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MASTER OF ARCHITECTURE
GRADUATION PORTFOLIO

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“Tactical Urban Interventions”

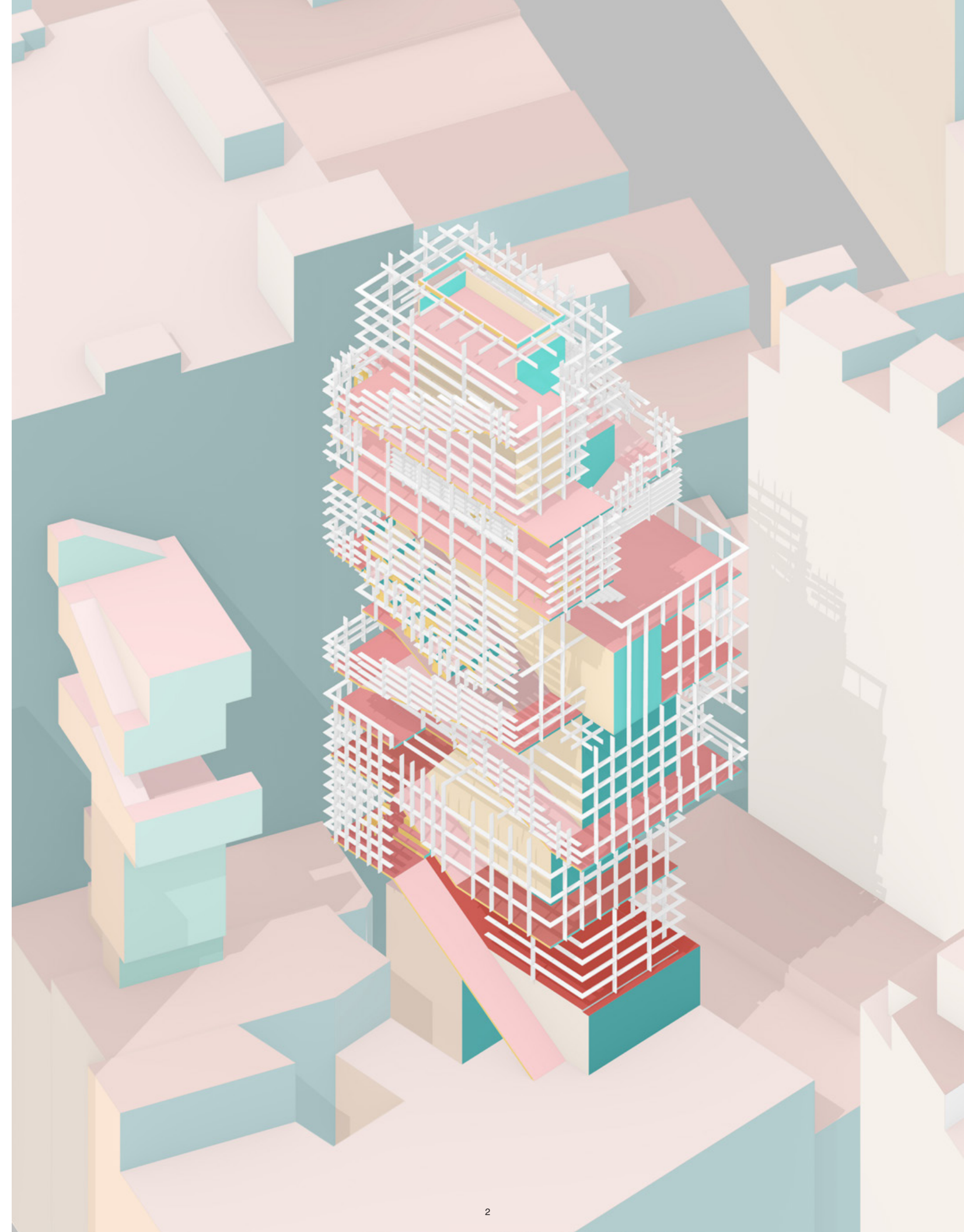
Columbia GSAPP Core I Studio
Professor Stephanie Lin
Site: New York, NY
Program: Media Center + Community Activator

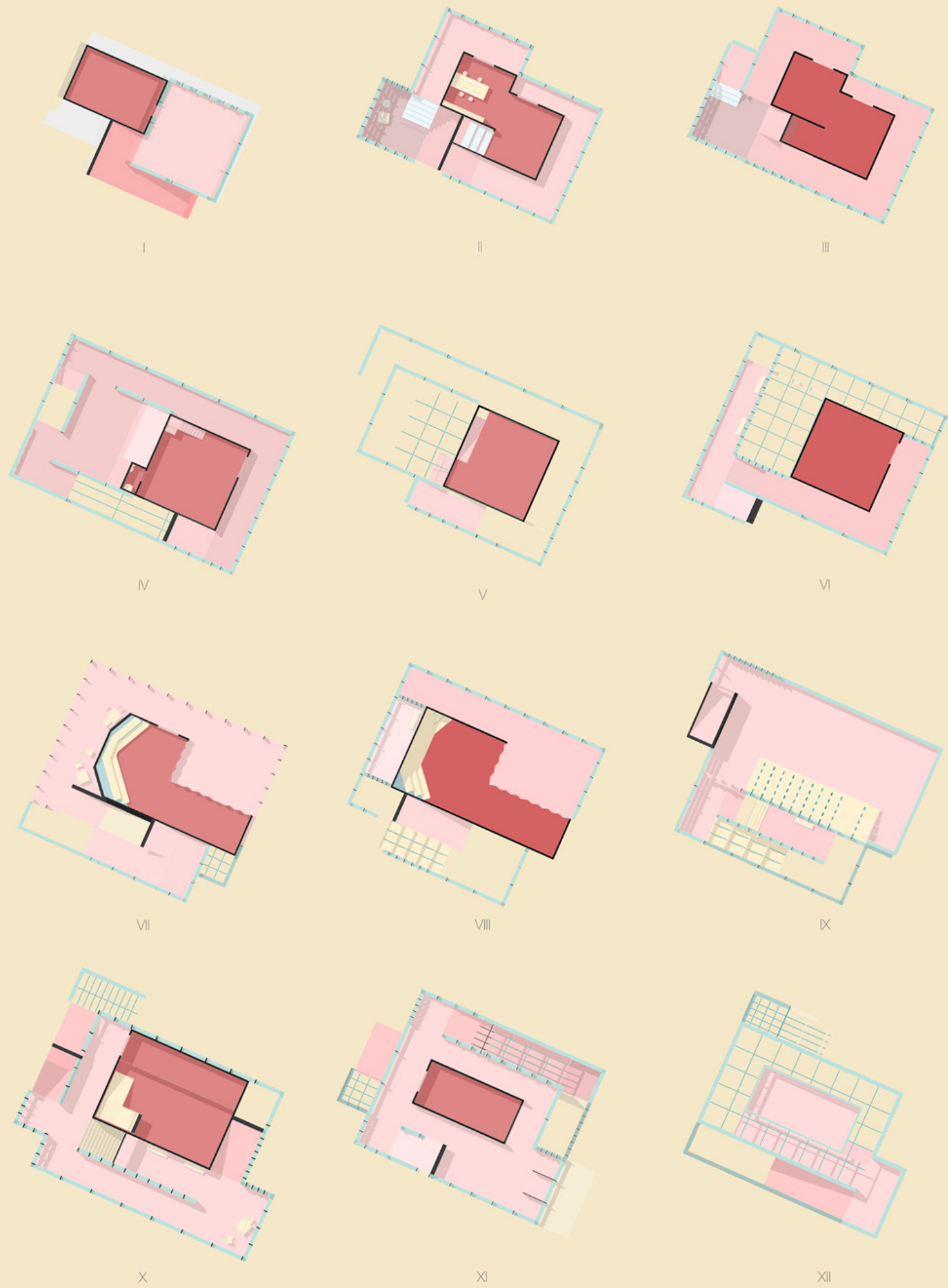
Using existing cultural nodes around the NOMAD district as precedents, the studio sought to develop tactical, guerilla interventions to create counter-tourism strategies. These counterpoints would provide a resistance to conventional cultural consumption. What kind of experiences cannot be recorded? How can tourism enhance an area rather than consume it?

An effort to create an open and democratized space responsive to the ever-changing needs of the public became the focus for my intervention. This intervention sought to provide people a solace from the constant barrage of capitalist forces, and the modern desire to find a quiet hallway from which to go home.

To achieve this, a series of abstracted scaffoldings were used to create grey zones that resided in a social areas between explicitly stated public/ private properties. Utilizing the plethora of vacant air rights of property lots, connections between cultural nodes were made.

These connections would also feature vertically oriented areas with easily interchangeable programs responsive to existing cultural nodes around them. Public space is therefore enhanced, even if it meant creating spaces that didn't exist yet on the traditional plane.



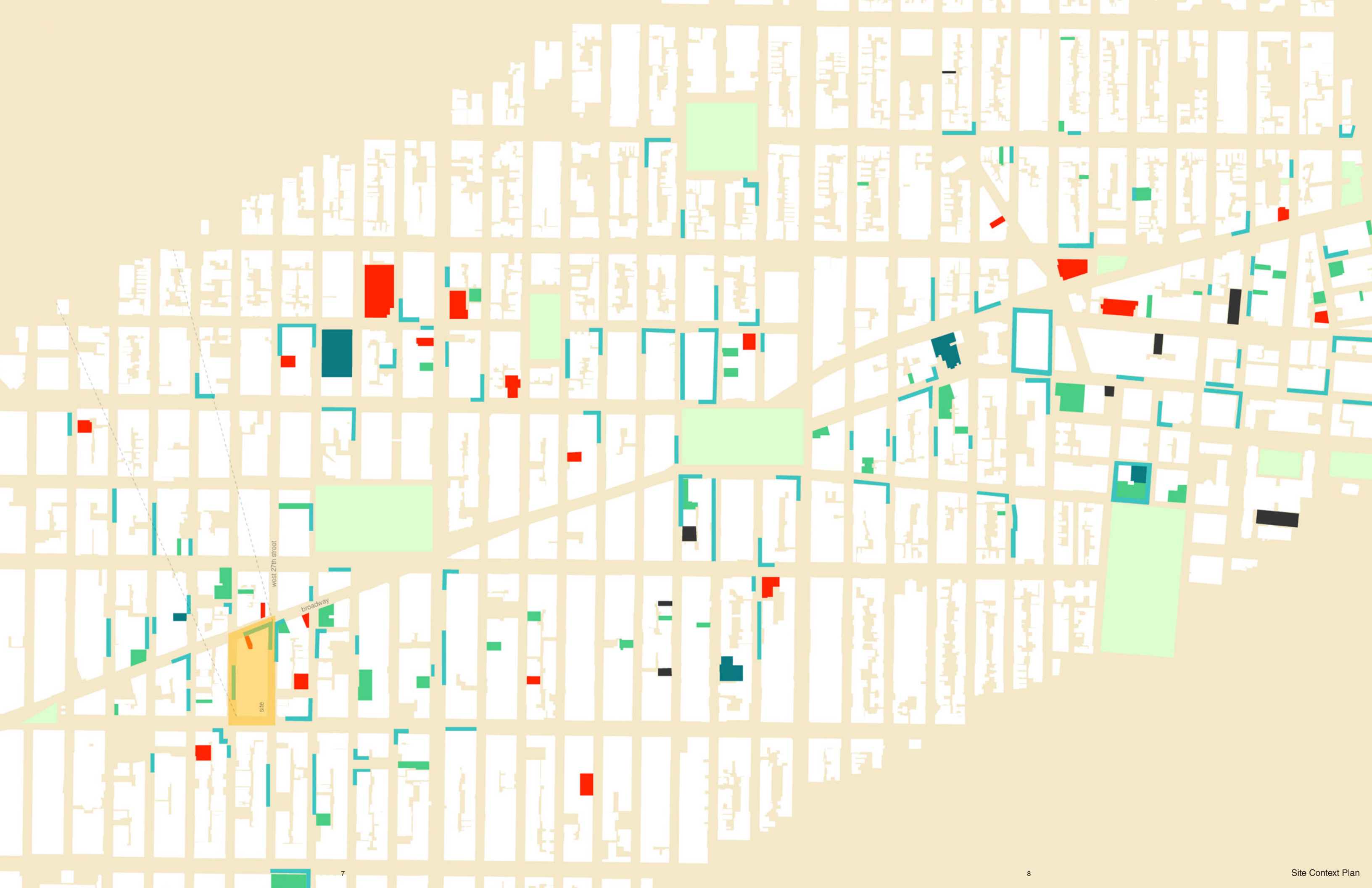




Program is not prescribed in this intervention. The space is designed according to the needs of the community, and ordered as the residents see fit.



This structure easily accomodates programs that are related to those that exist below, in the host building.



west 27th street

broadway

site

“Home, Unseen”

Columbia GSAPP Core III Studio
Professor Daisy Ames
In collaboration with Thom Chiu
Site: Bronx, New York, NY
Program: Housing

Our project considers problems of underutilization, displacement, single-unit, and single-parent renters in public housing.

Concerning underutilization and displaced seniors, our project seeks to create units that are specifically designed to facilitate separation and/or absorption of units that can easily adapt to changing family sizes. Since 32.5% of current Bronx public housing is underutilized, our project seeks to bring that number down to 0 by creating a miniature village.

Issues of safety, community, and surveillance are considered through augmentation of visibility and vision. Units are placed and arranged to provide a gradient of public to private, and visible to invisible.

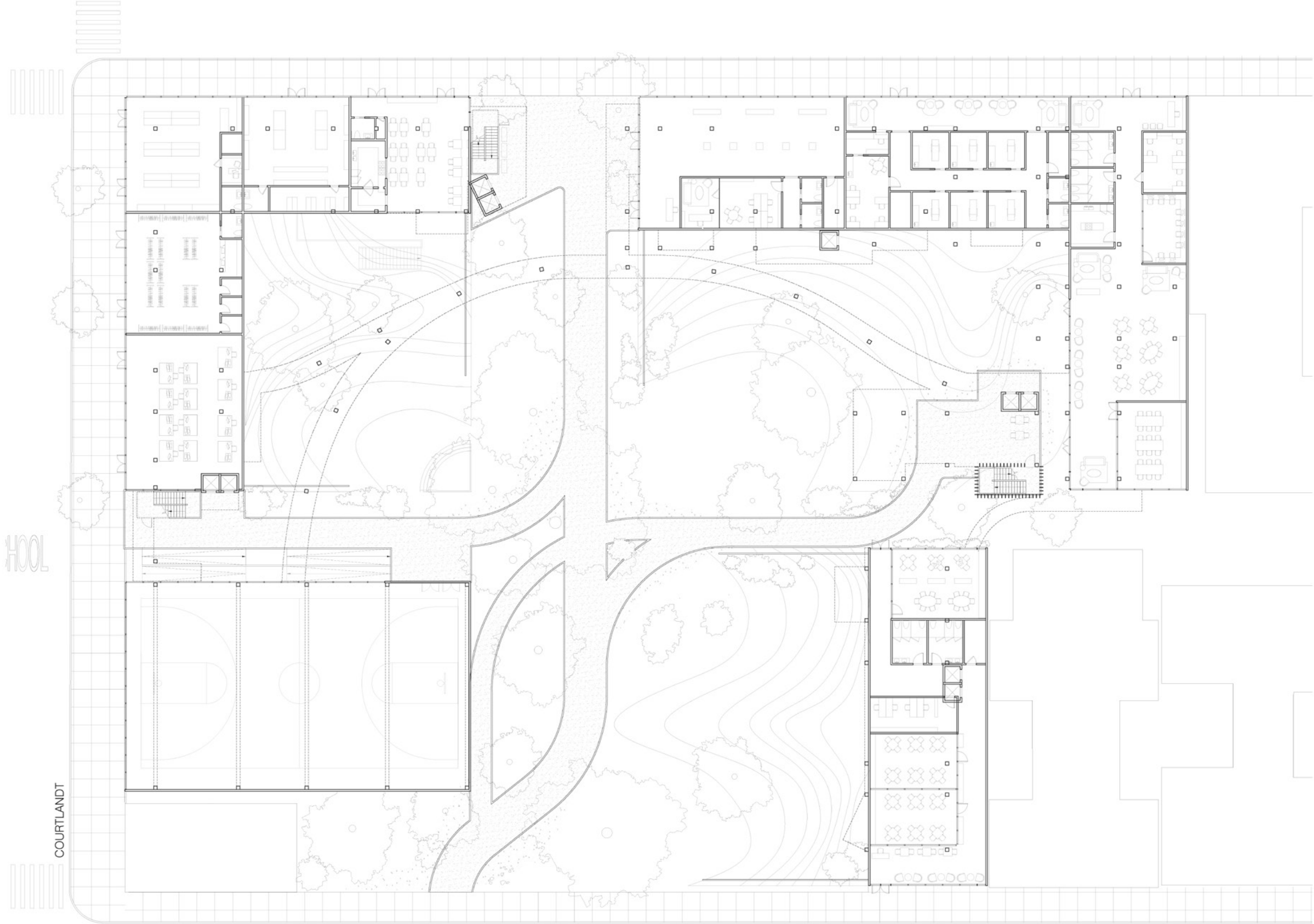
The ground floor responds to the current residents' needs. Specific requests such as healthy food vendors, employment training facilities, and childcare facilities were included in response to a 2016 survey taken from the residents of the Melrose area.

Adaptive housing through rearrangement of walls and entries allow neighboring units to be absorbed or detached based on the changing family or tenants. For example, a 2BR unit can detach into 2 1BR units when a child moves out and their room is no longer required.

The above idea of adaptability is again necessary with renters due to the changing demands and availability of units. By placing wet walls and collective spaces adjacent to each other, it is easier to connect and detach neighboring units.

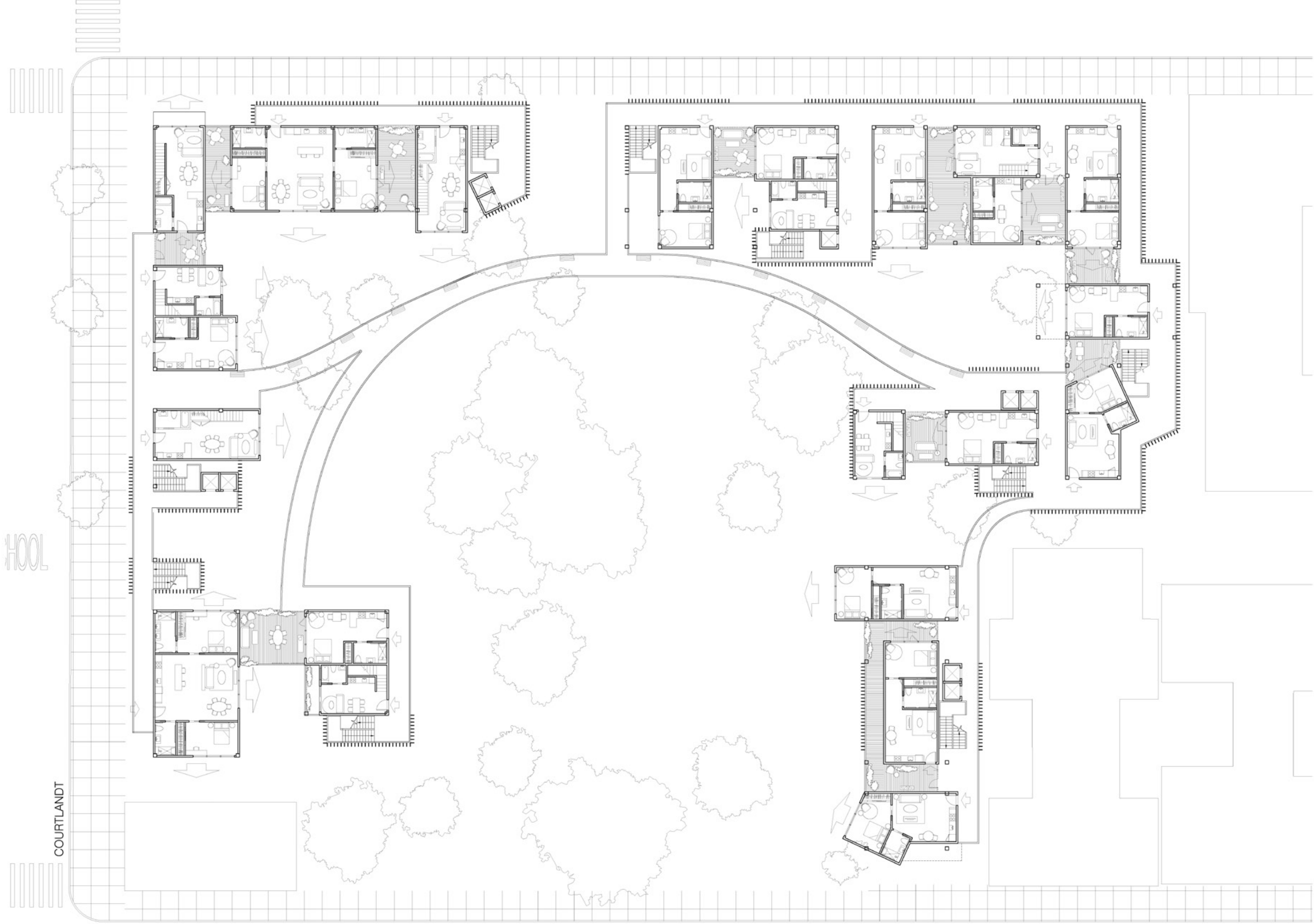






COURTLANDT

E. 151st



HOOL

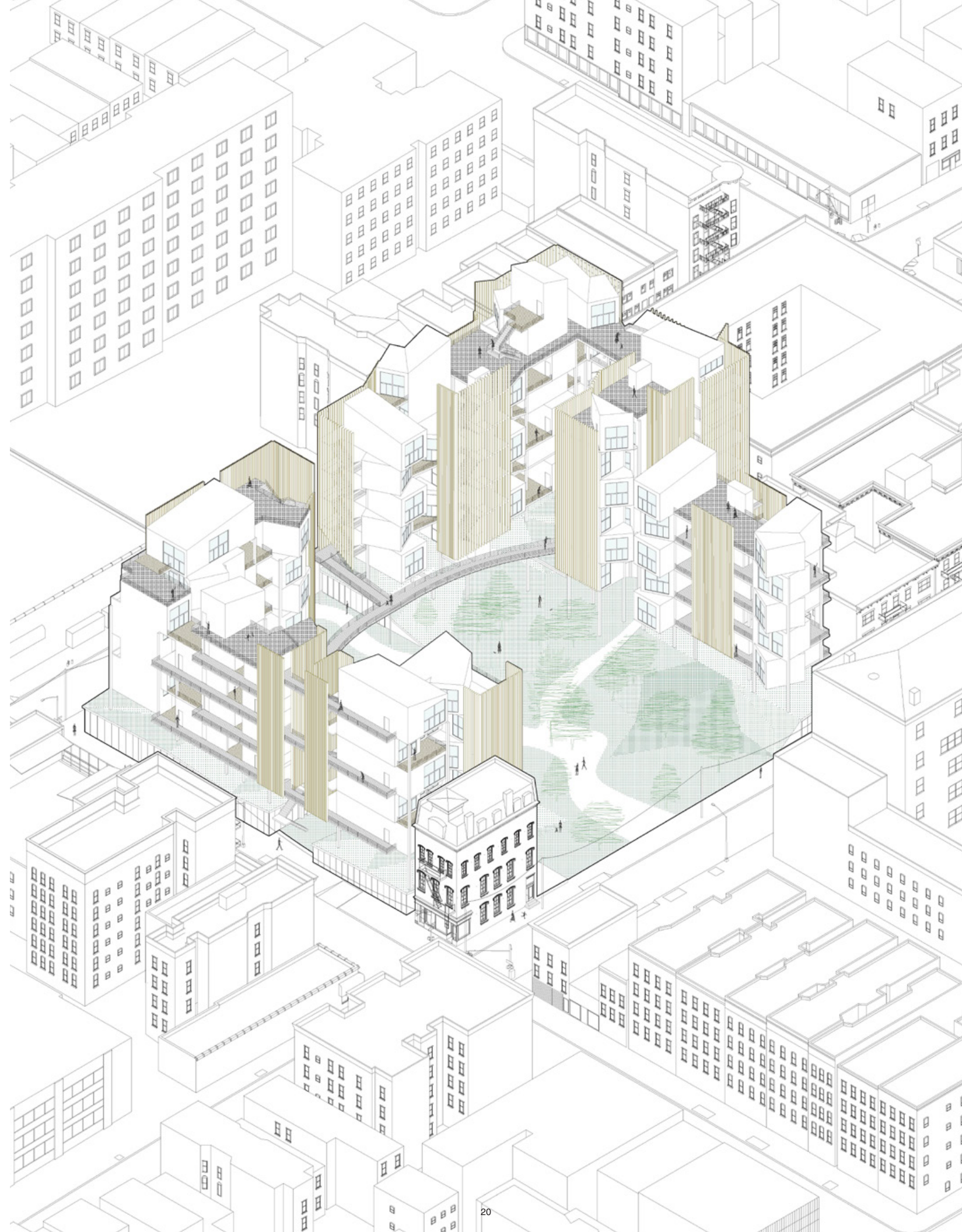
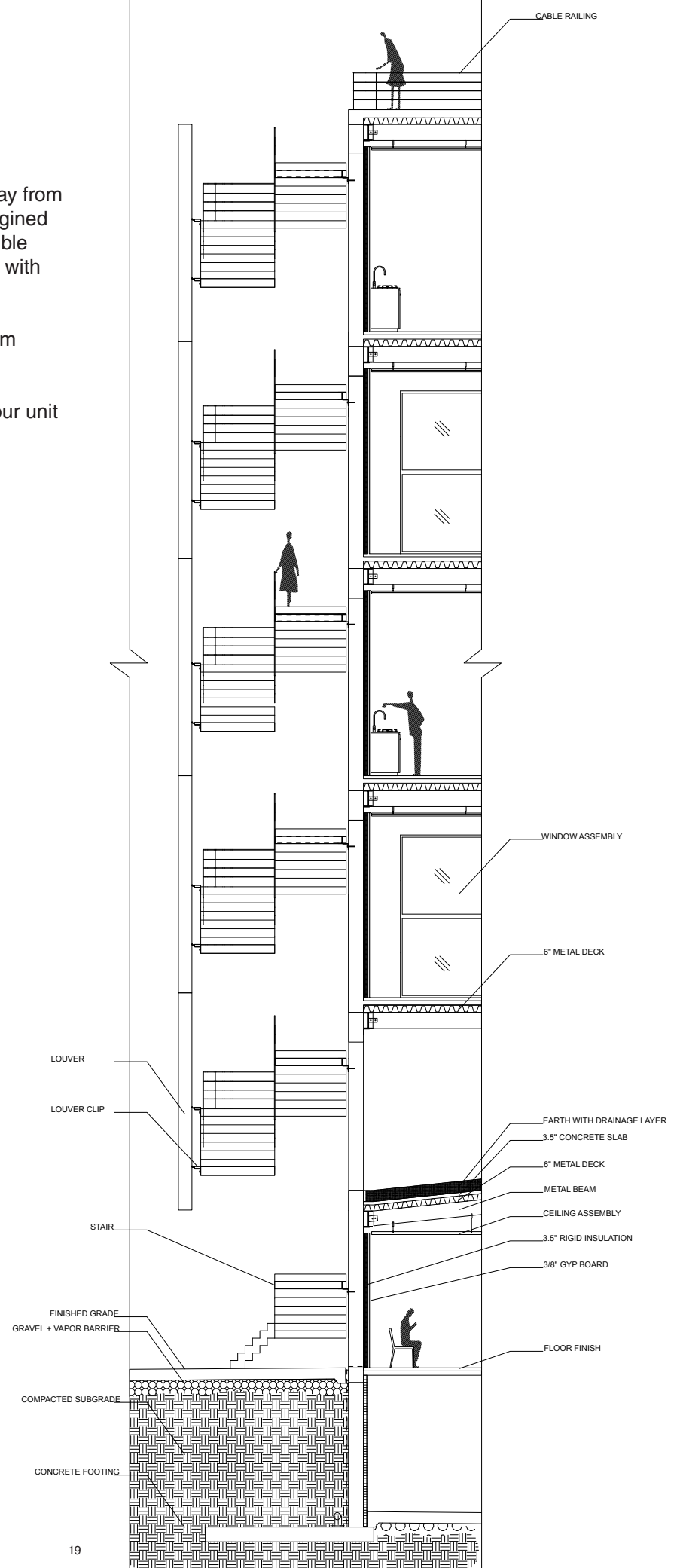
COURTLANDT

E. 151st



Privacy between units is also kept by pointing windows away from other windows' fields of vision. The front/back yard is reimagined for the city, creating semi-private porch spaces that are visible to the community. These spaces allow meeting or lounging with other neighborhood dwellers.

