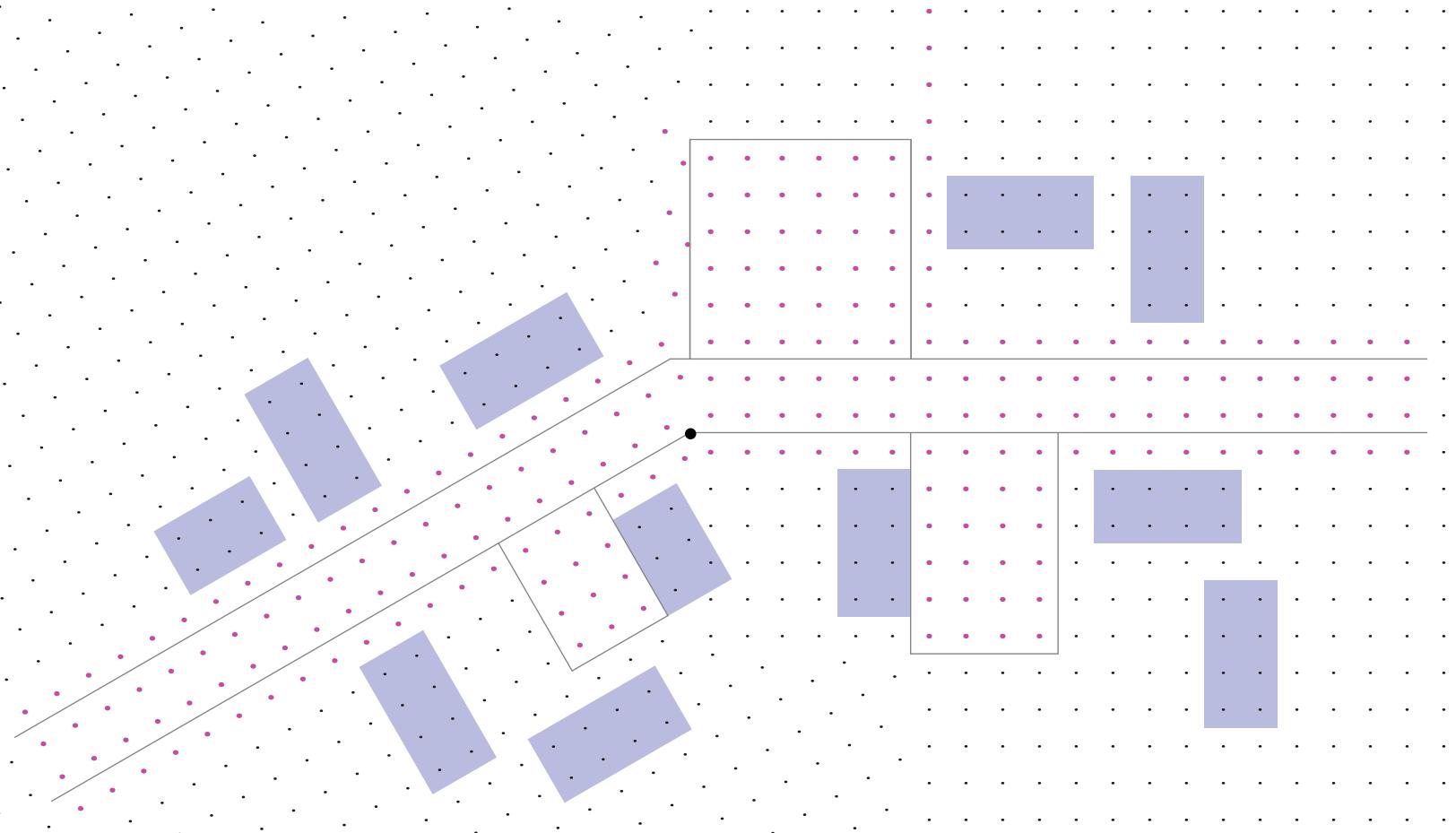
IDENTIFICATION OF NON-OCCUPIABLE GRID POINTS

Dwellings cannot be placed on top of the street, courtyards, or stairs