The site block would be divided using grid lines created from the facades of existing buildings, and the sightlines from neighboring residential buildings surrounding our site. The resulting overlapping lines would provide a framework for our unit fragments to be placed.





The housing massing is initially sculpted by pointing away from the vision of the surrounding housing units. The housing masses are simply collections of organized housing units, woven together by an elevated walkway that doubles as communal public space.

By framing specific views for each window, visibility and privacy are protected to avoid views into other units as best as possible. Bedroom frames, being the most private, avoid pointing into another window.









“Bridging the Gap”

Columbia GSAPP Advanced IV Studio
Professor Phu Hoang
Site: Newburgh, NY
Program: Sauna + Animal Hospital/ Aviary

This project began by identifying the Incomplete Zoo. Zoos began as spaces that were intended to store animals for entertainment.

Separate from the real world, they were spaces that did not accurately represent our relationship with living animals nor our place within earth's numerous habitats.

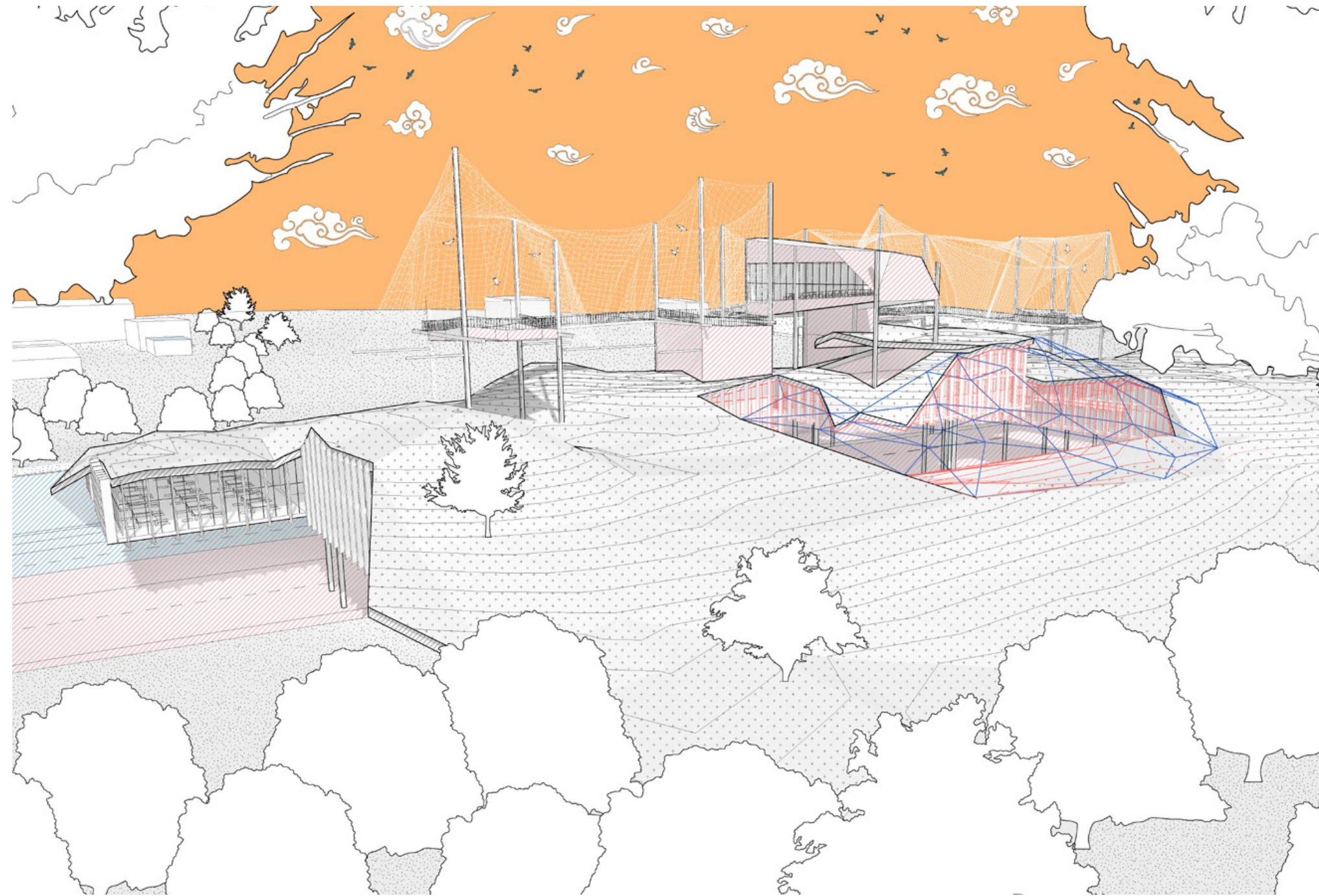
My research showed similarities between zoo exhibits and museum exhibits that featured inanimate objects. A similar amount of space was dedicated for both examples - exposing a critical disconnect in human perception of the world and its living inhabitants.

This project sought to revitalize and reconnect fragmented animal habitats along the electric corridor of Newburgh. Another group in this studio proposed a project to revitalize and reconnect fragmented human habitats within the city of Newburgh.

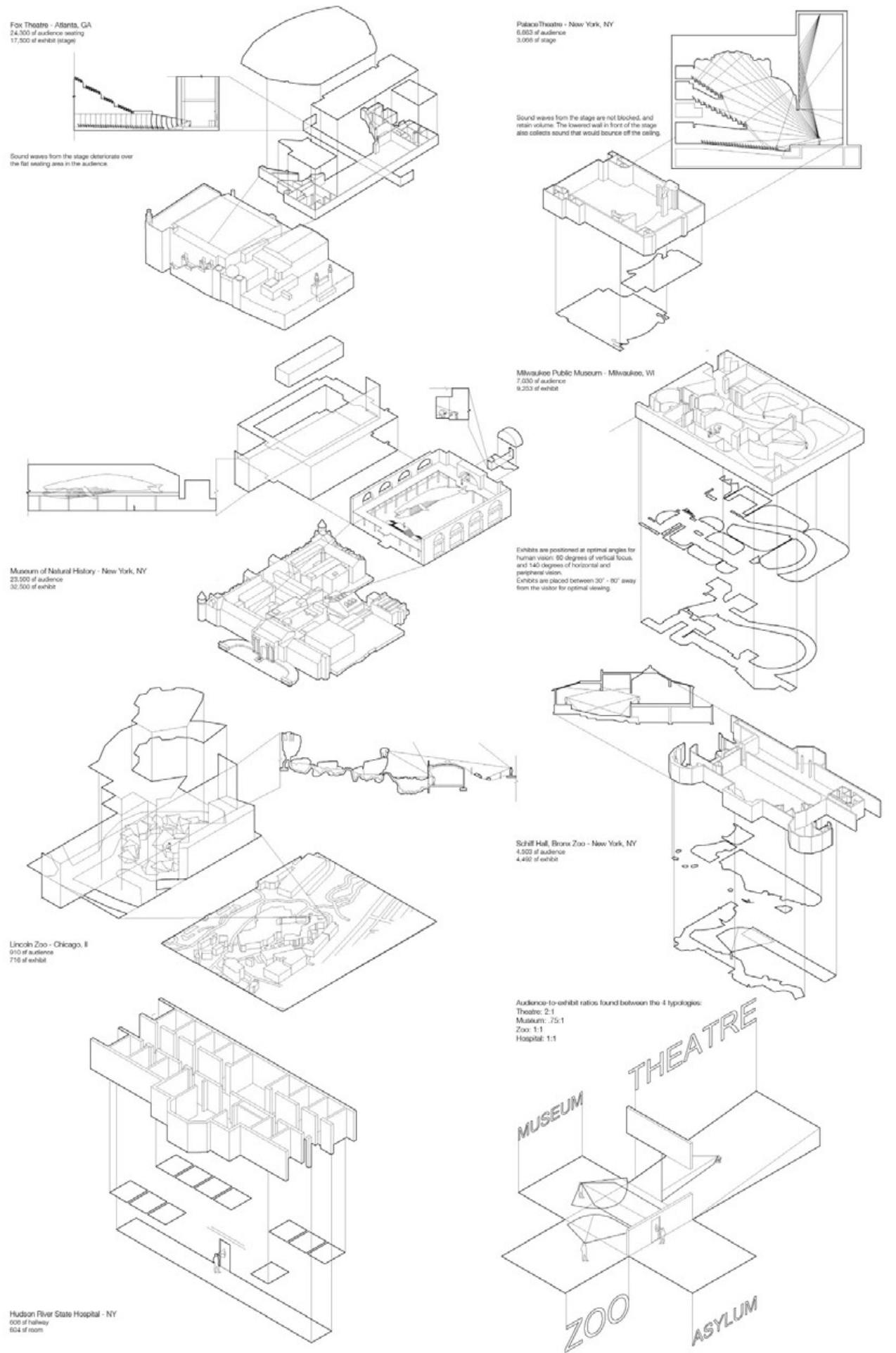
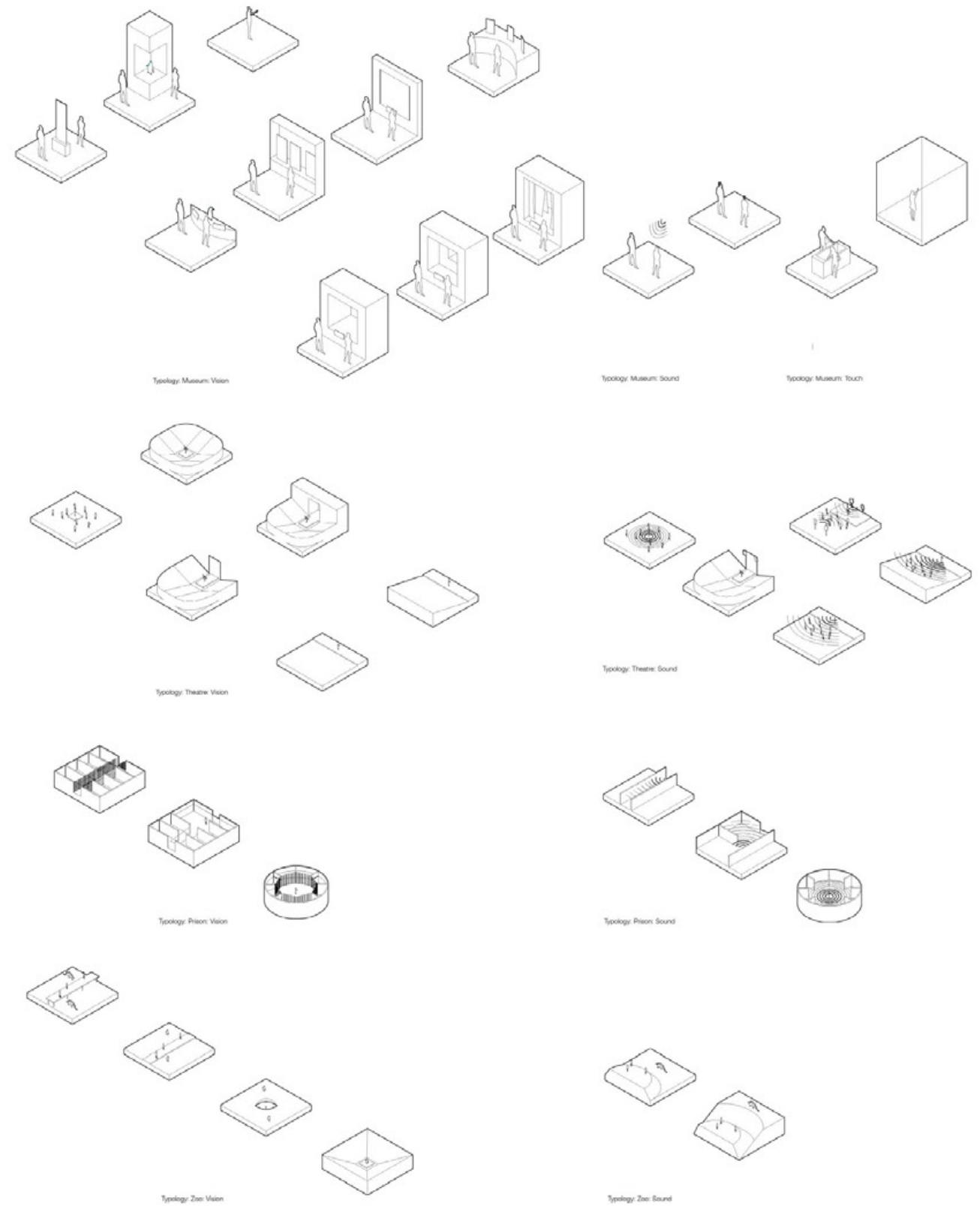
These two projects work together to create a network of habitats, and inhabitants, that consequently fosters empathy, and a sense of coexistence between previously disconnected members of the local ecosystem.

The project links a human retreat with animal rescue operations through a reimagining of a traditional Korean “jimjilbang.” These sauna, restaurant, and rest spaces provide a safe retreat for humans while also providing an animal care retreat in close proximity.

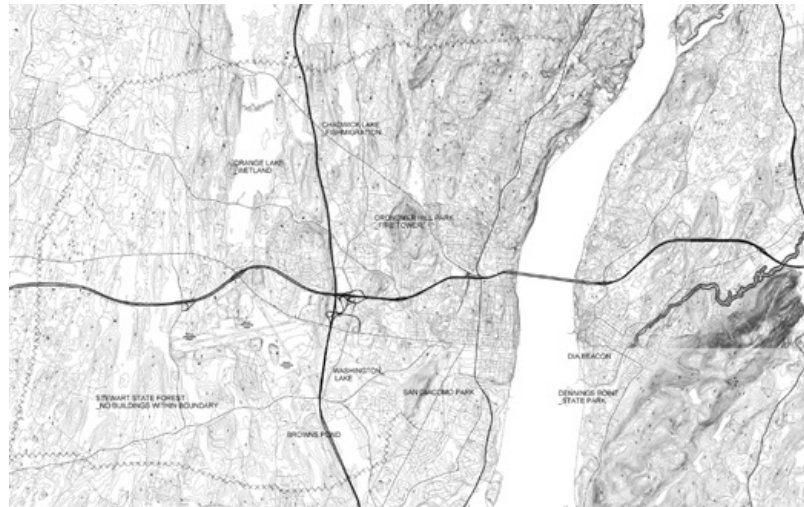
These businesses are typically extremely low-cost opportunities to rest and relax for 24 hours, and have been used to conduct meetings and vacations.



The incomplete zoo - compared to a jail, theatre, and museum.
 Neither a space for animals, nor for humans.
 Inaccurate representations of animal relationships, that are a
 separation from the real world.







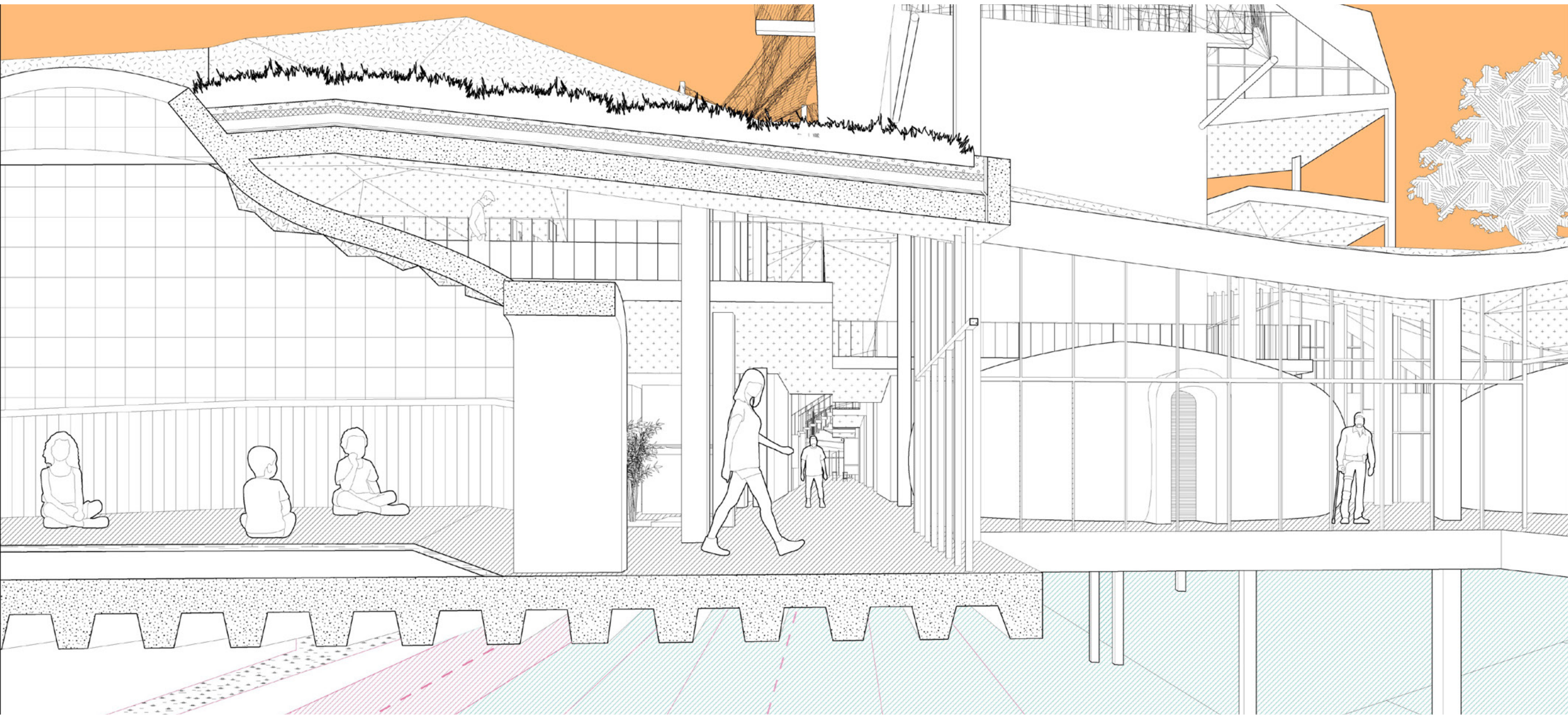
Street Map

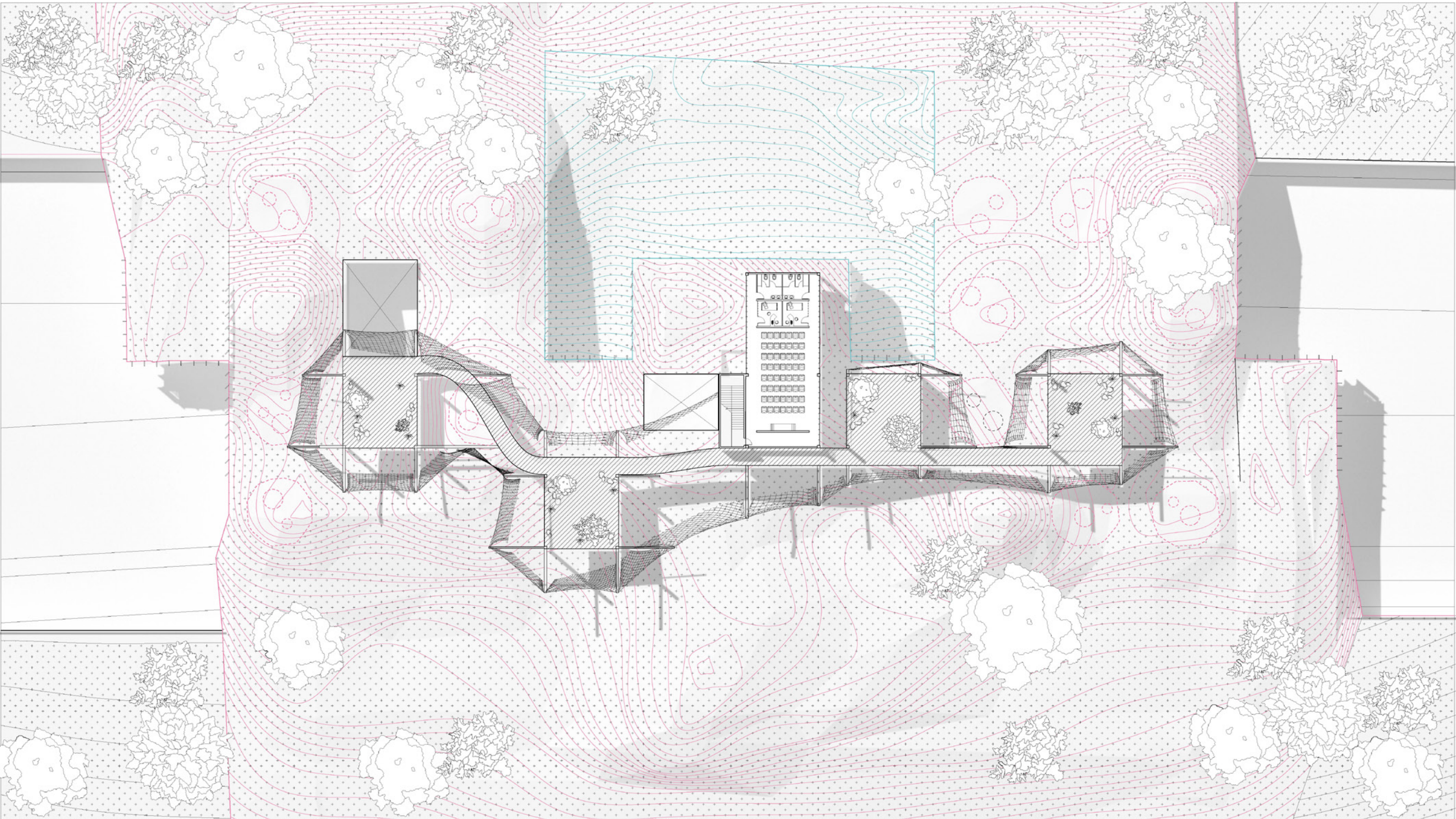


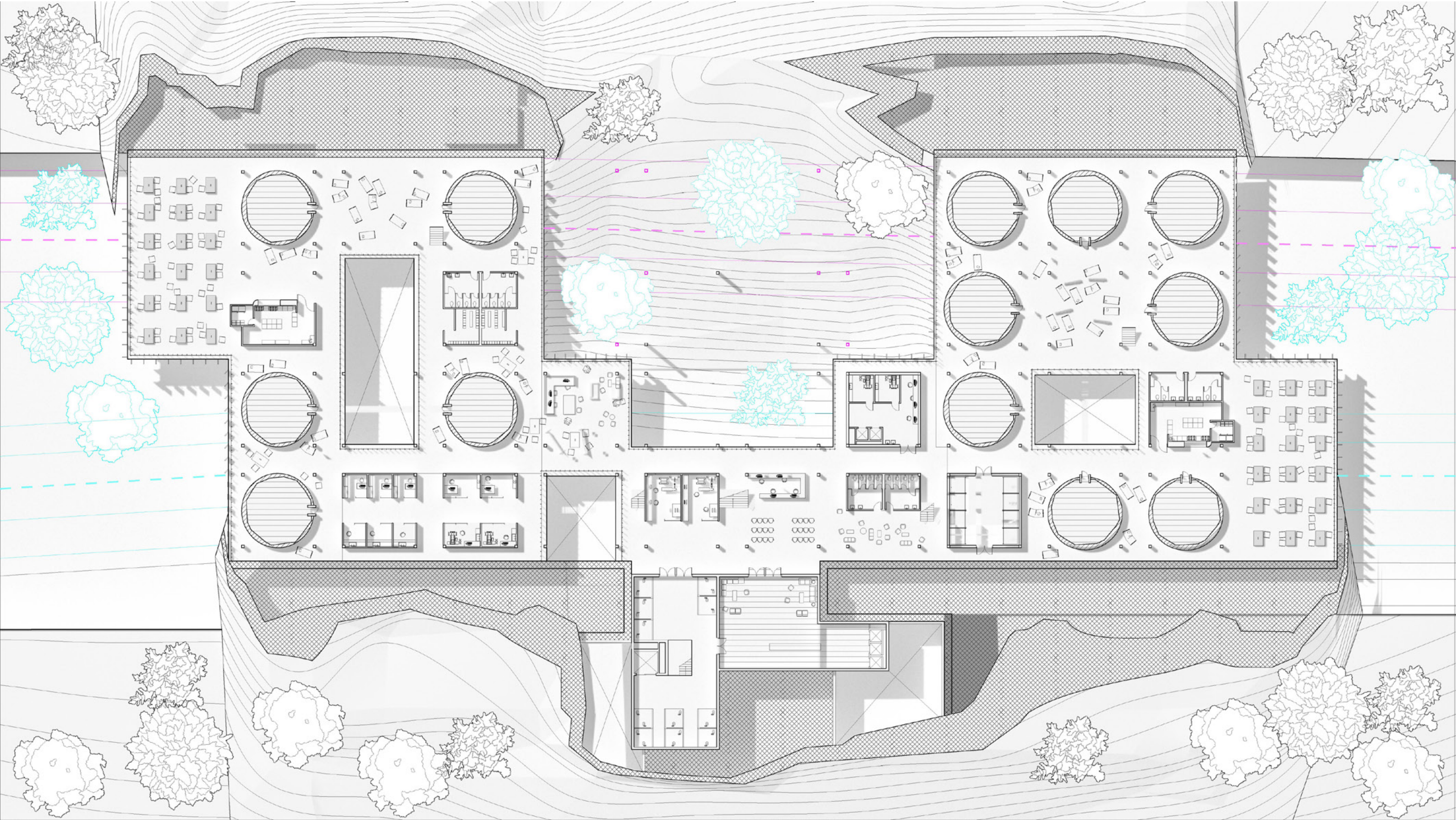
Endangered Animal Habitats



Potential Sites







“Plein Air”

Columbia GSAPP Advanced VI Studio
Professor Nahyun Hwang
In collaboration with John Trujillo
Site: Colfax, LA
Program: Research Facility

In sixty-one active sites across mainland United States “piles of discarded content from bullets, chemical makings from bombs, and raw explosives – all used or left over from the manufacture and testing of weapons ingredients – are doused with fuel and lit on fire, igniting infernos that can be seen more than half a mile away.

The burning waste is rich in lead, mercury, chromium, and compounds like nitroglycerin and perchlorate, all known health hazards.” Such plants are often near towns that feature abnormally high rates of sickness.

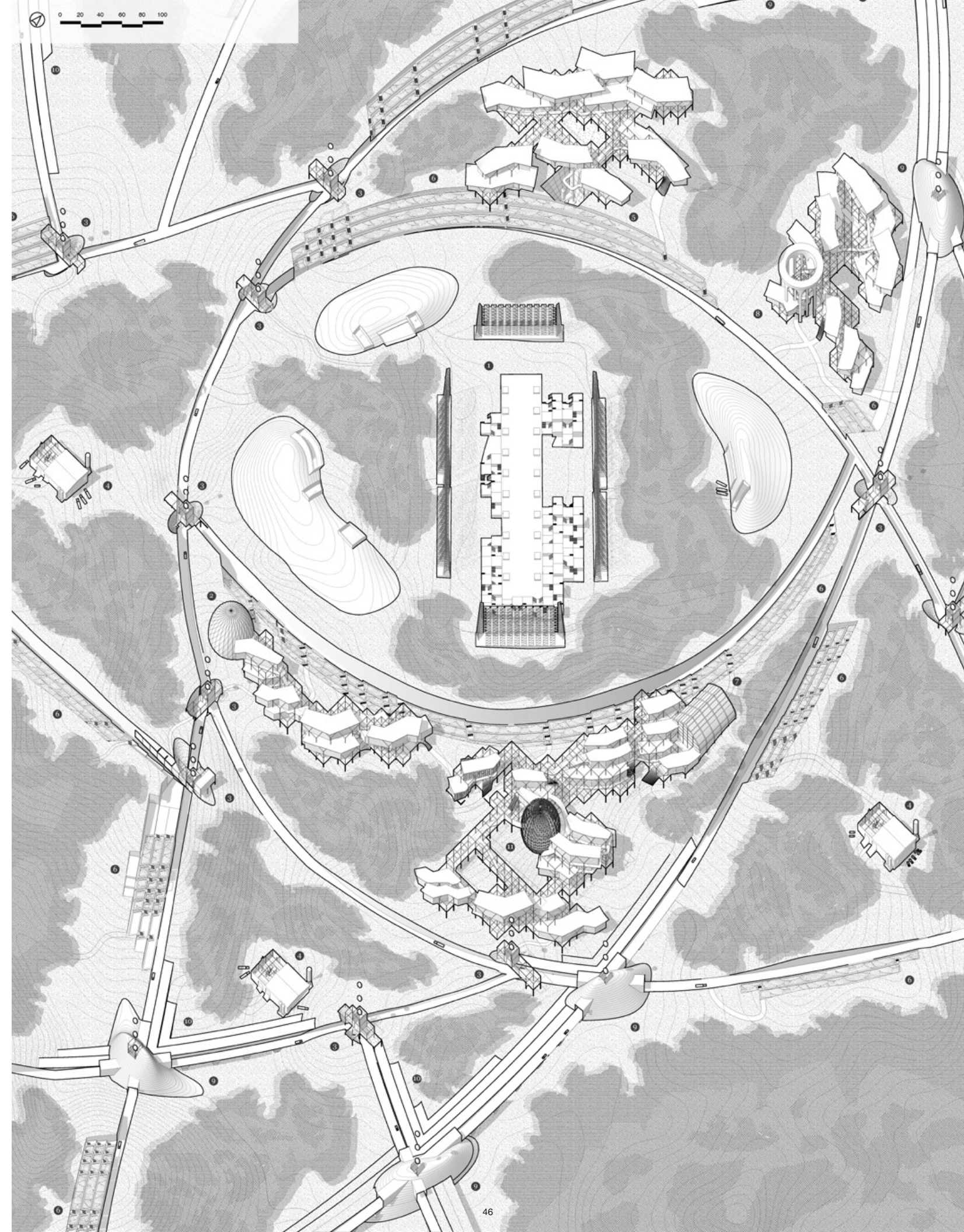
While congress banned American industries and localities from burning toxic waste openly, the Department of Defense was given a temporary exemption from this rule. It continues to neglect the expiration date of the sanctioned reprieve, as well as the few rules that do apply to their permitted open burns.

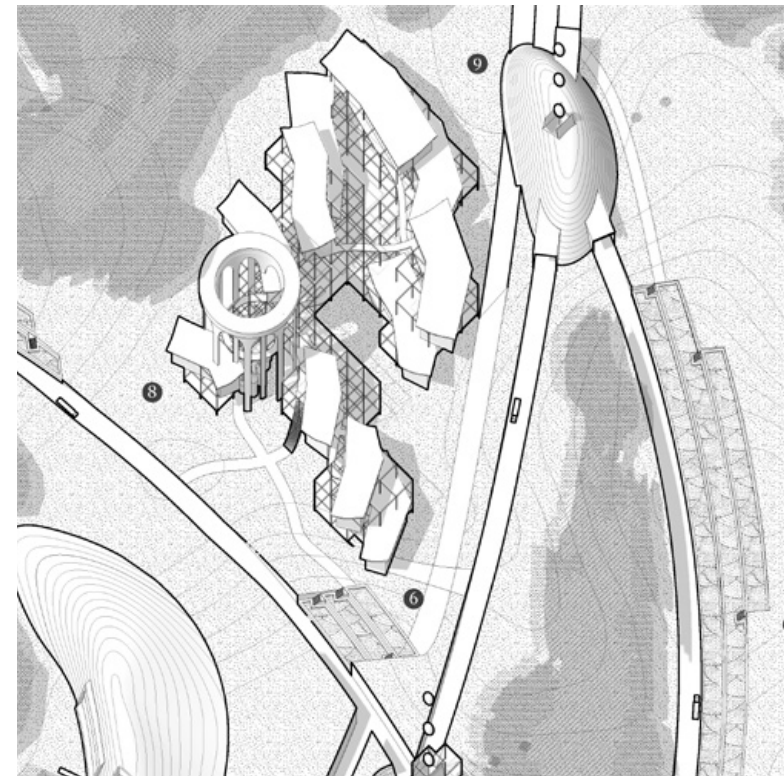
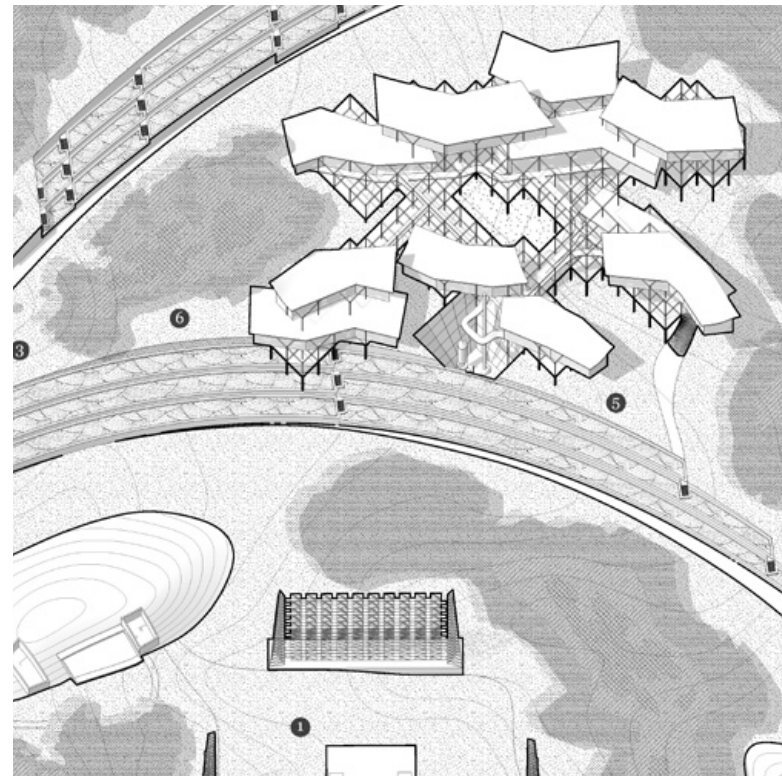
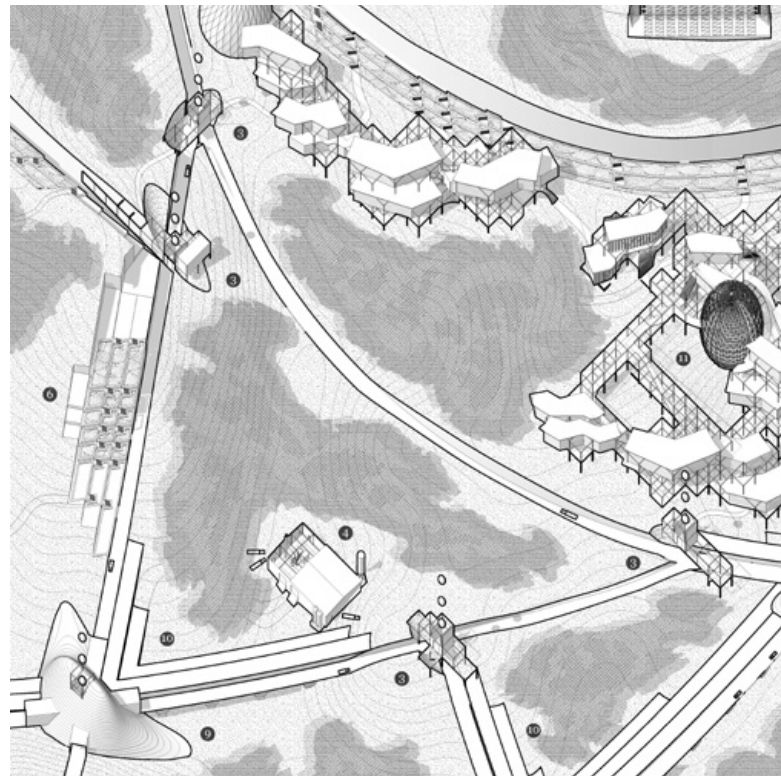
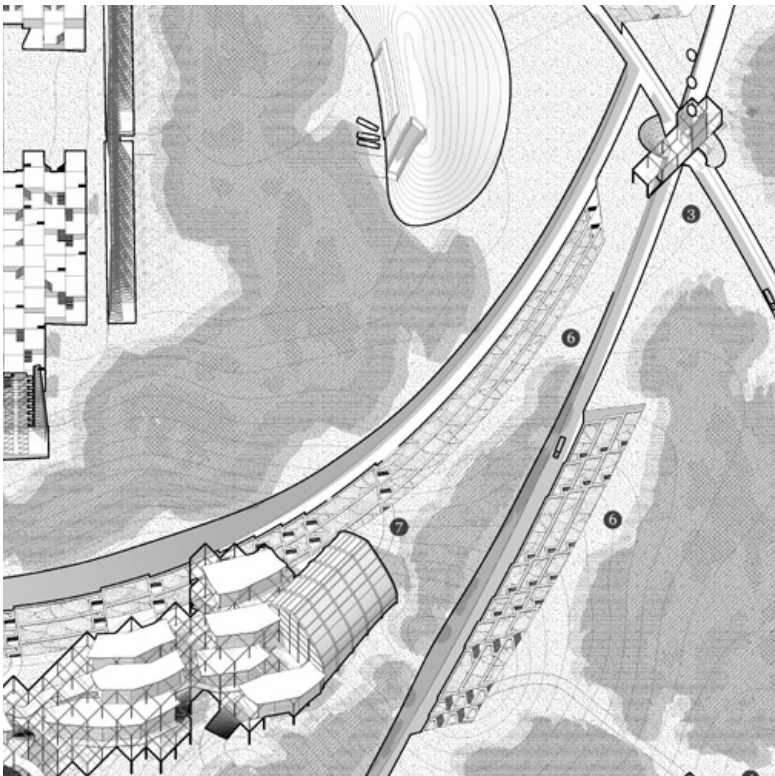
The ingredients of the burn emit harmful toxins and carcinogens that have been reported to cause serious health conditions upon exposure. Some have been linked to Agent Orange, and have also been found at Ground Zero.

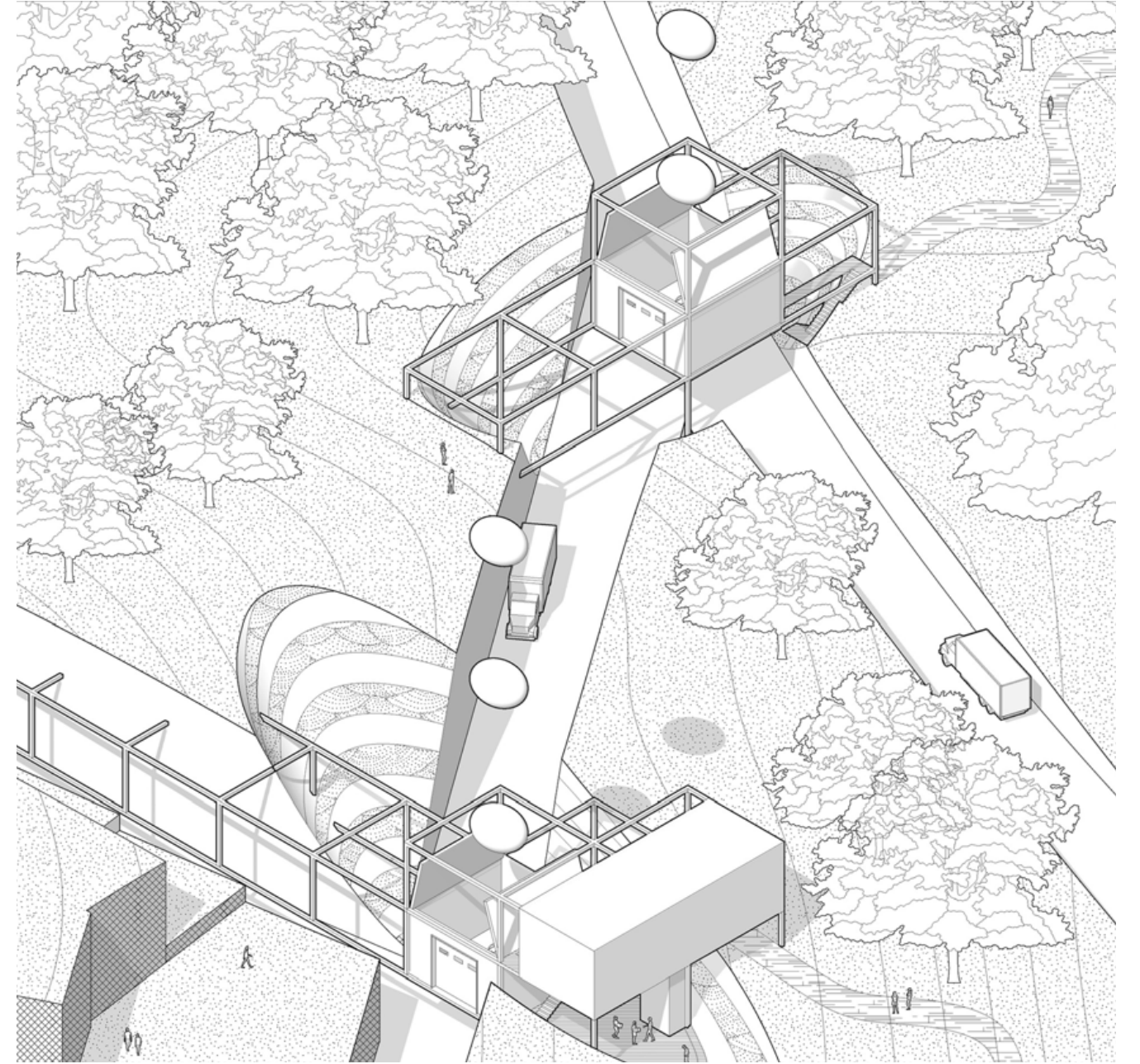
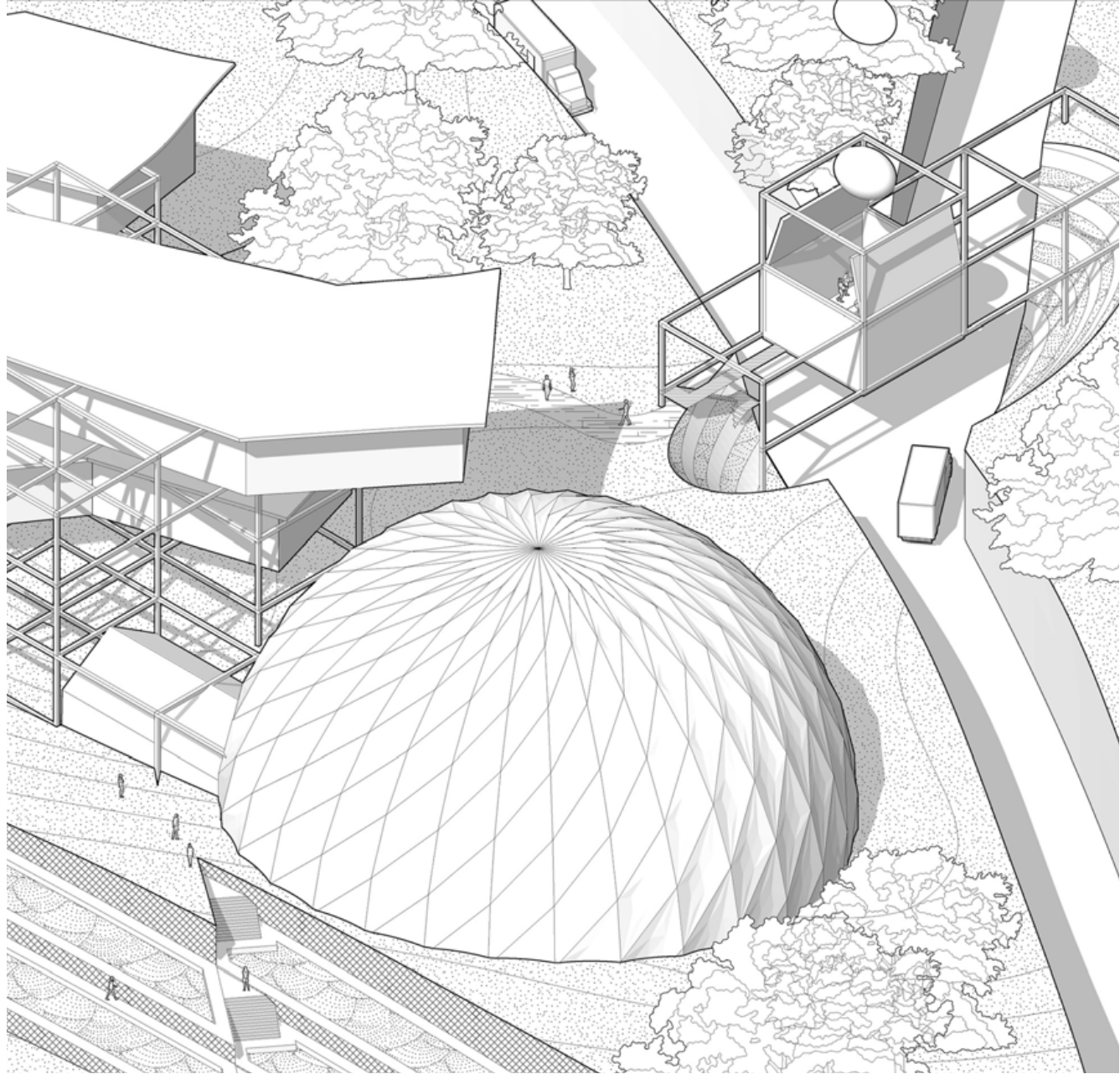
It was soon discovered that these open pit burns were sanctioned and somewhat regulated by the EPA, and allowed the DoD or any of its contractors to bypass standard pollution regulations in the name of national security.