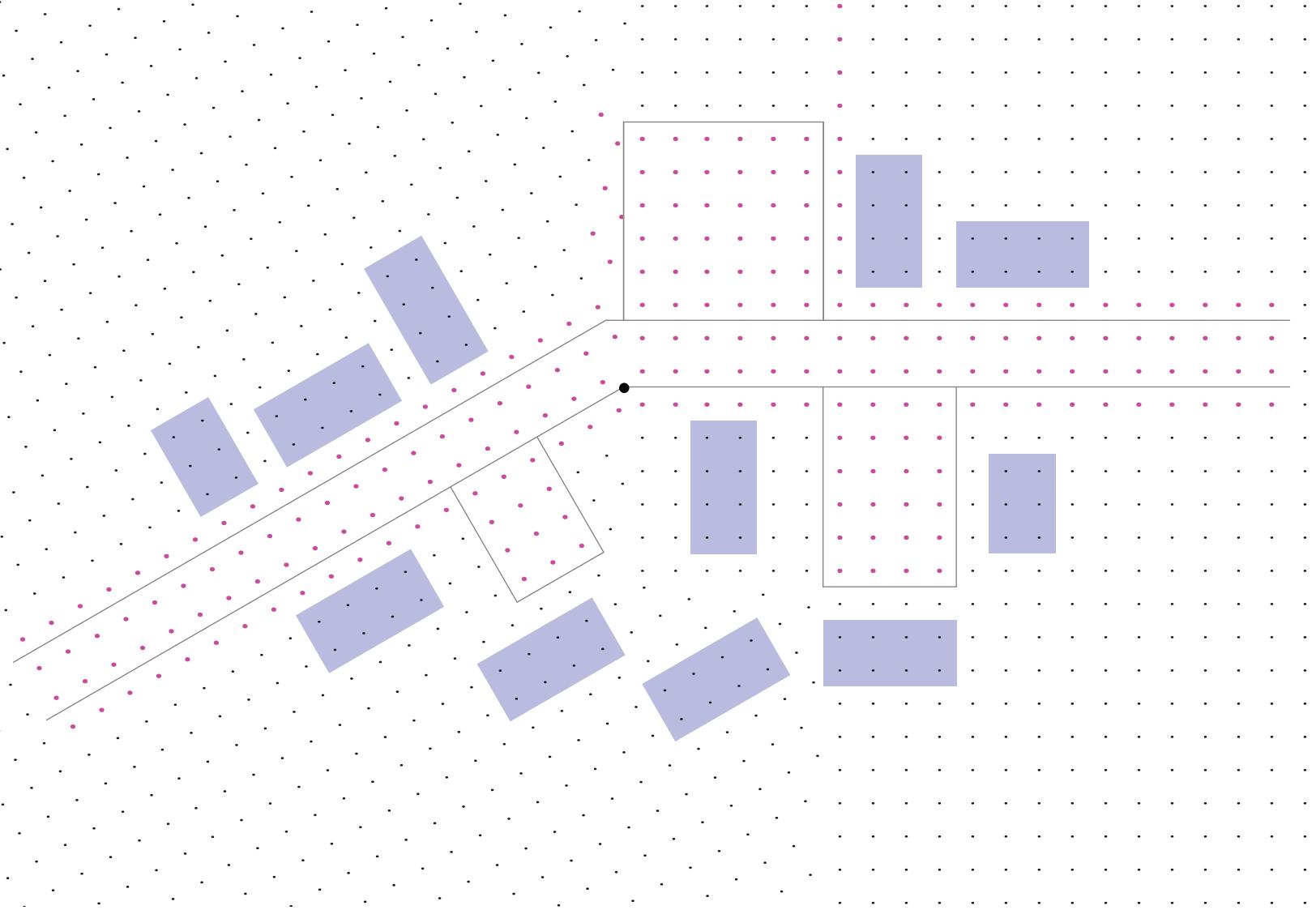
ONE STORY DWELLING LOCATIONS

One story dwellings are randomly placed with an attraction towards the origin point



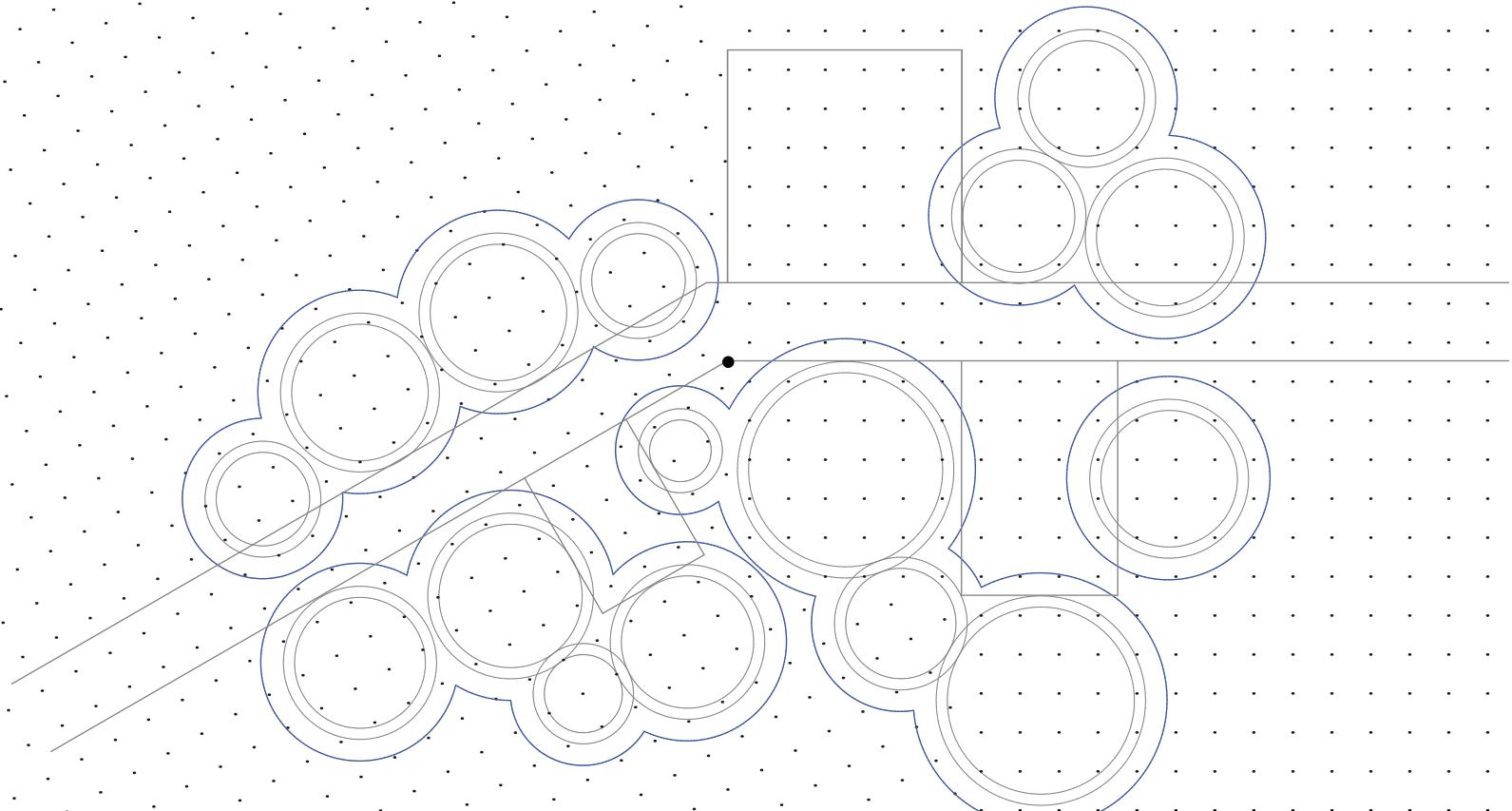
ONE STORY DWELLING LOCATIONS

*One story dwellings are randomly placed with an attraction
towards the origin point*