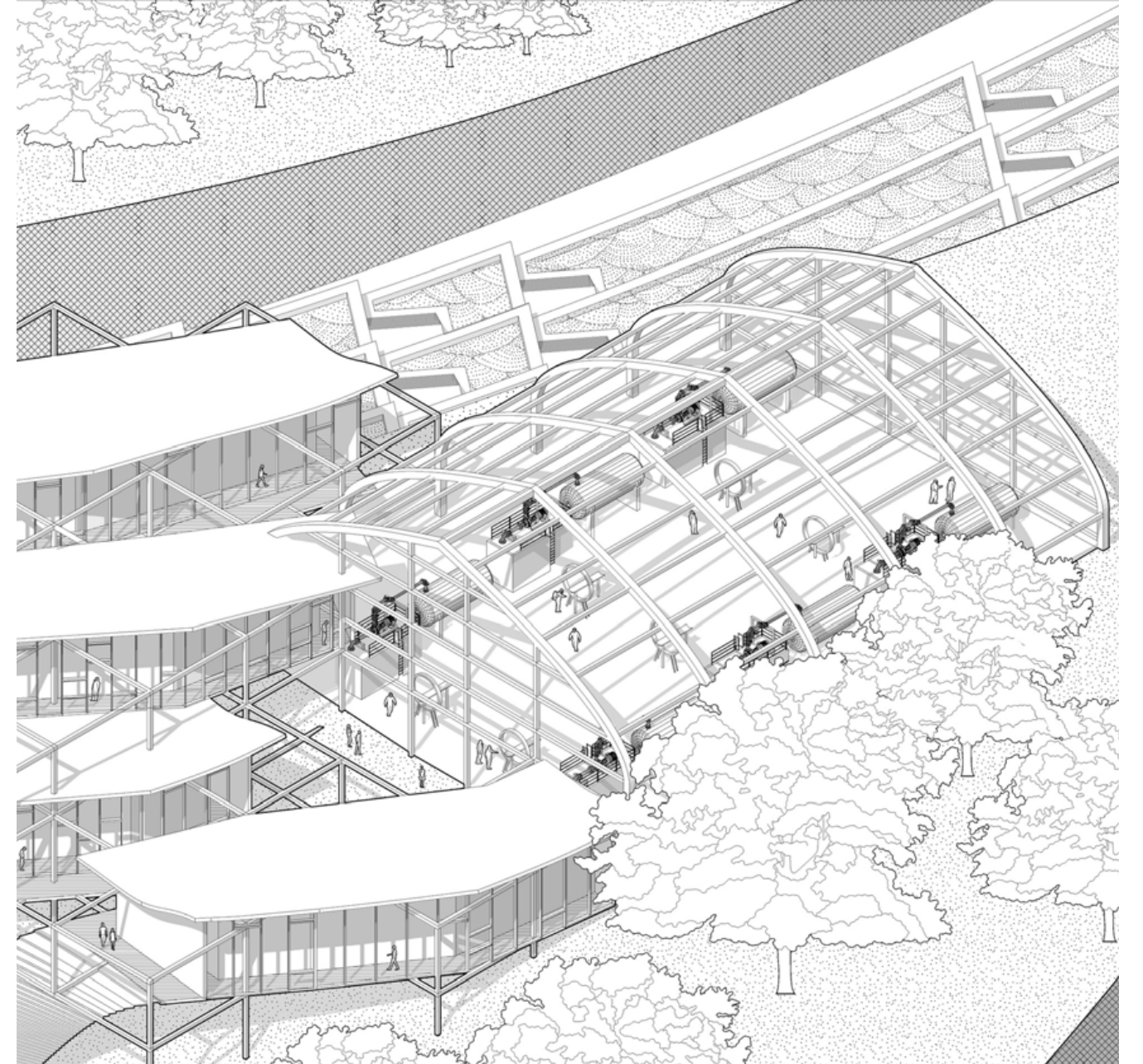
There are hundreds of sites abroad, most located at active bases and warzones - Iraq specifically had about 150 burn sites. Domestically, there are about 61 active burning sites.

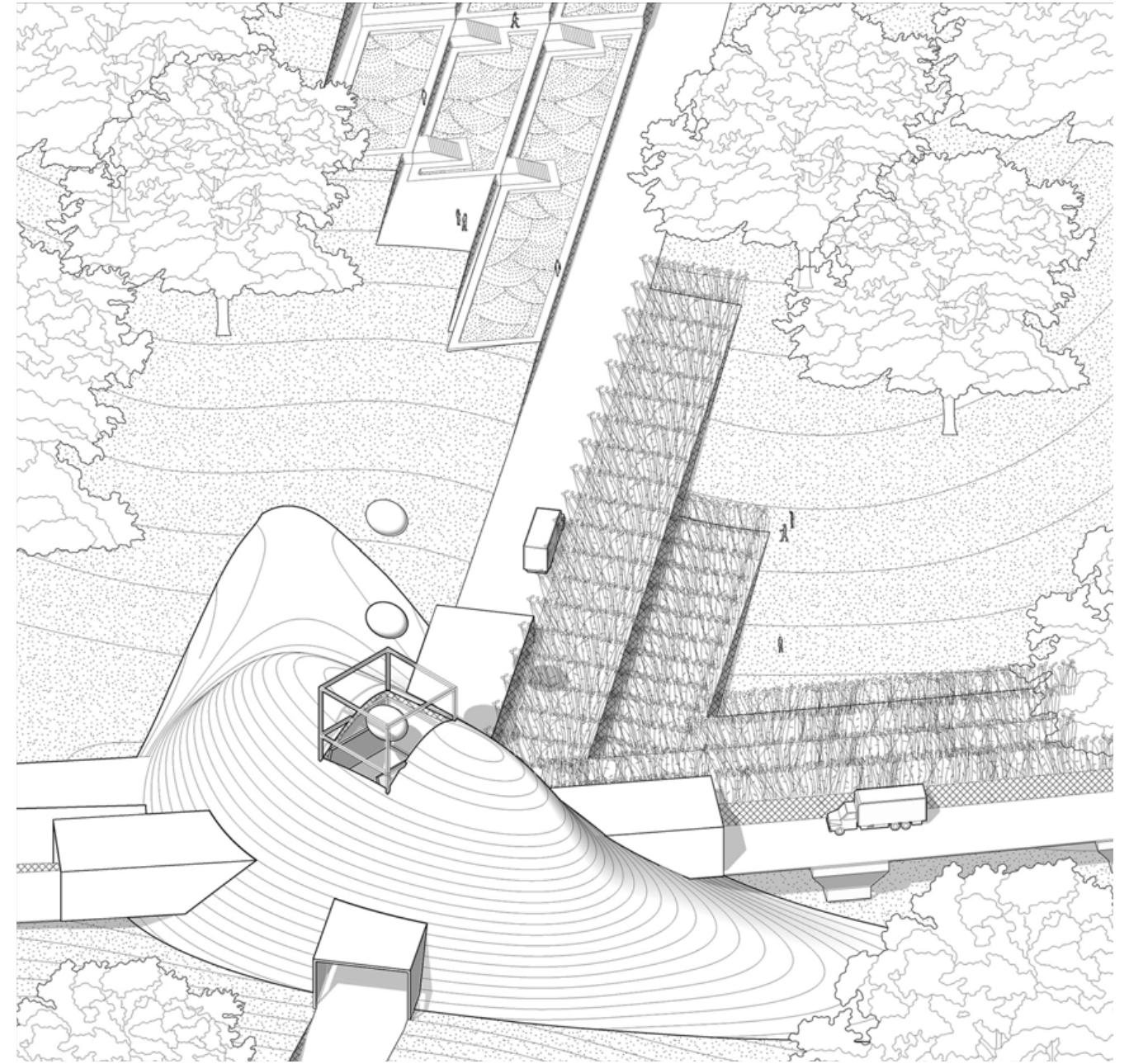
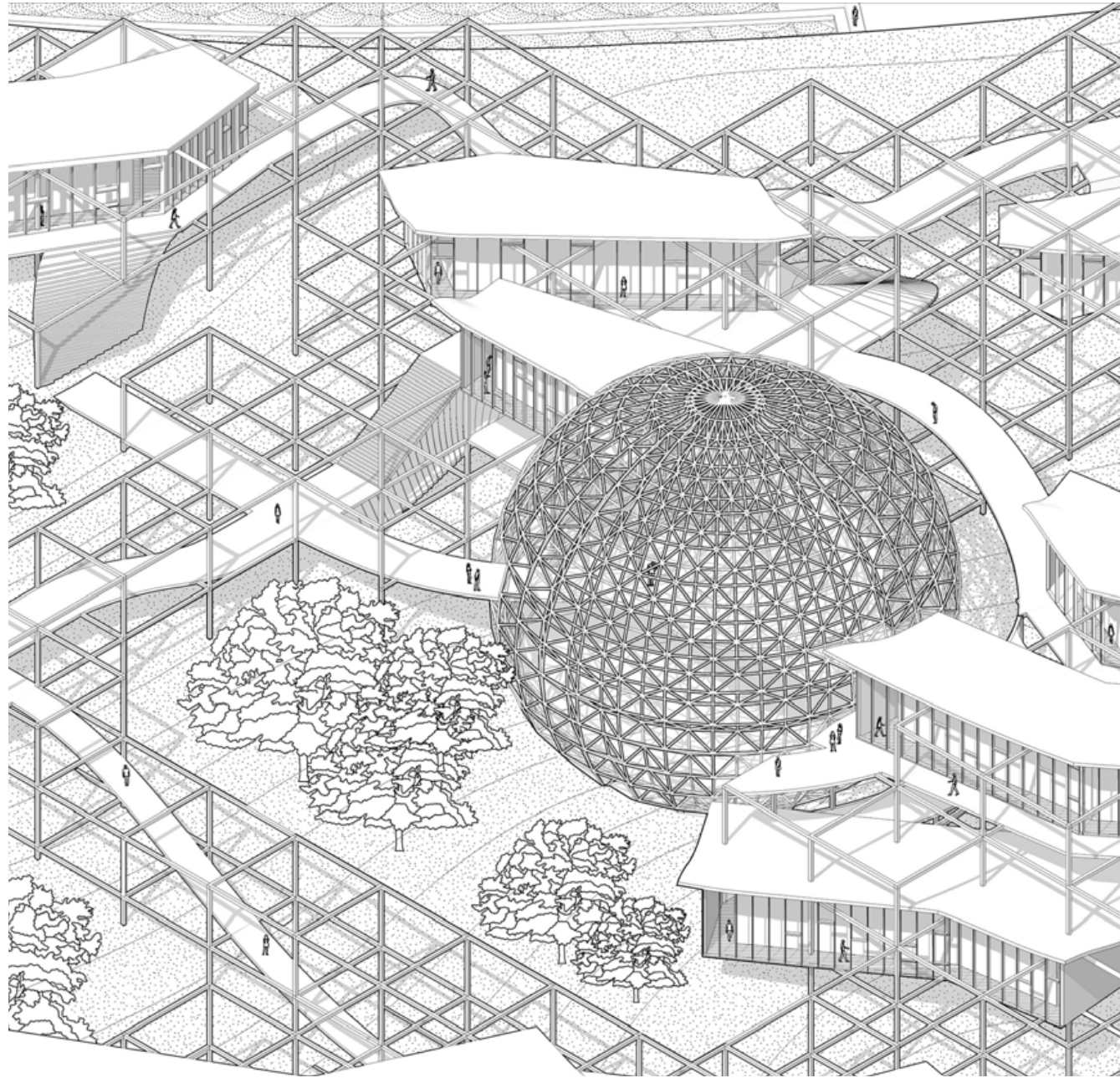
Most domestic sites are munitions factories located primarily next to poorer, rural communities. In addition to the DoD, private corporations and contractors also contribute heavily to the sanctioned burns.

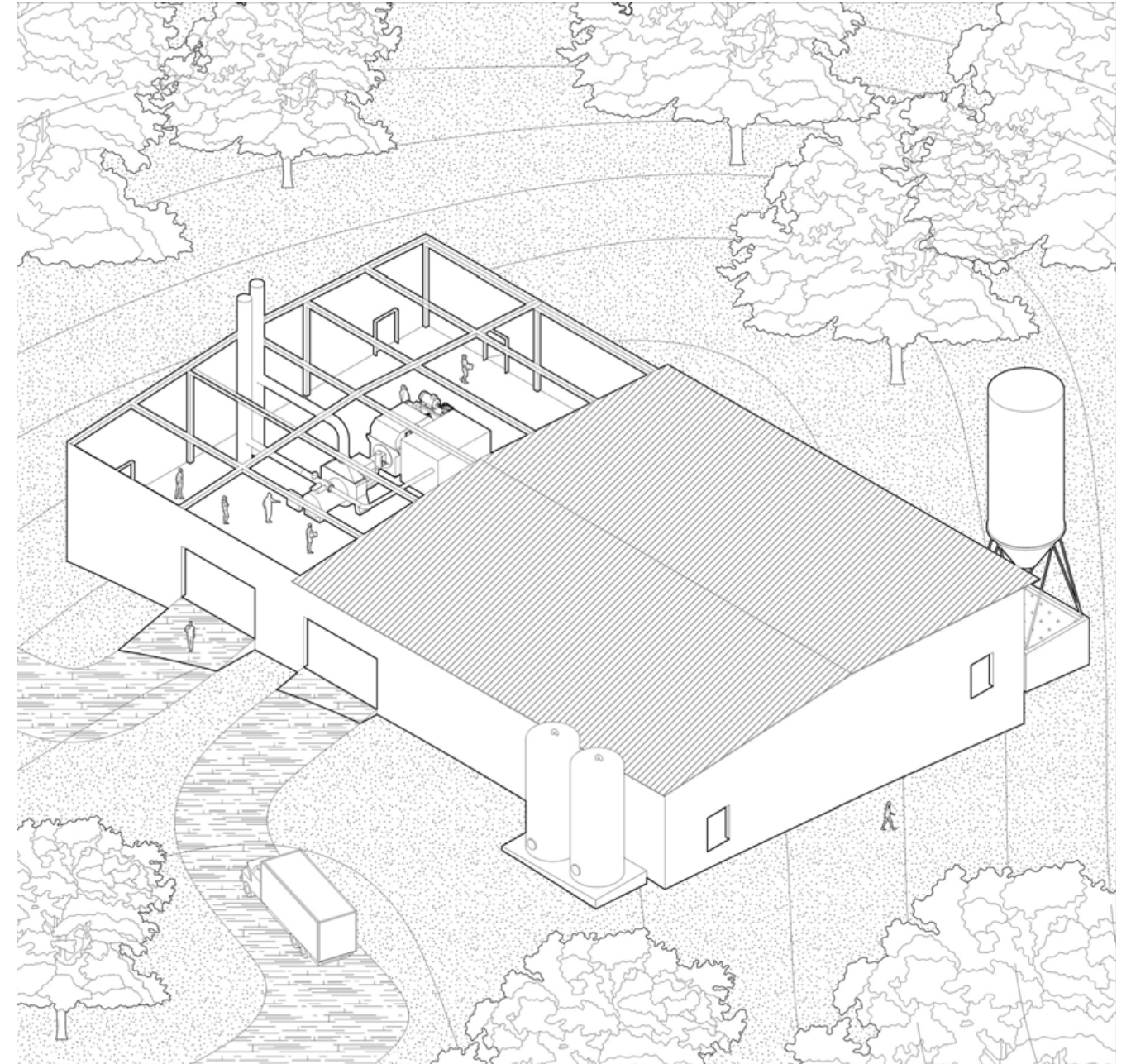
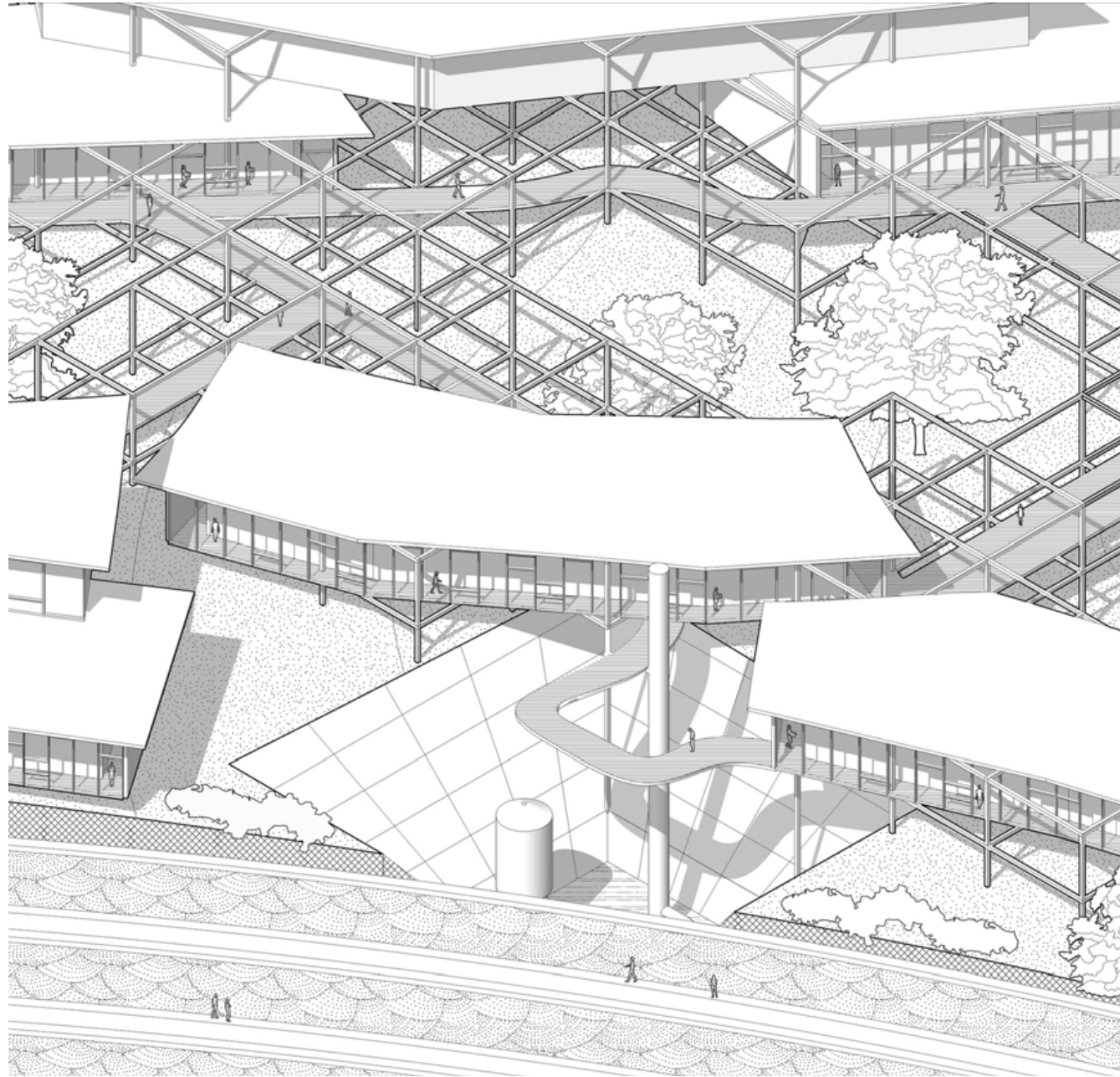












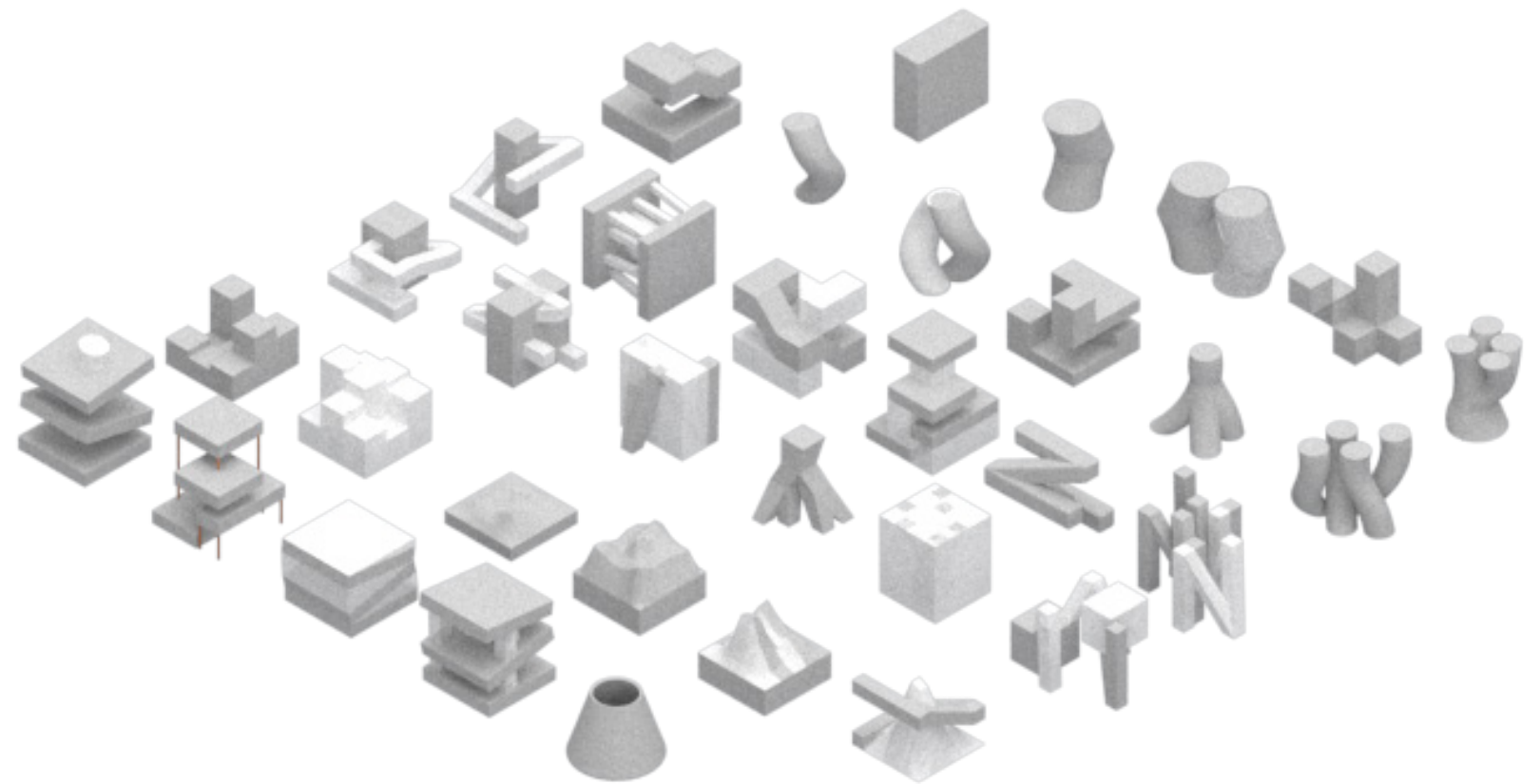
“Library for the Illiterate”

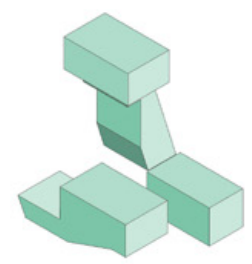
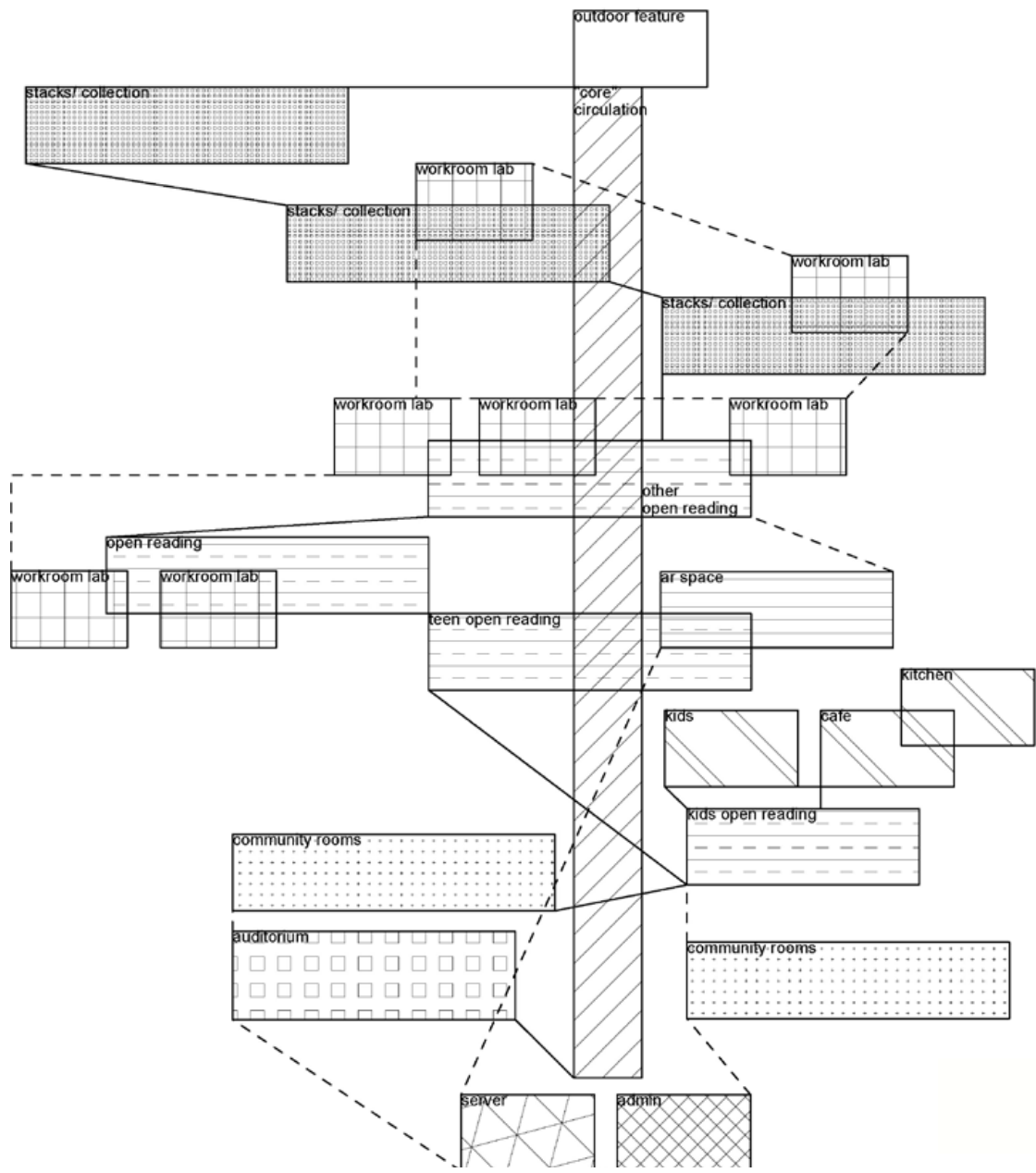
Columbia GSAPP Core II Studio
Professor Christoph Kumpusch
Site: New York, NY
Program: Library

Despite the wealth of information and communication accessible to us through the internet, misunderstanding and conflict magnify our differences. Conflict is born from the inability to sympathize or understand the differences of others' lives, backgrounds, and other social factors. In this era of free and endless data, it can be difficult to access the exact piece of information one might need to find in their life. An attempt to organize this information into a physical catalogue of information should be made; a Library of Memory would seek to combat the misunderstandings and prejudices that arise as a result of contextual or sympathetic illiteracy.