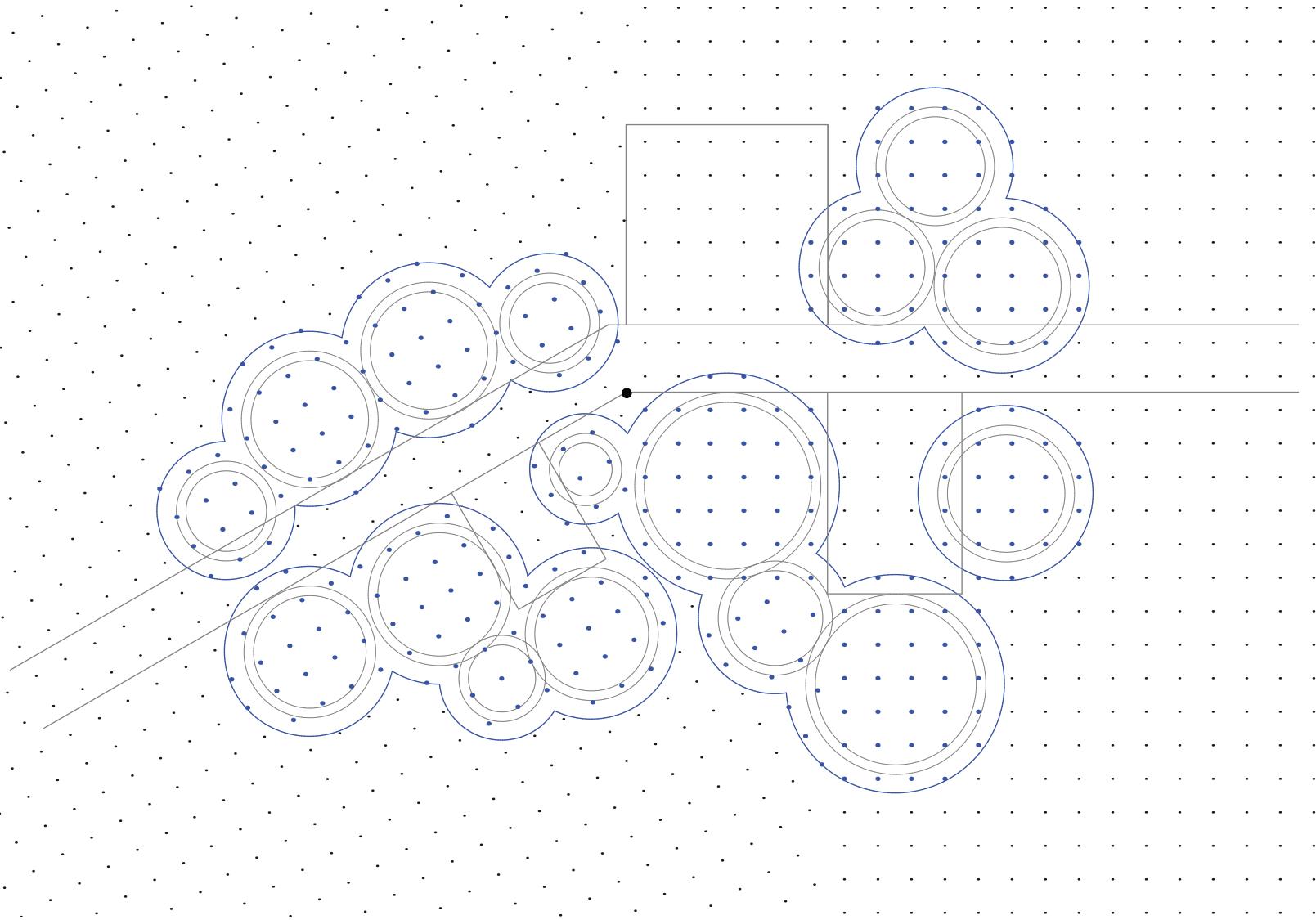
ONE STORY DWELLING LOCATIONS

*One story dwellings are randomly placed with an attraction
towards the origin point*