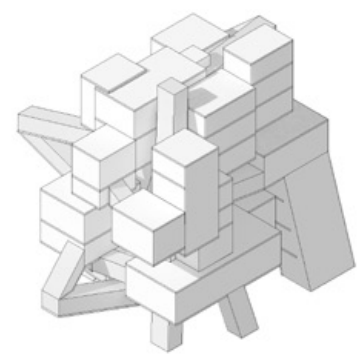
Historically, the physical form of the library had been dictated by the preservation of physical books that were kept within. As methods of data collection have evolved, the book container should also change form and program. Most recently, the tug-of-war between public and private space has given rise to a “third space” that exists between the two privacies. Of course, a library should hold books, serve as a community center, and provide a public area of gathering like many existing libraries. However, in this era of rapid change, information and history should be presented alongside the growth that communities experience in the applicable area.

In addition, the library community space should also evolve to create a space that would encourage understanding and discovery of unlike-minded people, instead of simply being a laptop-charging counter. Much like the “lab spaces” present in many new libraries, areas of learning “all attest to the notion that media consumption and creation lie on a gradient of knowledge production.” However, in addition to the upload of culture, these spaces can also serve as areas of experimentation for arguing conflicting ideas. Several ideas can be used to facilitate understanding: anonymous communication/argument areas, bulletin board- styled message areas that focus on controversial topics, small yet numerous collection areas for controversial topics in modern news, and audio/visual memory recording spaces. With the advent of virtual reality, experiences are also able to be recorded and archived. A library of experiences would be an engaging way for people of different backgrounds to understand the hardships each other's group may face.

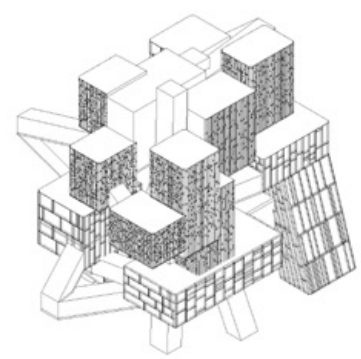




community spaces



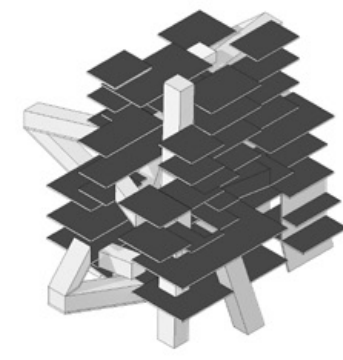
combined program



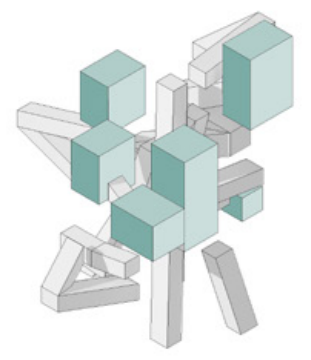
library proposal



stacks



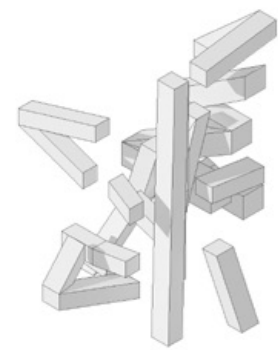
floor plates



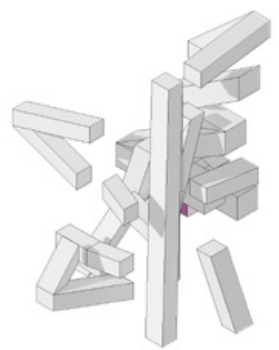
workroom / lab



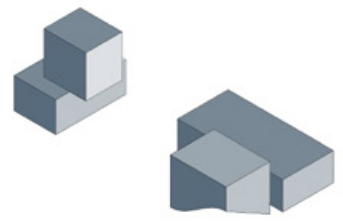
cafe



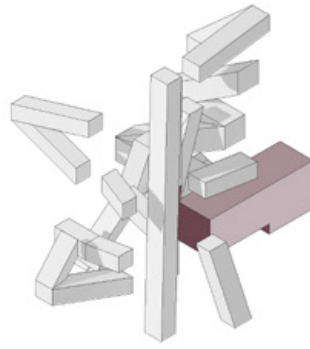
workroom / lab



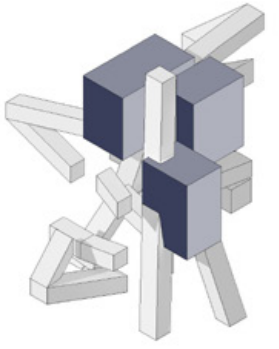
cafe



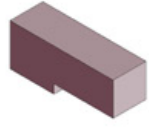
open reading



auditorium



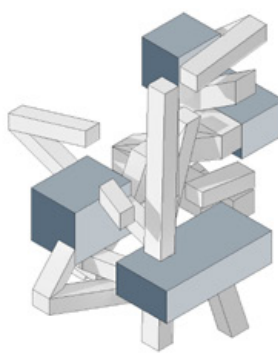
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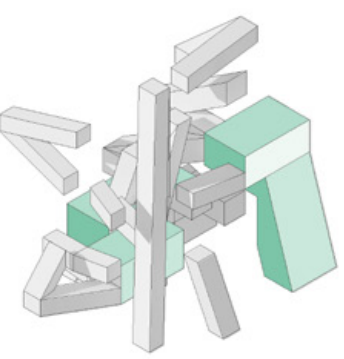
auditorium



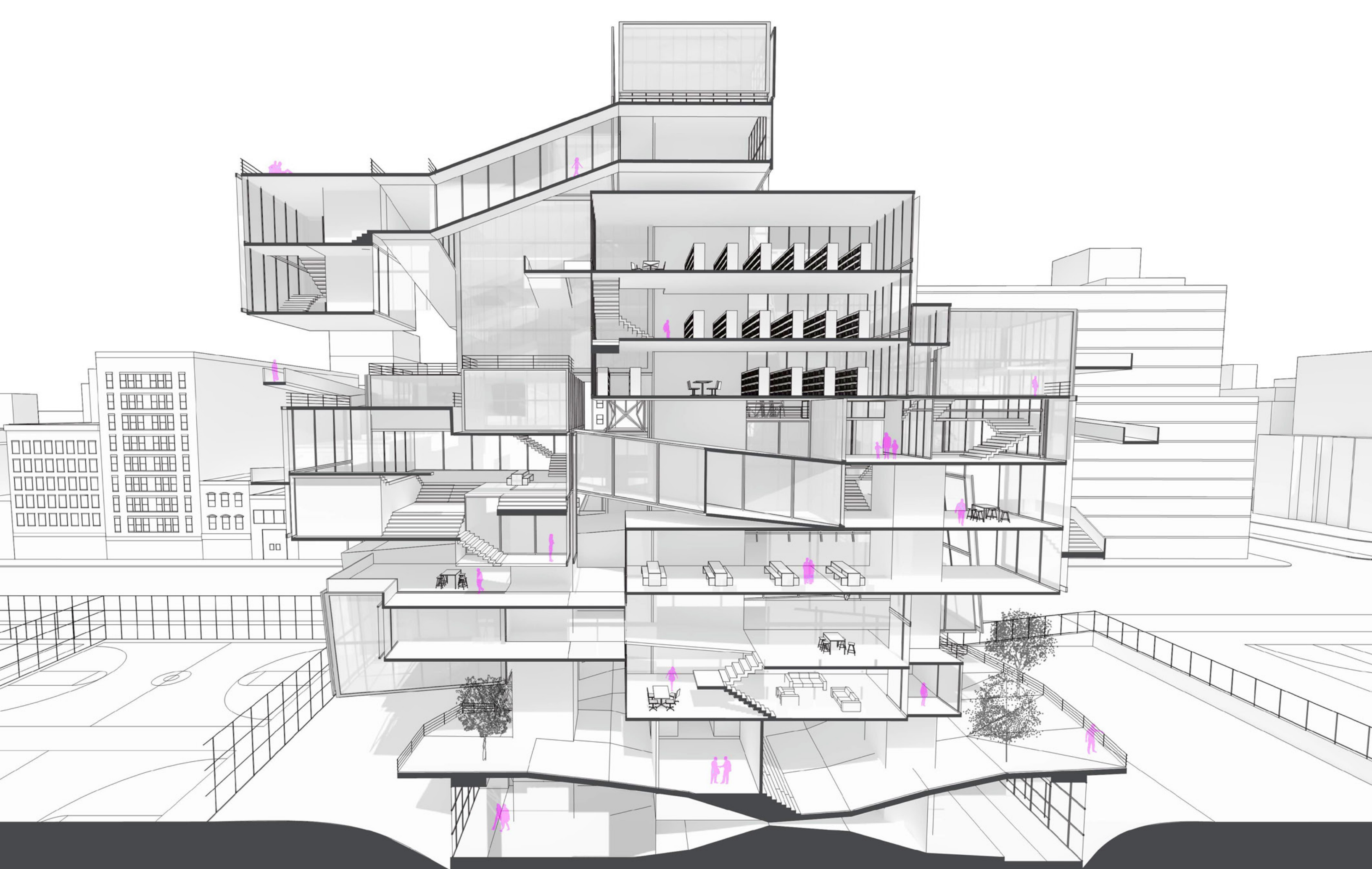
circulation

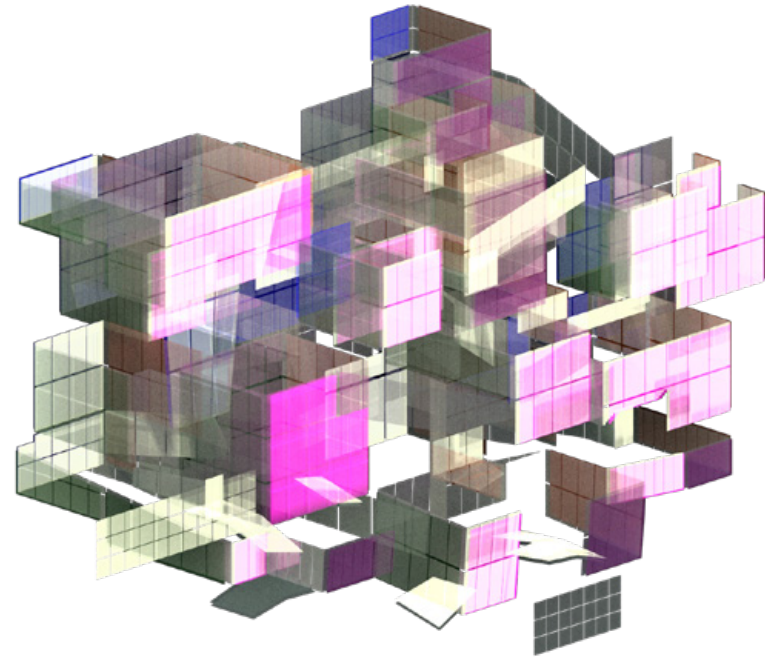


open reading



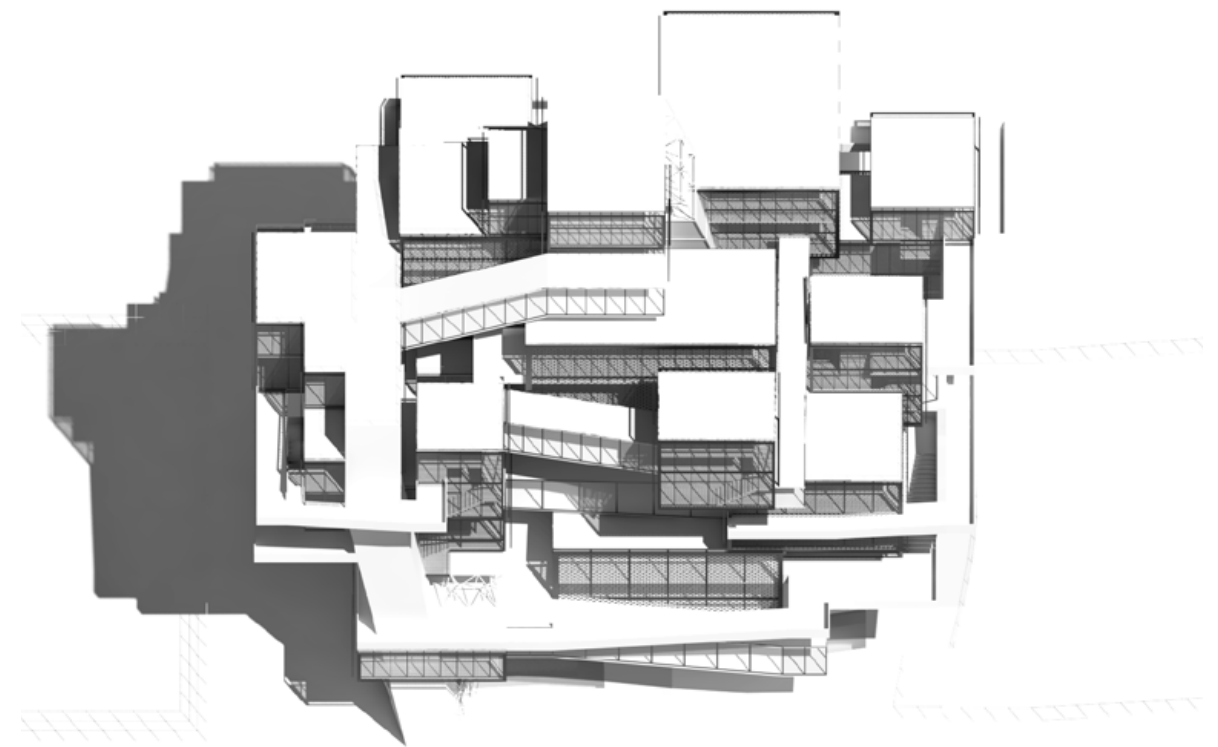
community spaces

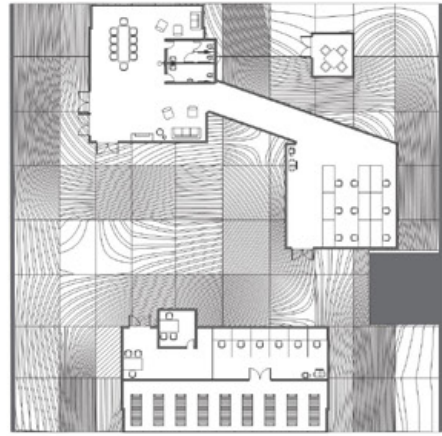




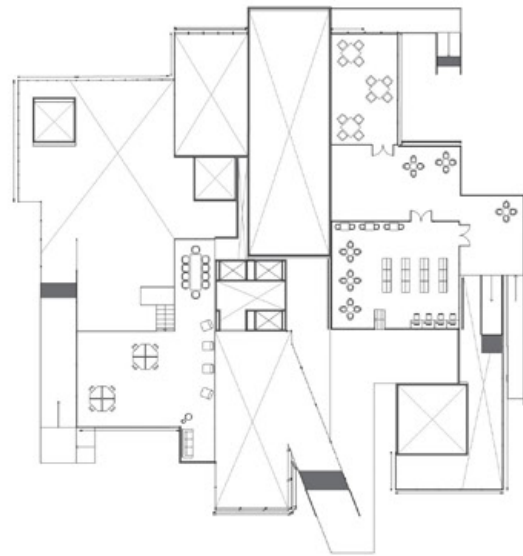
Ultimately, the library would continue to serve its purpose as a hub of learning, meeting, and equality. However, given NYC's diverse background and America's constant conflict with people of different backgrounds, lifestyles, and beliefs, the library could evolve to become kind of a temple of moderation; a sacred space where beliefs mold to fact and reality, and where personal reality evolves as a result of learning.

The library could even mimic the structure of the information cloud, without home or central base. "Where does the library start and where does it end, in relation to its physical and virtual territories?" Learning is enhanced by speech and experience, where previously it had been presented only by text and writing.

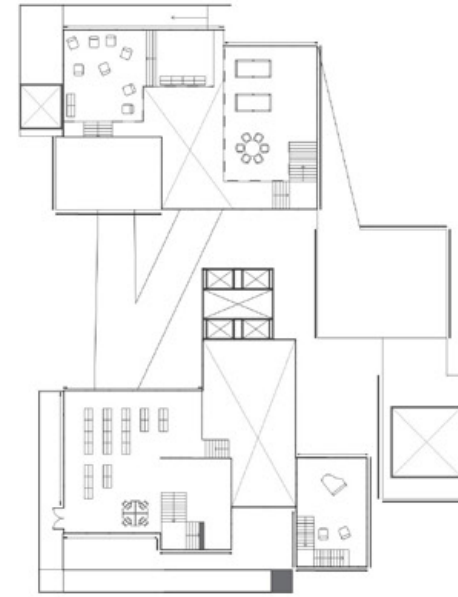




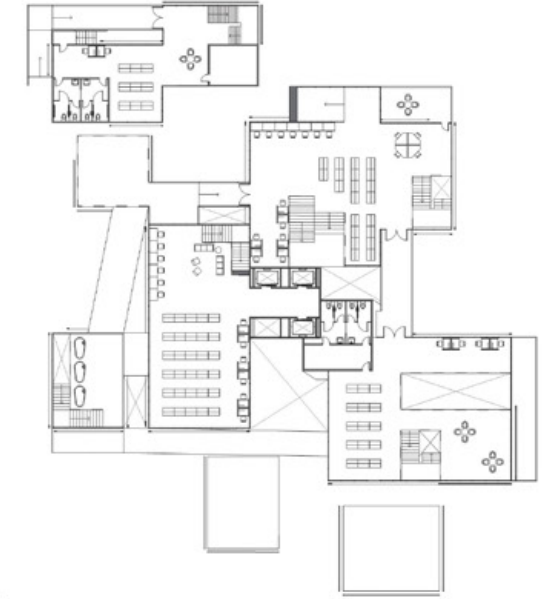
basement level



floor 2



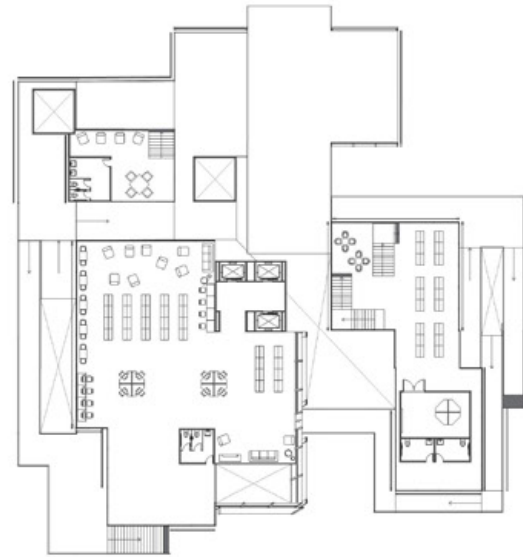
floor 5



floor 8



ground level



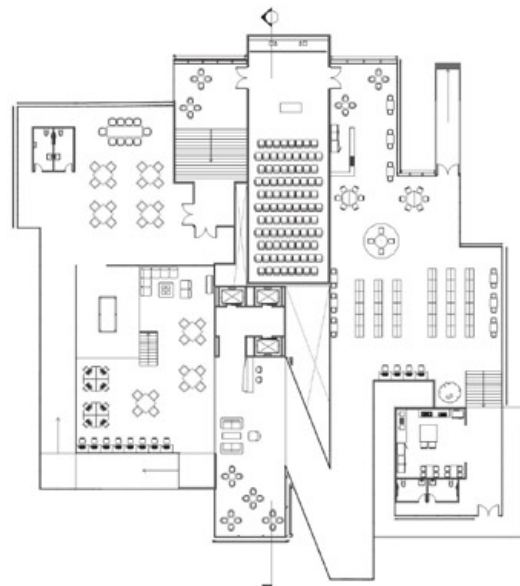
floor 3



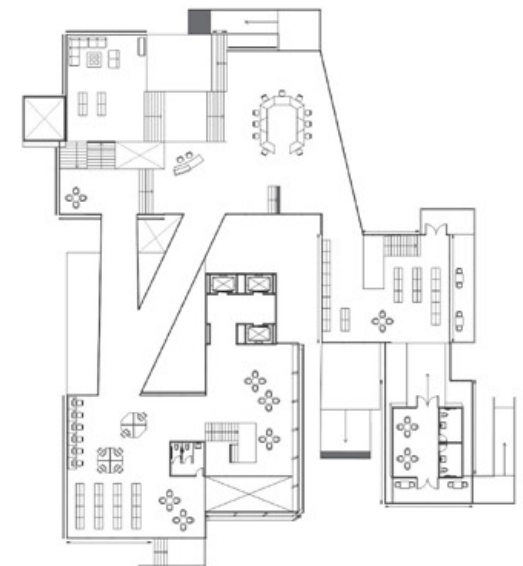
floor 6



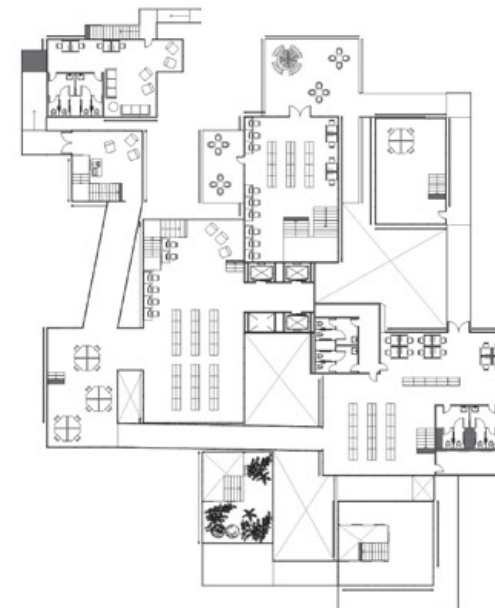
floor 9



floor 1



floor 4



floor 7



floor 10



“Risk Reversal”

Columbia GSAPP Advanced VI Studio
Professor David Benjamin
In collaboration with Takashi Honzawa
Site: Los Angeles, CA
Program: Site Remediation + Habitation

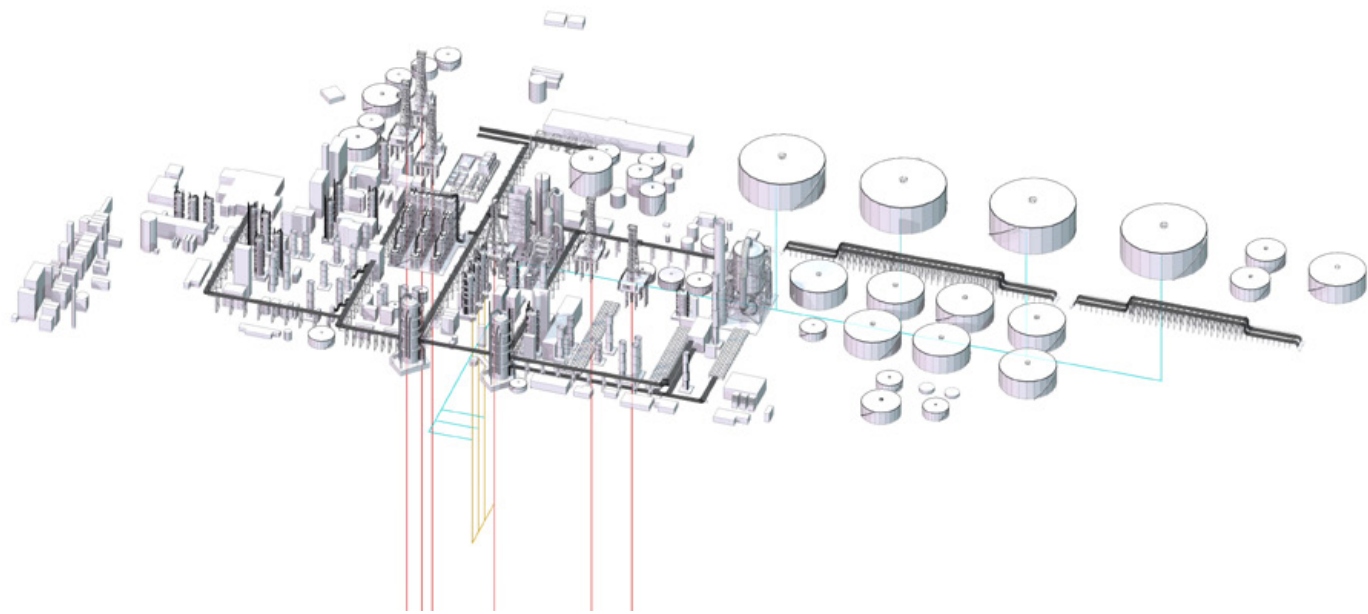
Adaptive infrastructure based on outdated energy productions is created using tools that take advantage of the varying climate of 2040. Los Angeles’ physical and social infrastructures need to reflect the reality of energy scarcity.

Our strategy is to provide a framework of living that would be the new foundation for people to fill in - a model for a new way of living with climate change and uncertain weather patterns. The project takes existing oil extraction practices and reverses them in 6 phases - from carbon extraction to carbon sequestration.