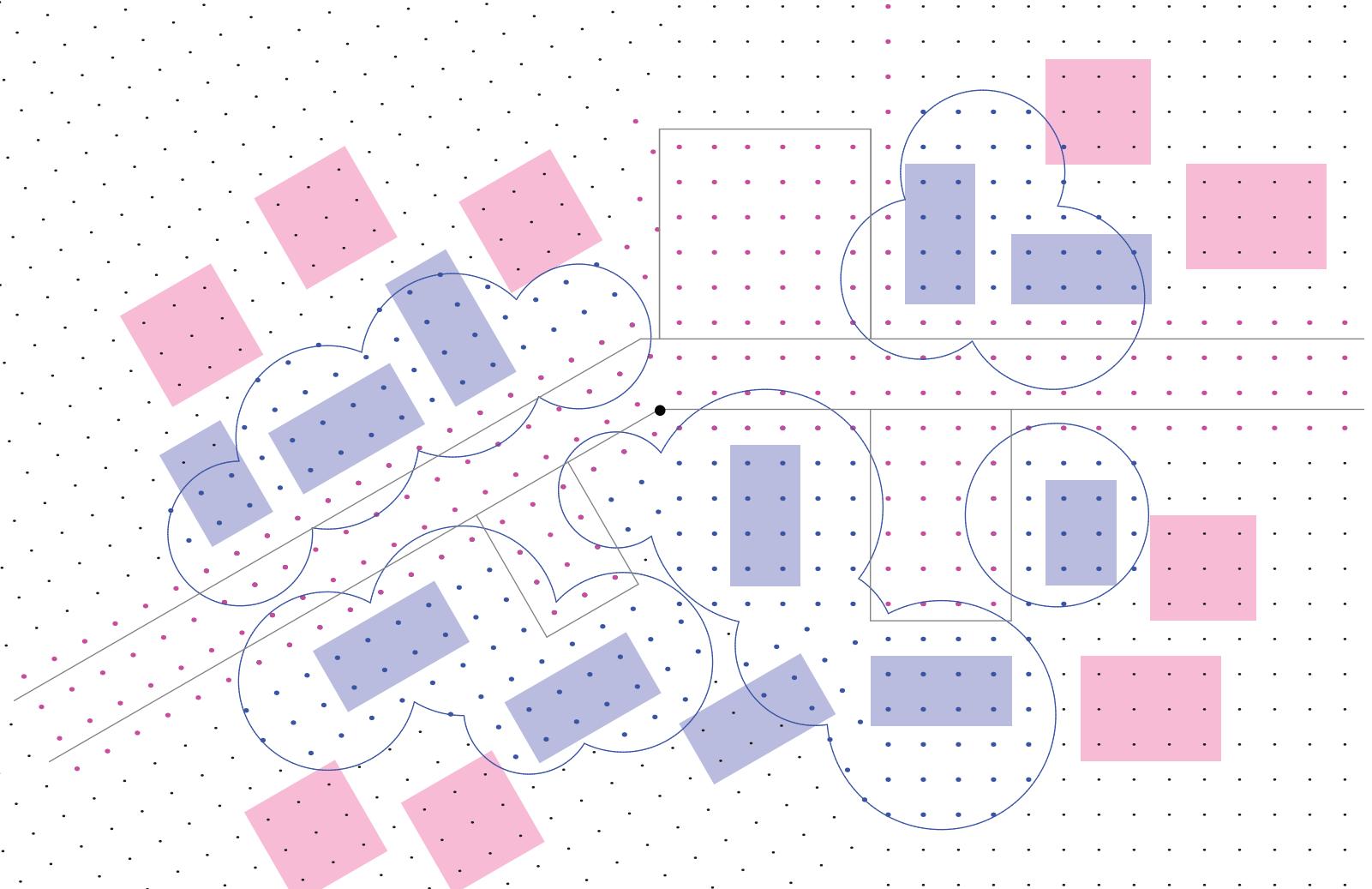
TWO STORY DWELLING LOCATIONS

Two story dwellings cannot be placed over the ground floor program. A boundary is determined to define this.