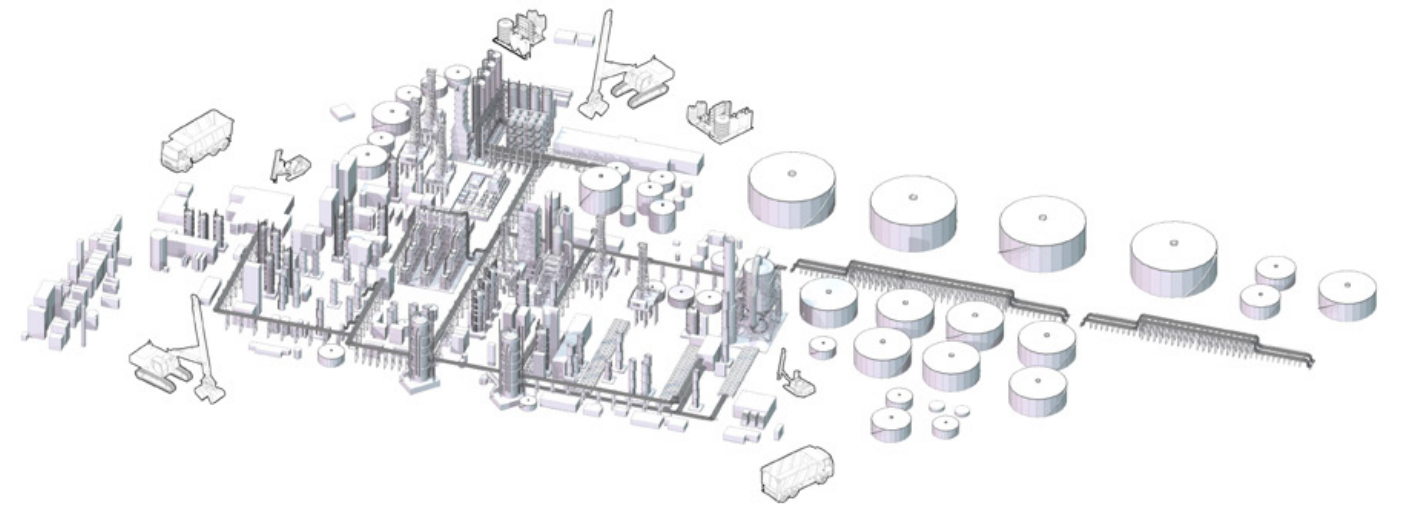
The project will reclaim the Valero Oil Refinery and drill sites into alternative energy production and experimental carbon capture methods and Introduce car-exclusionary interventions around these production sites to remove public health risk.

Programs of these interventions will demonstrate a new model for living with these alternative modes of energy production and carbon capture - food, housing, etc. Interventions are justified with real-world data and revenue studies to offset costs and generate profit from new energy production and resident health.

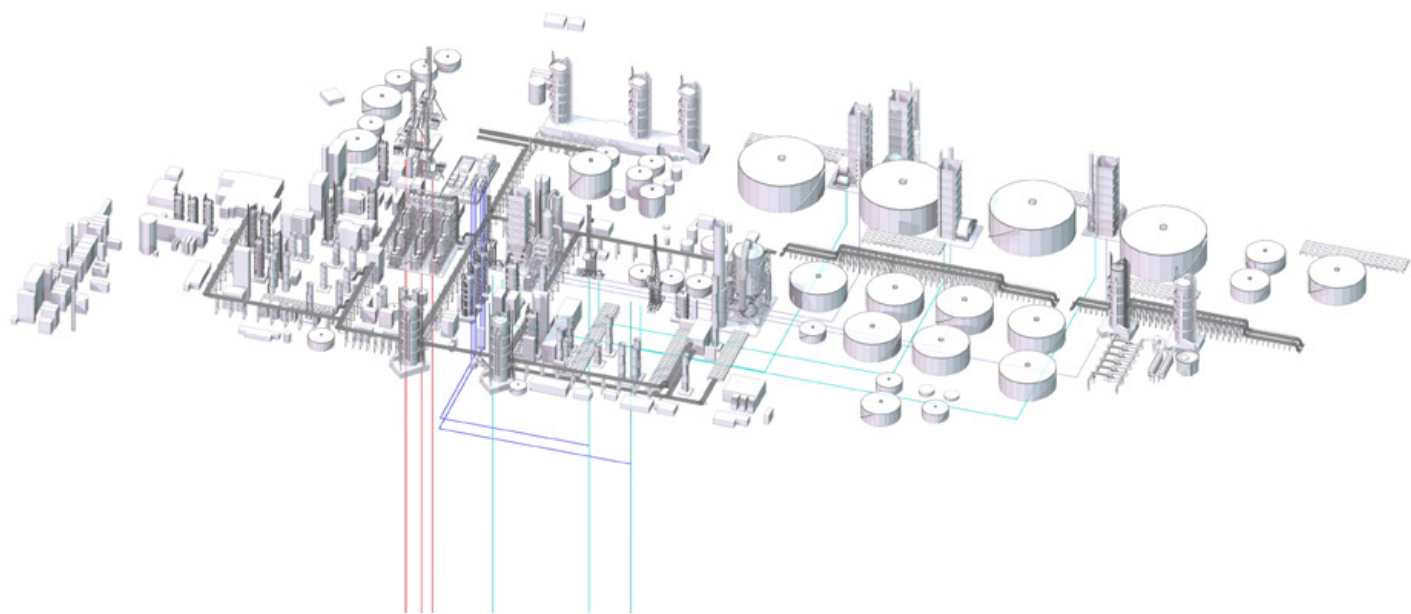




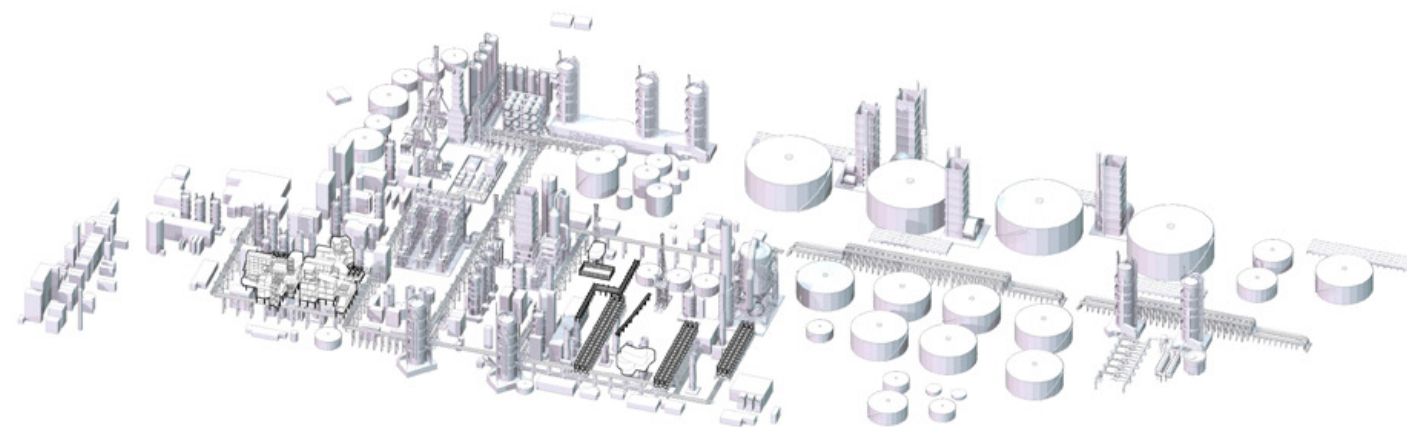
Present Refinery Site Condition
(2022)



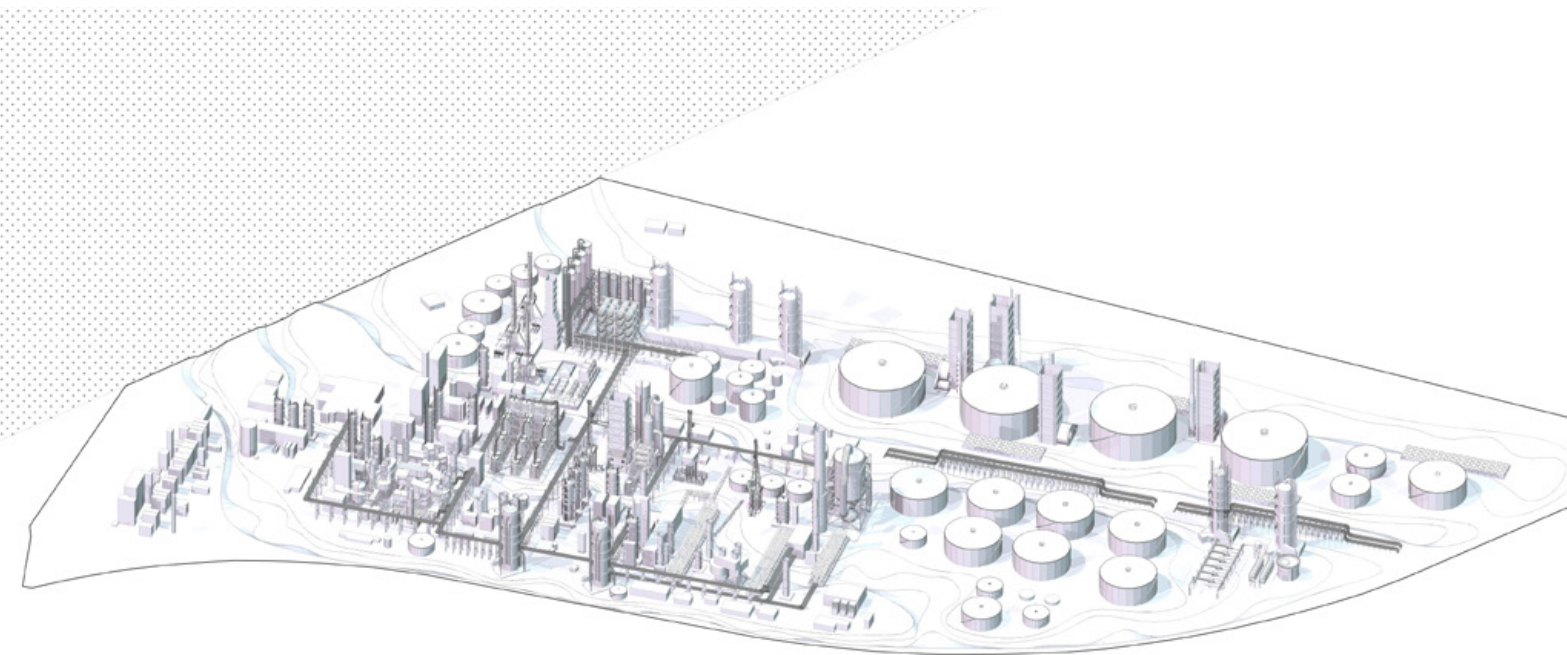
Site Remediation
(2025)



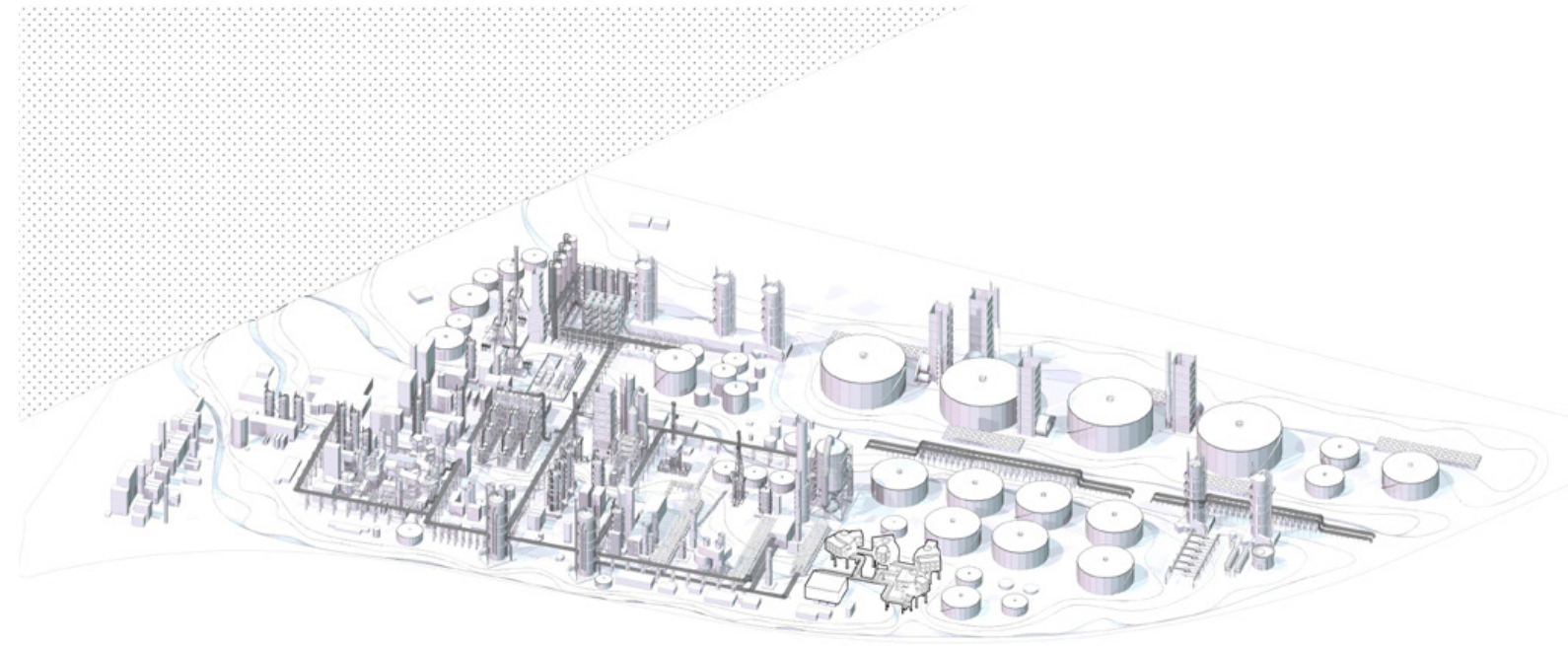
Geothermal Energy Refitting of Former Oil Wells
(2025)



Experiemental Carbon Capture Technology Implementation
(2027)



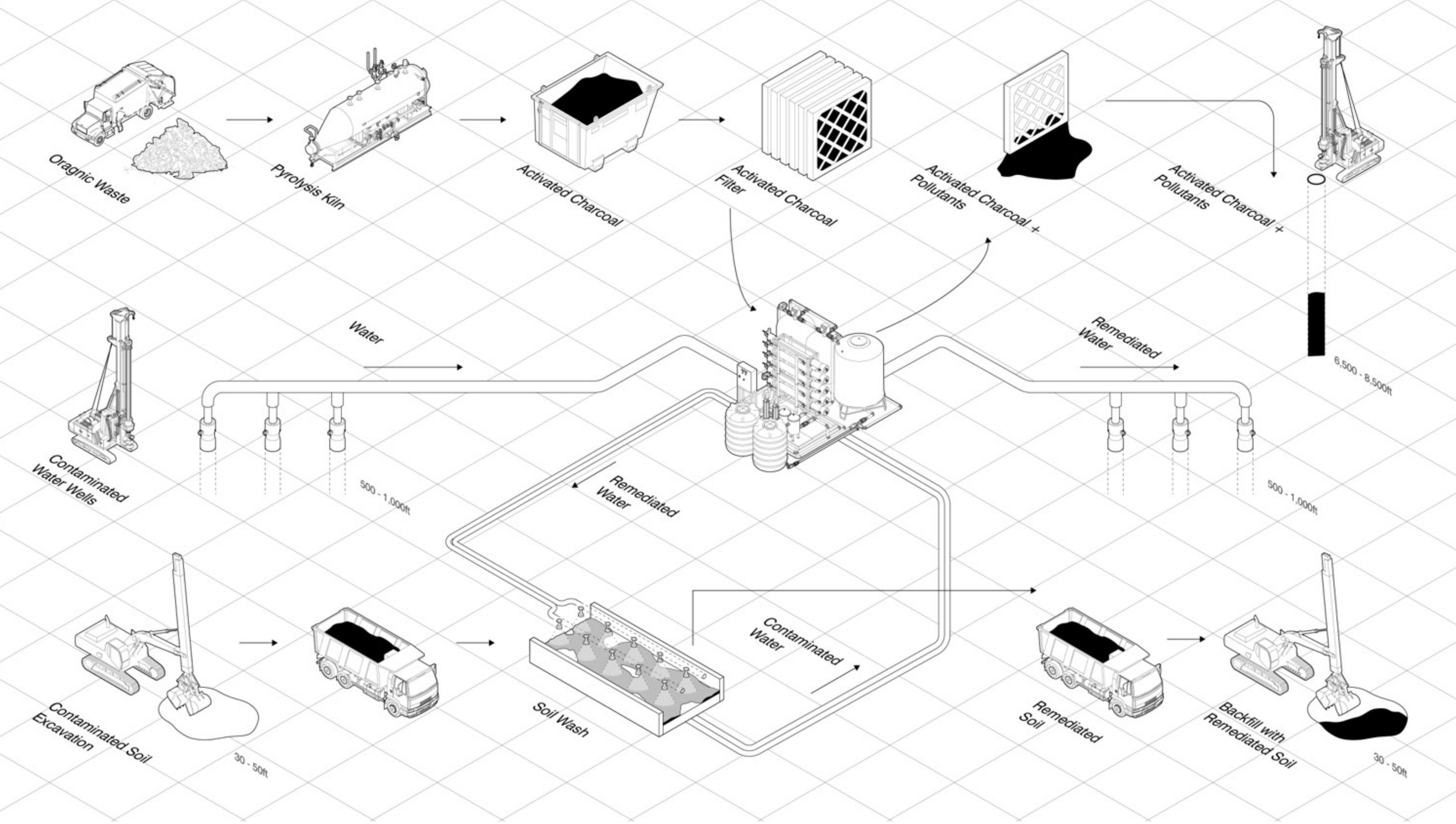
Remediation Wetland Construction
(2030)



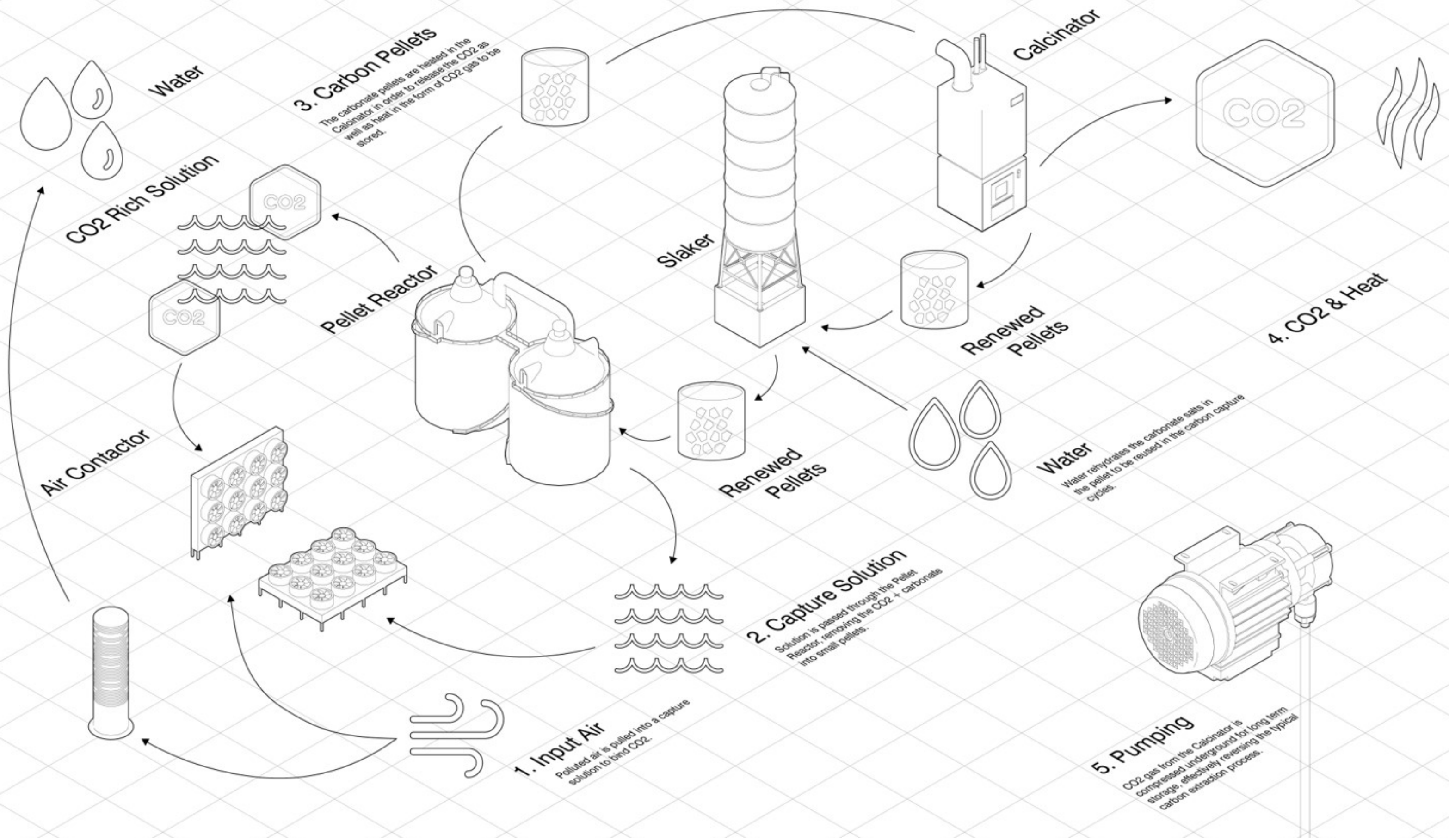
Housing Cross-Laminated Timber Construction
(2035)



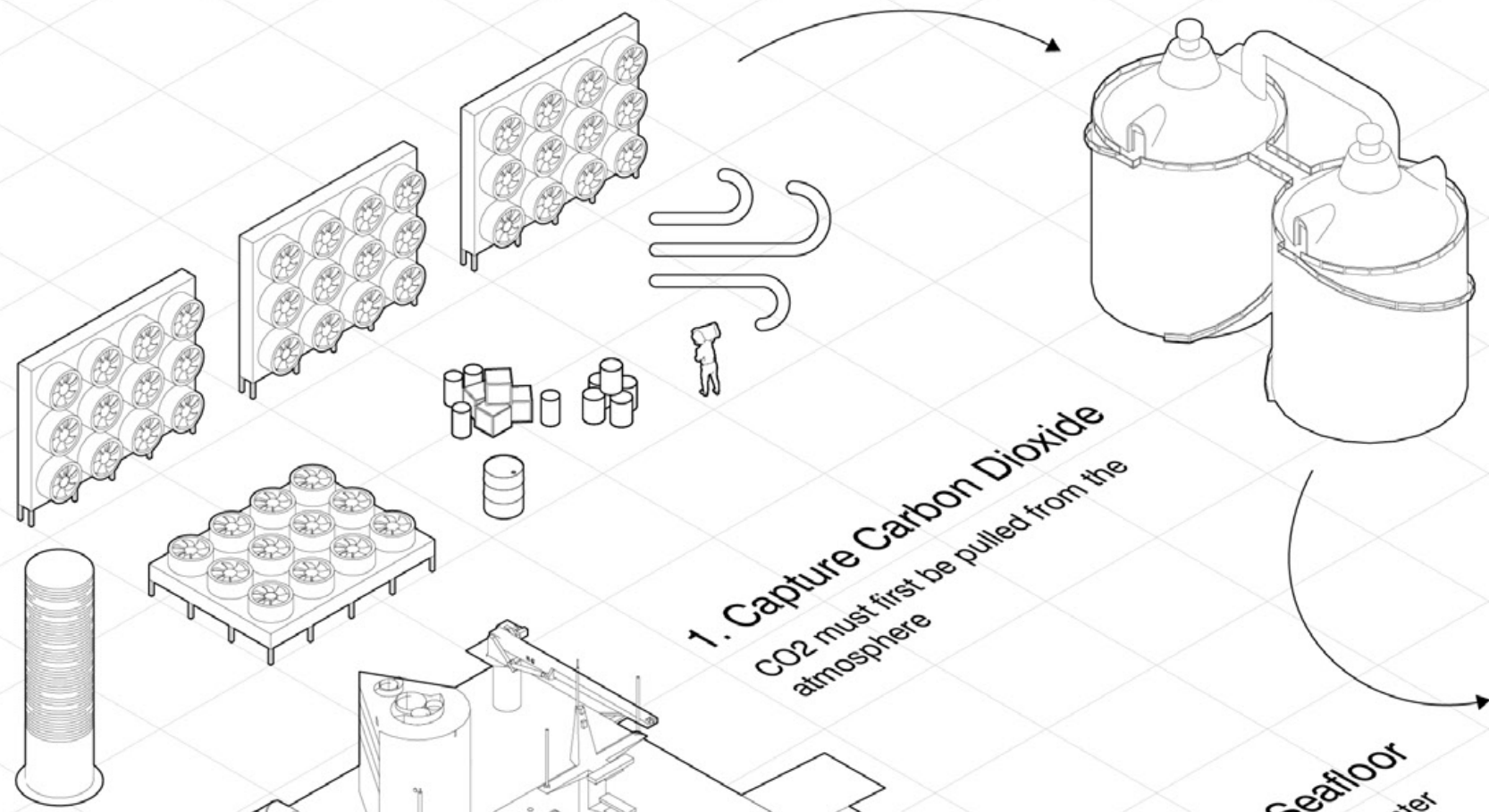




The IPCC AR6 Report of 2021 indicates that the remaining carbon budget to remain within 1.5°C of global warming is 400 billion tons CO2. If the current rate of emission continues, the global carbon budget will run out in 9 years, and the global CO2 emission will reach 1.2 trillion tons.