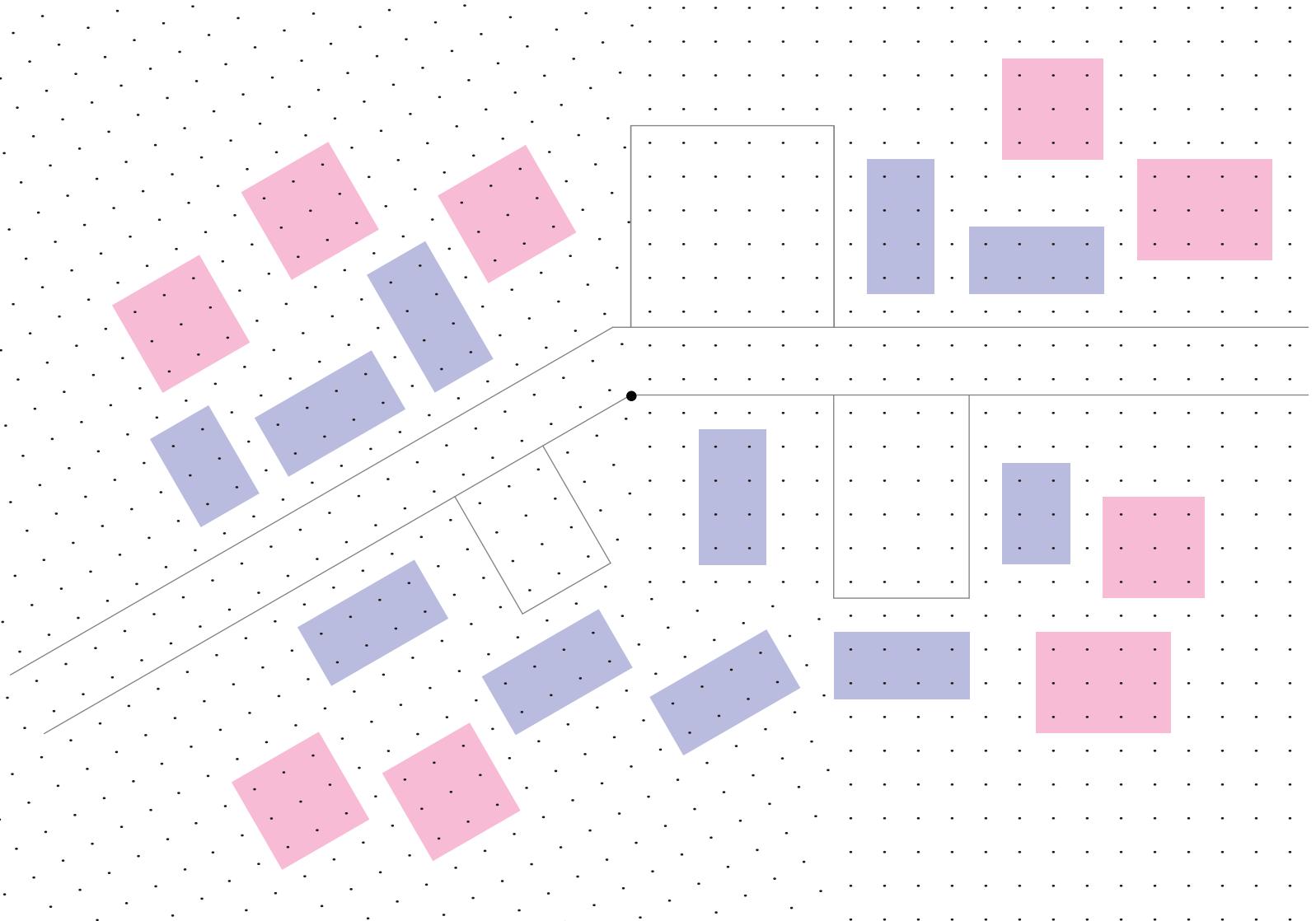
TWO STORY DWELLING LOCATIONS

Grid points within the boundary are identified.



TWO STORY DWELLING LOCATIONS

Two story dwellings are placed outside of the defined boundary, and attract to one story dwellings to form enclosed outdoor spaces.



PLACEMENT OF DWELLINGS

Dwellings are placed on available grid points, they are attracted to the origin point and always have at least one grid point between them.