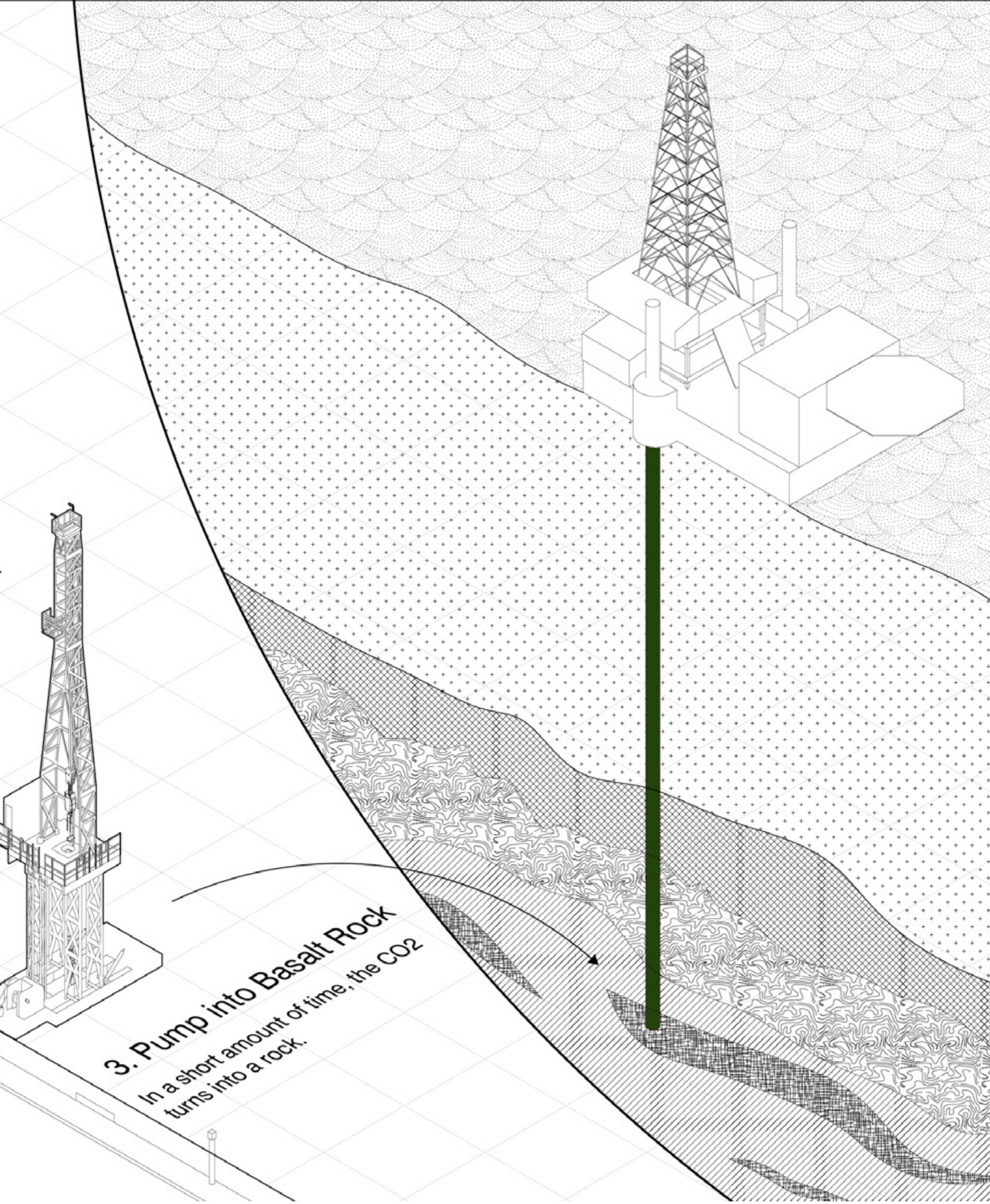
28 million metric tons of CO₂ can be sequestered at the Wilmington refinery each year. There are 573 refineries in the world (461 international and 112 United States).



1. Capture Carbon Dioxide
 CO2 must first be pulled from the atmosphere

2. Pump Below Seafloor
 CO2 is pumped down the water column, into the sub seafloor.

3. Pump into Basalt Rock
 In a short amount of time, the CO2 turns into a rock.



If the same effort can be replicated at all of the refineries in the world, 7.08 billion metric tons of CO2 can be sequestered every year, and by 2050, 170 billion metric tons of CO2 can be sequestered. This will achieve 30% of the effort to meet the IPCC's carbon budget goal.



“Waterscape”

Columbia GSAPP Architecture Technology V
 Professor David Benjamin
 In collaboration with Urechi Oguguo, Adela Locsin, & Lauren Scott
 Site: Brooklyn, New York, NY
 Program: Green Energy/ Remediation + Industrial Workplace

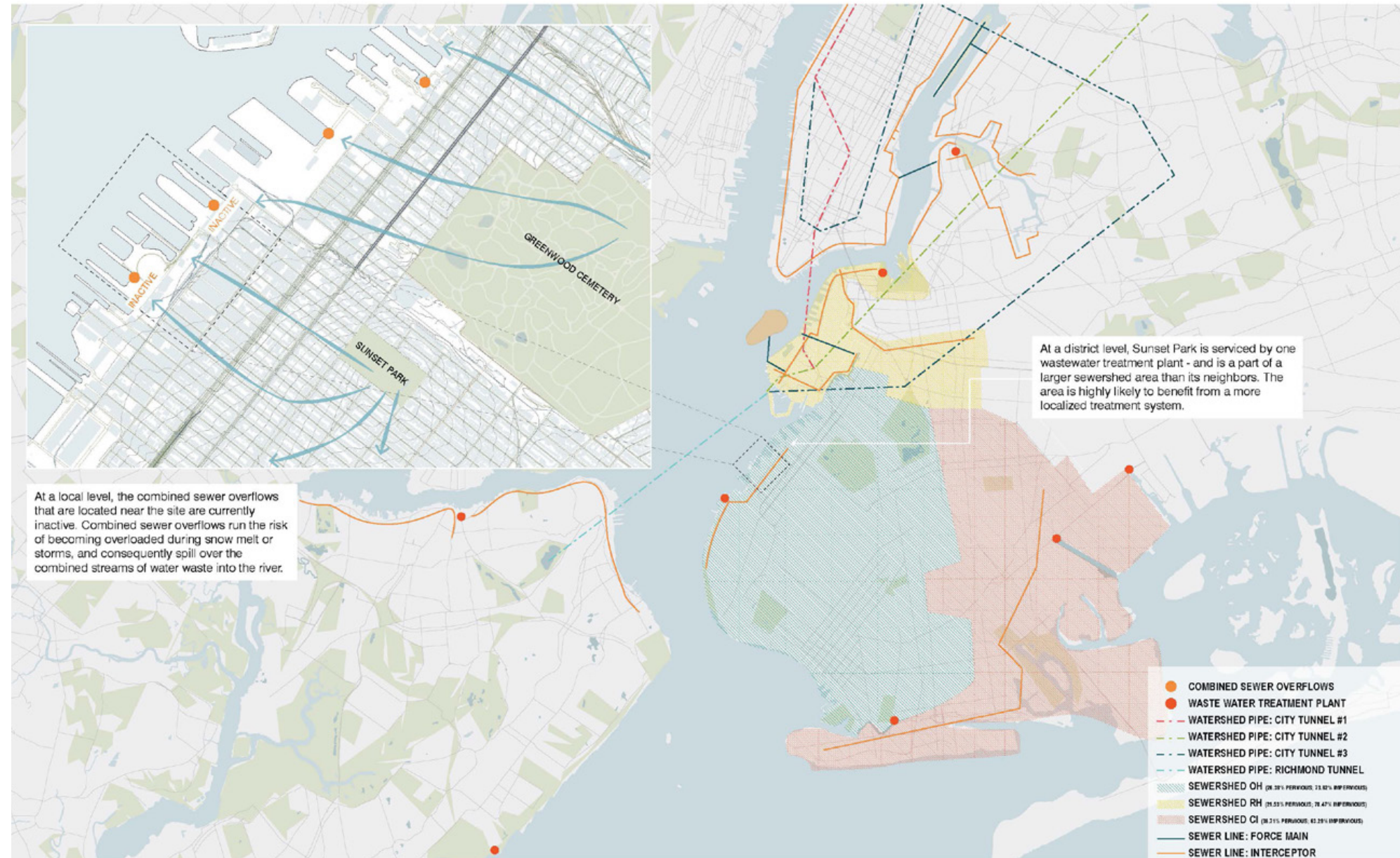
Our team focused on water treatment on the site while highlighting the importance of the water's edge on the Sunset Park neighborhood. Responding to two of the most prominent program components in the brief, the project primarily consisted of a combination of residential and industrial facilities.

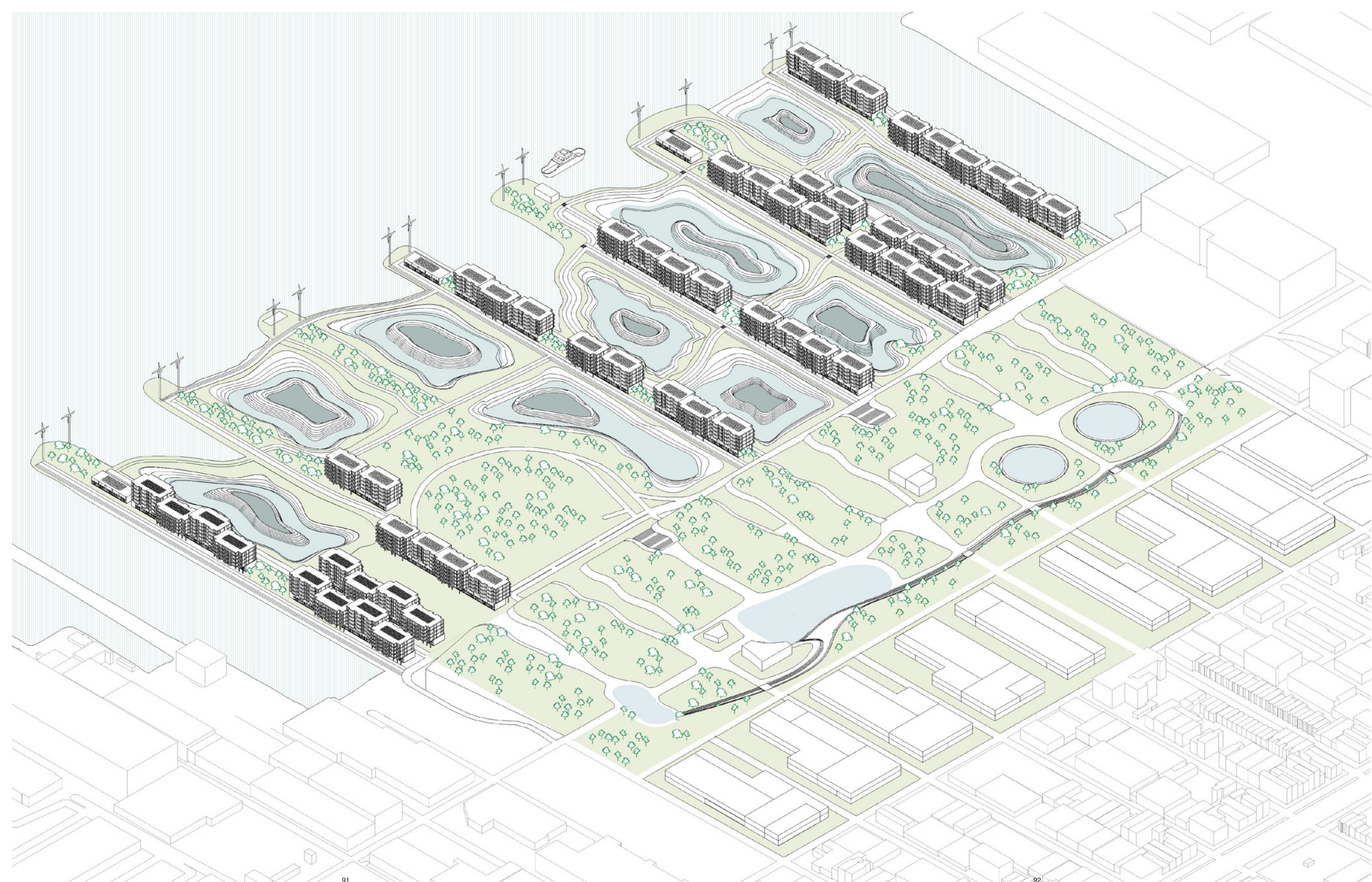
These two programs will come together to form a new typology of integrated eco tourism and living. Our project could be a canal city with a porous edge, involving water treatment, water based transportation, and water based energy production.

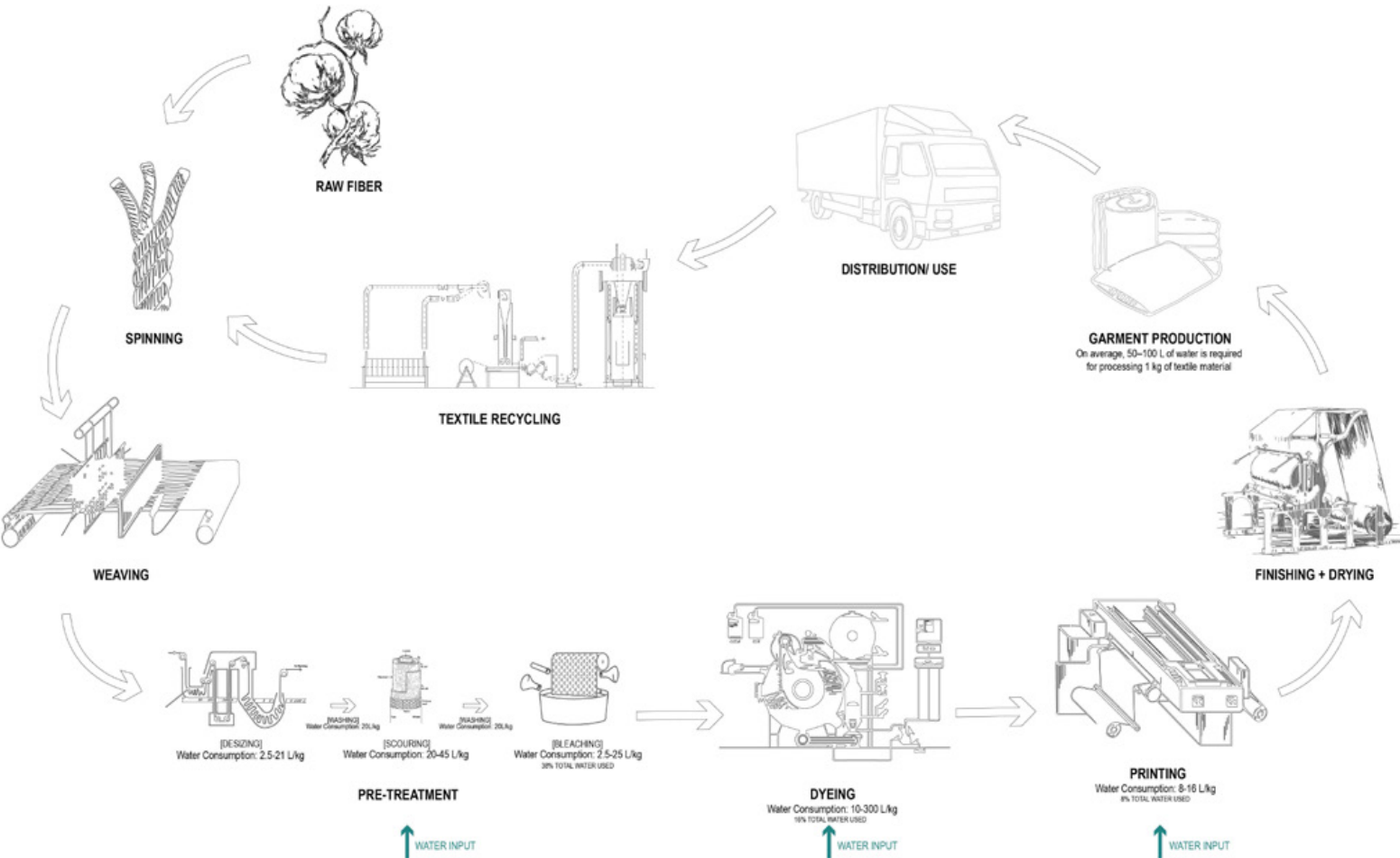
We capture rain and storm water from two locations: the bioswales and the rooftops of our site. The middle filtration band processes wastewater from the manufacturing processes to be reused in the manufacturing and commercial band.

The central pool of the wetlands between piers process blackwater from housing. When they are finished processing in the protected pools, they flow out to the larger surrounding greywater pools, which are reused within housing and the protected wetlands, which help prevent storm surge.

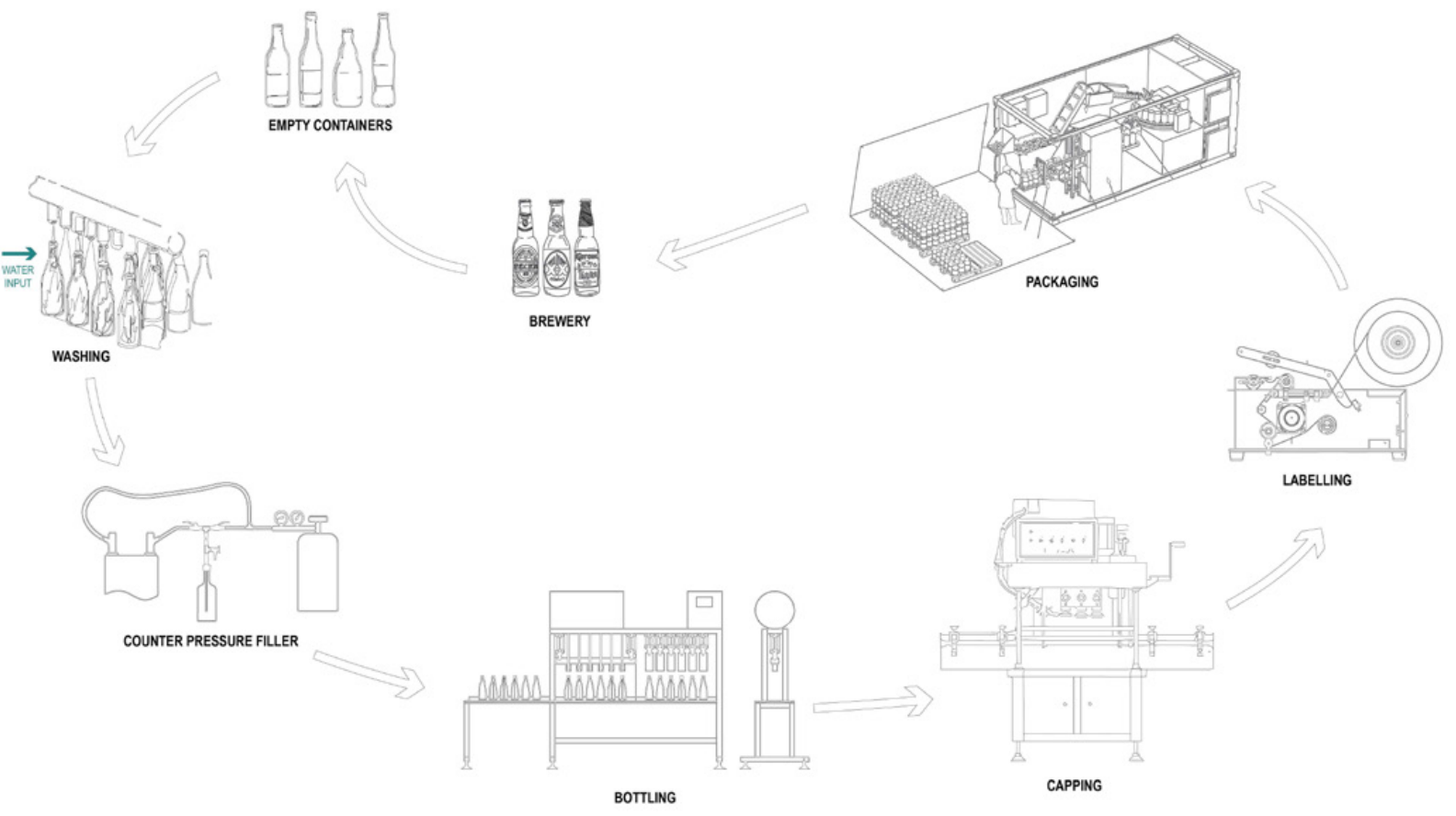
Any excess stormwater runoff from the neighborhood that has gone through the manufacturing/filtration band also is caught in these greywater pools, as the last step in the flow from Sunset Park down to water.



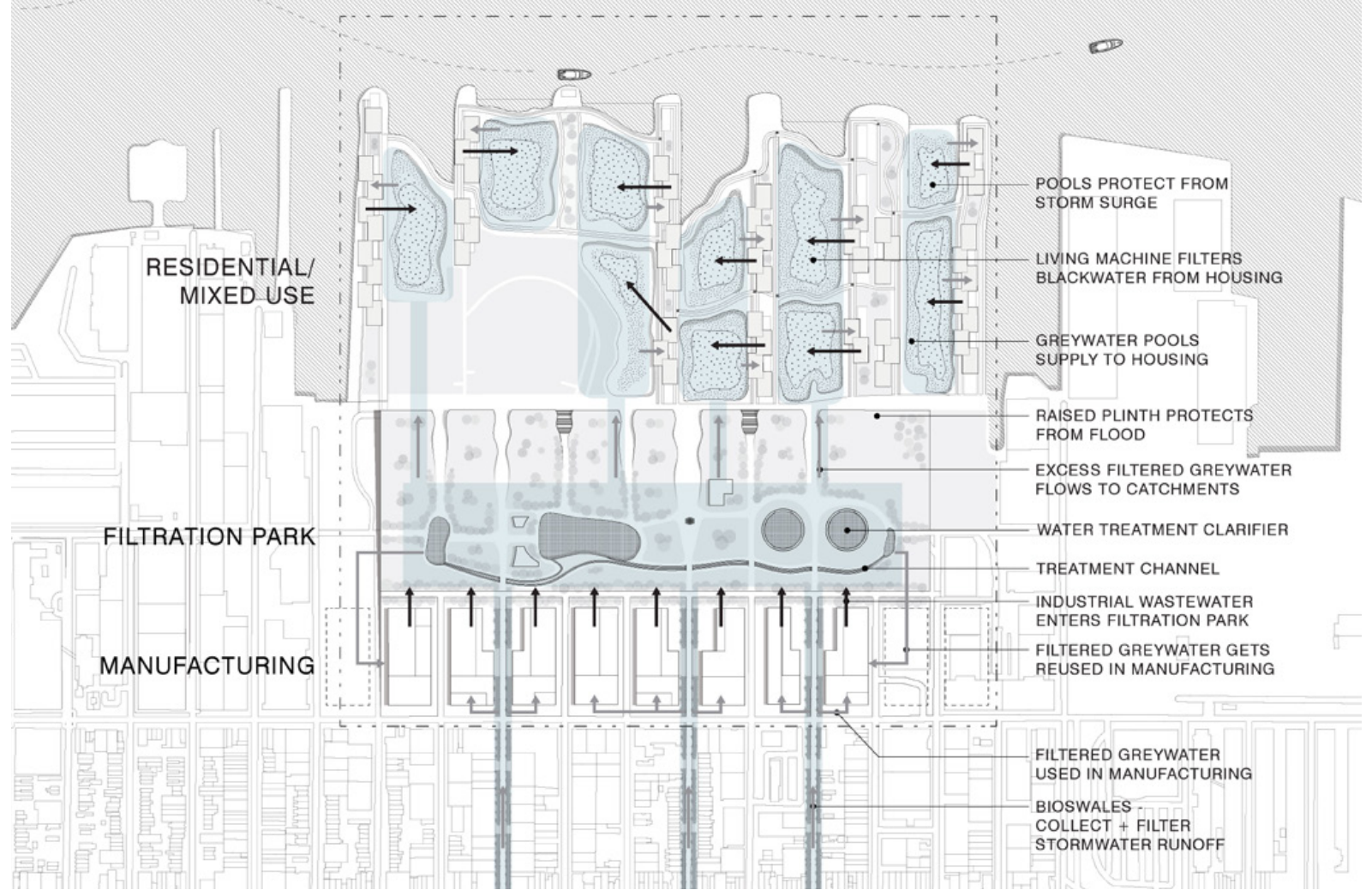




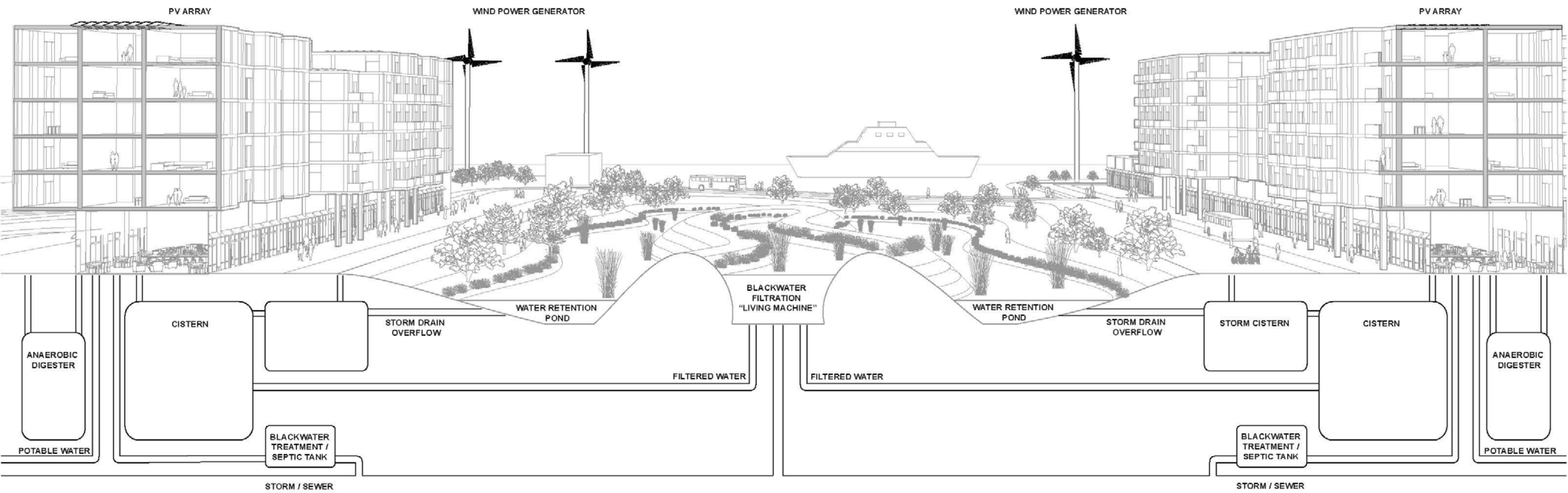
Textile Manufacturing Process



Bottle Manufacturing Process



Site Water Reuse Diagram



If 100 panels were located on each residential building:

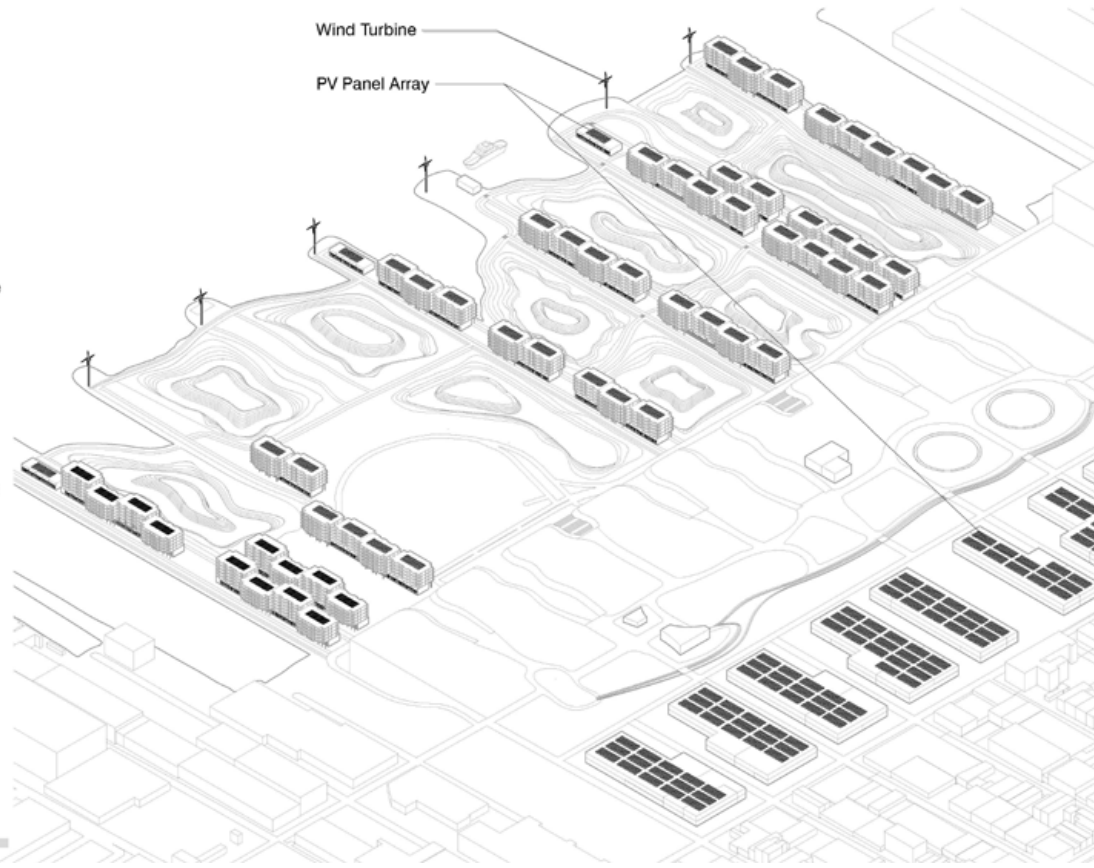
100 x 54 x 73.5 (panel output) = **396,900 kWh per year** for residential potential solar energy

Passiv Haus = about **1.39kWh/sf/yr target.**

Assuming Passiv Haus status, residential would take up 1,890,000 sf of space, requiring **2,627,100 kWh/yr**

Partial offset from residential solar panel array possible.

An average onshore wind turbine with a capacity of 2.5 megawatts can produce **about 6 million kWh/ yr.**



If 500 panels were located on each manufacturing building:

500 x 8 x 73.5 = **294,000 kWh per year** for commercial

Commercial buildings on average = **22.5kWh/sf**

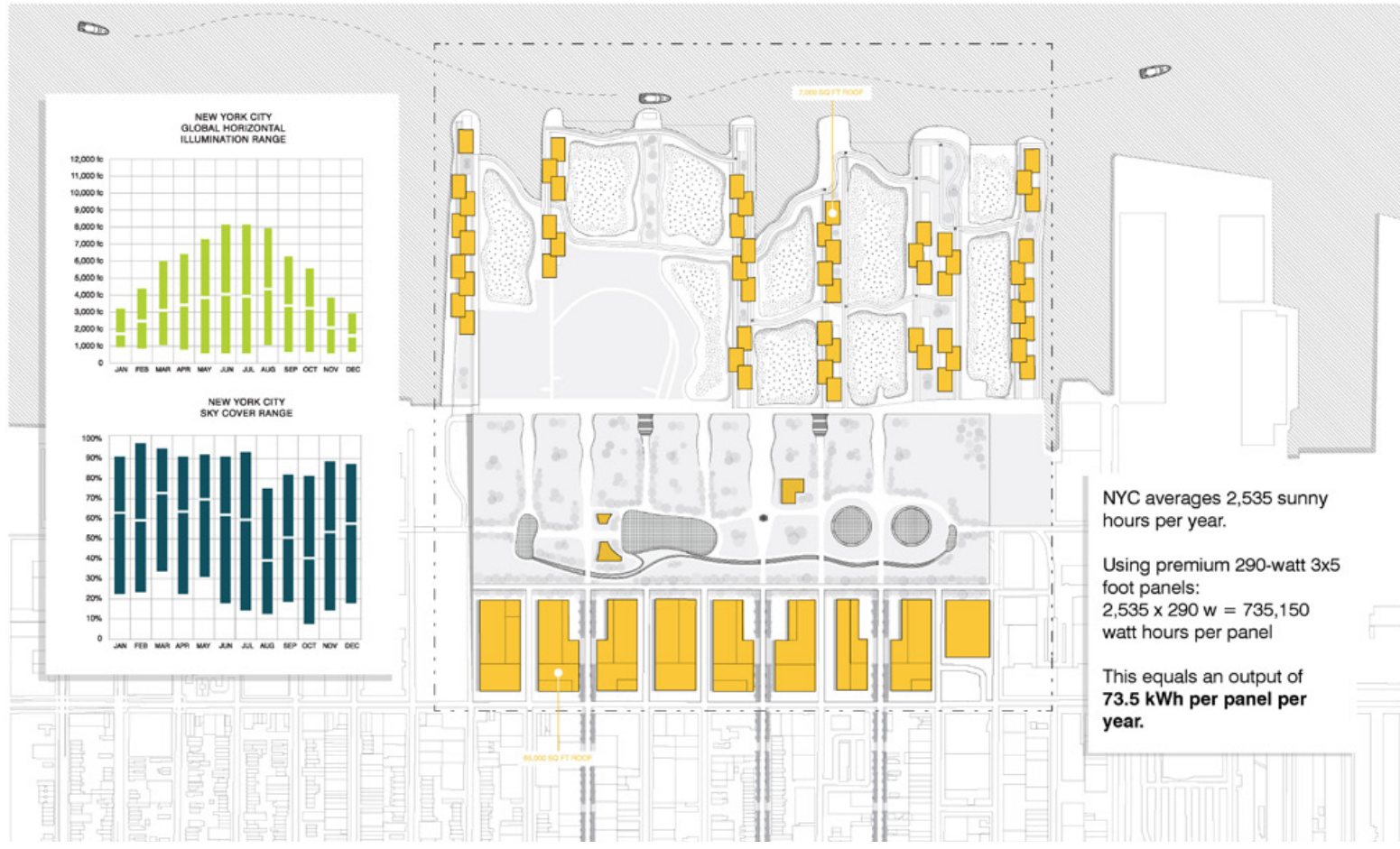
8 - 60,000sf buildings, and 54 - 7000 sf buildings on site. (858,000 sf total)

requires **19,305,000 kWh/sf /yr**

Partial offset of commercial uses possible onsite from PV arrays. At least 3 wind turbines required to offset commercial/ manufacturing costs.

690,900 kWh per year total can be gained from use of PV arrays onsite.

Energy Strategy Diagram



NYC averages 2,535 sunny hours per year.

Using premium 290-watt 3x5 foot panels:
2,535 x 290 w = 735,150 watt hours per panel

This equals an output of **73.5 kWh per panel per year.**

Energy Capture Potential Diagram

“Techniques of the Ultrareal”

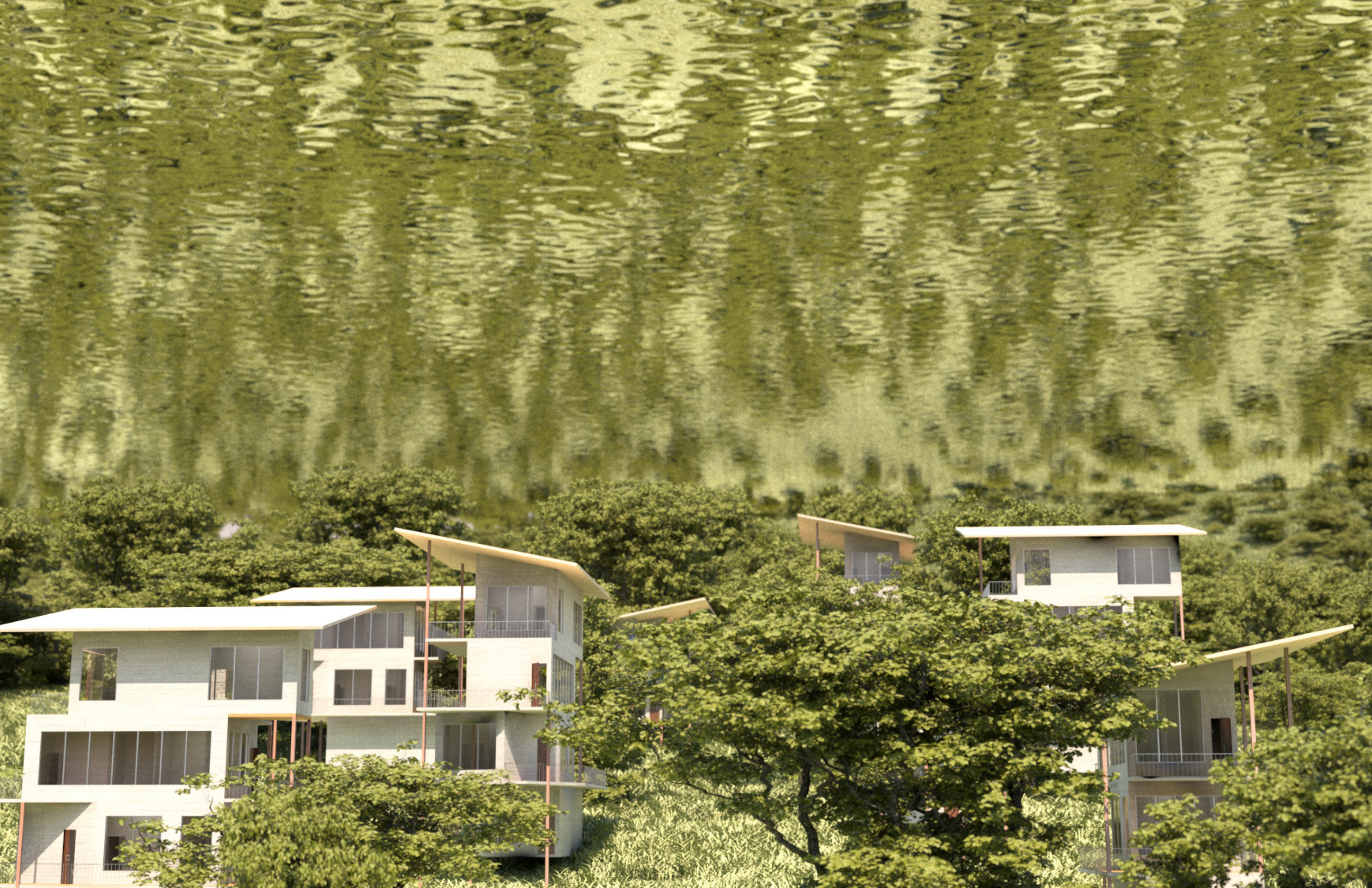
Columbia GSAPP Visual Technology - Techniques of the Ultrareal
Professors Joseph Brennan & Philip Crupi

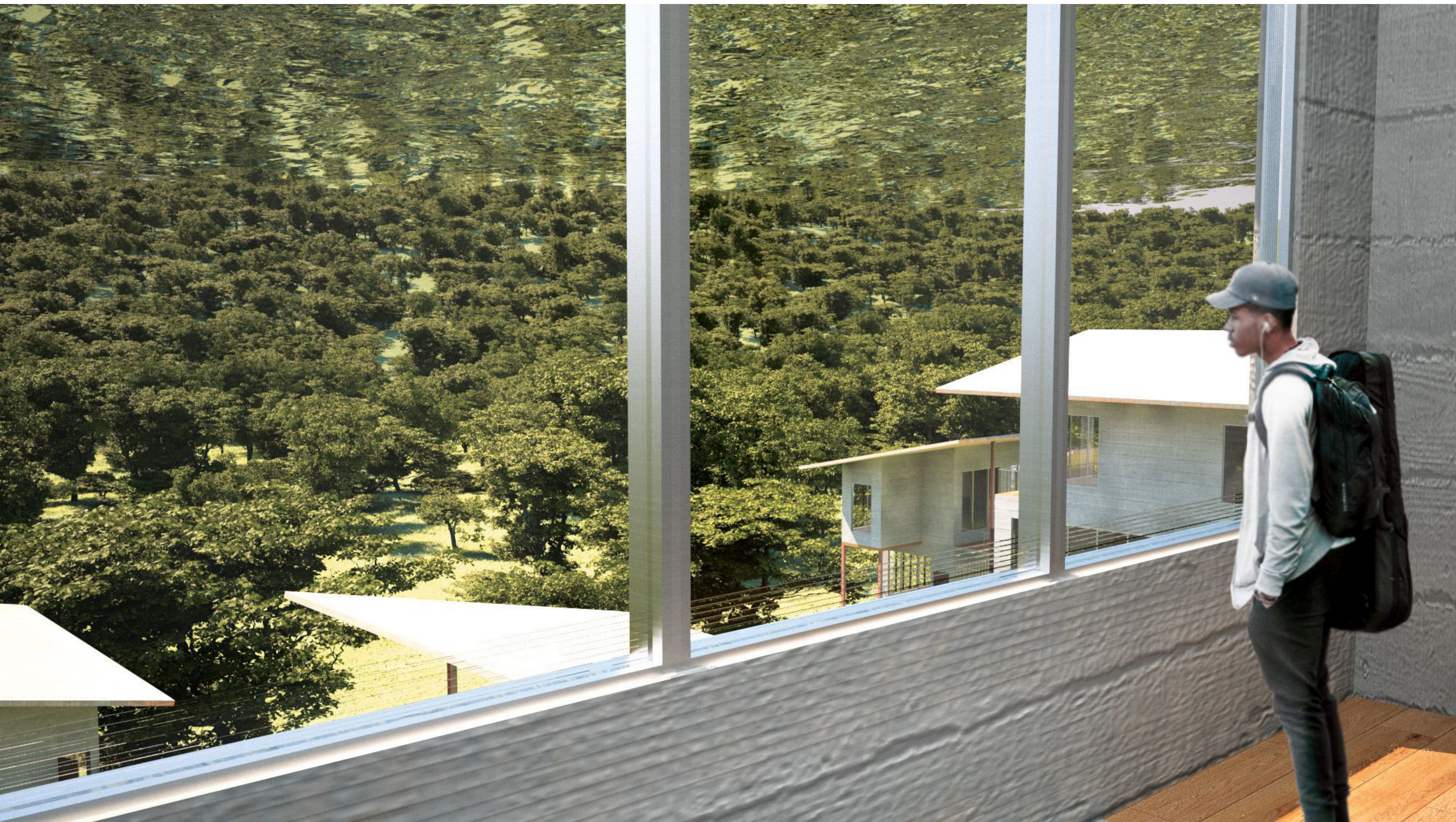
This class focused on creating photo-realistic renderings of conceptual dreamscapes. Utilizing 3DS Max, Rhinoceros, and V-Ray, students crafted renderings from a preliminary sketch, all the way to a finished rendering.

In addition to learning a completely new software, concepts of composition, lighting, and physical camera usage were explored during the semester.

The final images represent an exploration of a conventional forest scene juxtaposed with a surreal seascape in place of the sky. The result is a disrupted mirror image of the original scene represented in the rendering’s “sky.”









“Rethinking BIM”

Columbia GSAPP Visual Technology - Rethinking BIM
In collaboration with Leo Wan, Alexa Long, & Audrey Dandenault
Professor Joseph Brennan

This course introduced workflows between several software that culminated in a reimagining of an existing building. Choosing the 111 W 57th Street Tower by Shop Architects, our group explored several new software, including Revit, Galapagos, and Ladybug to optimize a facade system for the building .

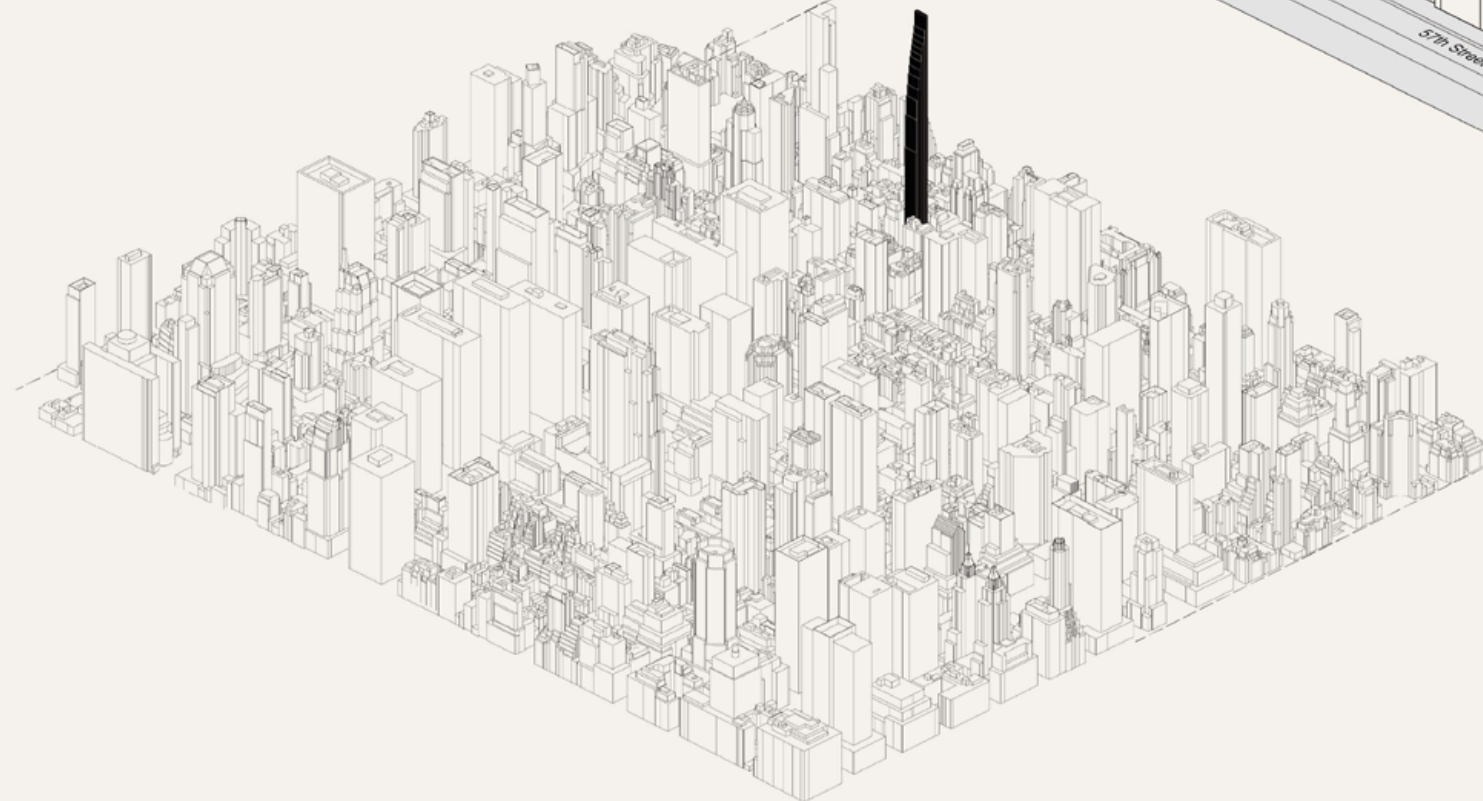
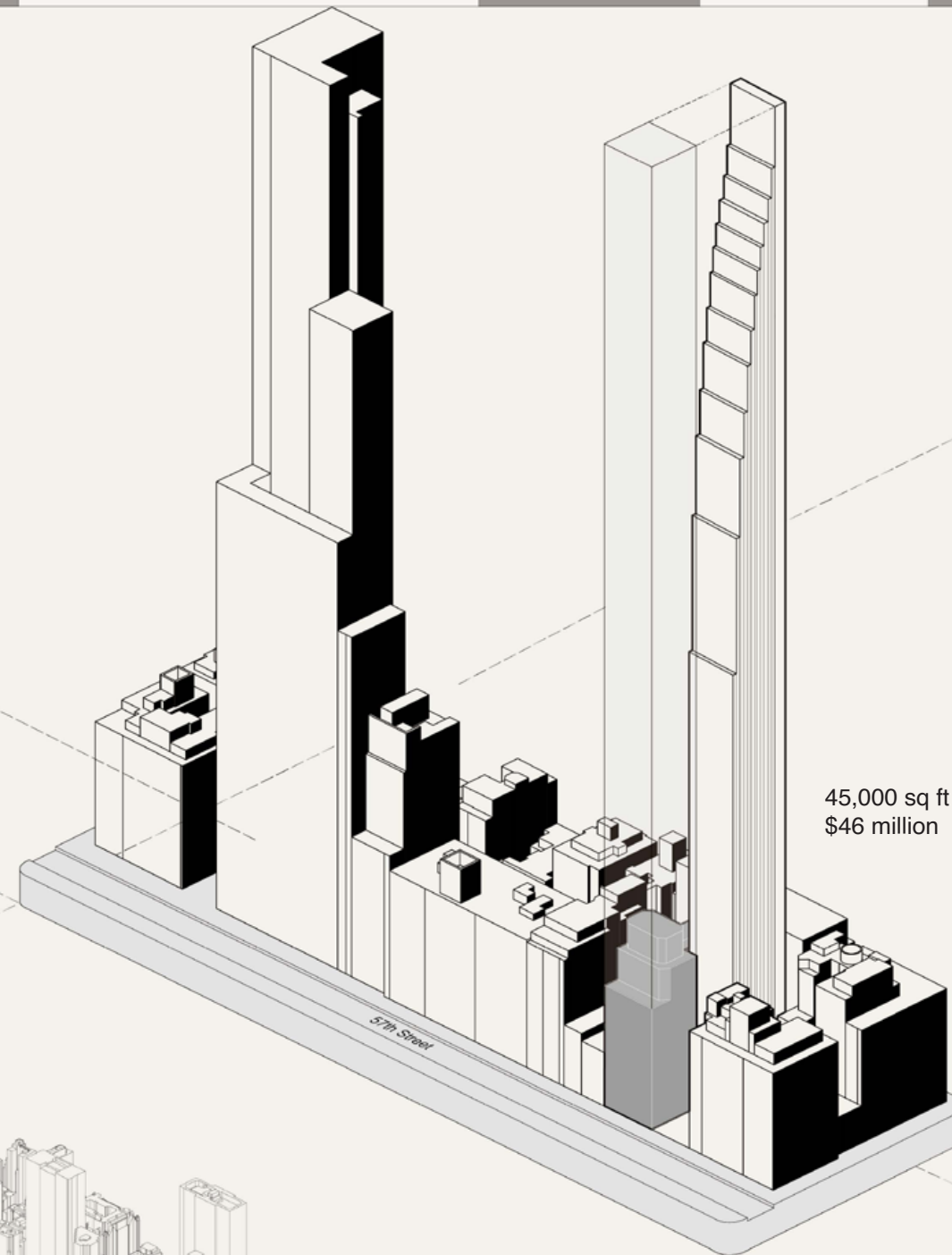
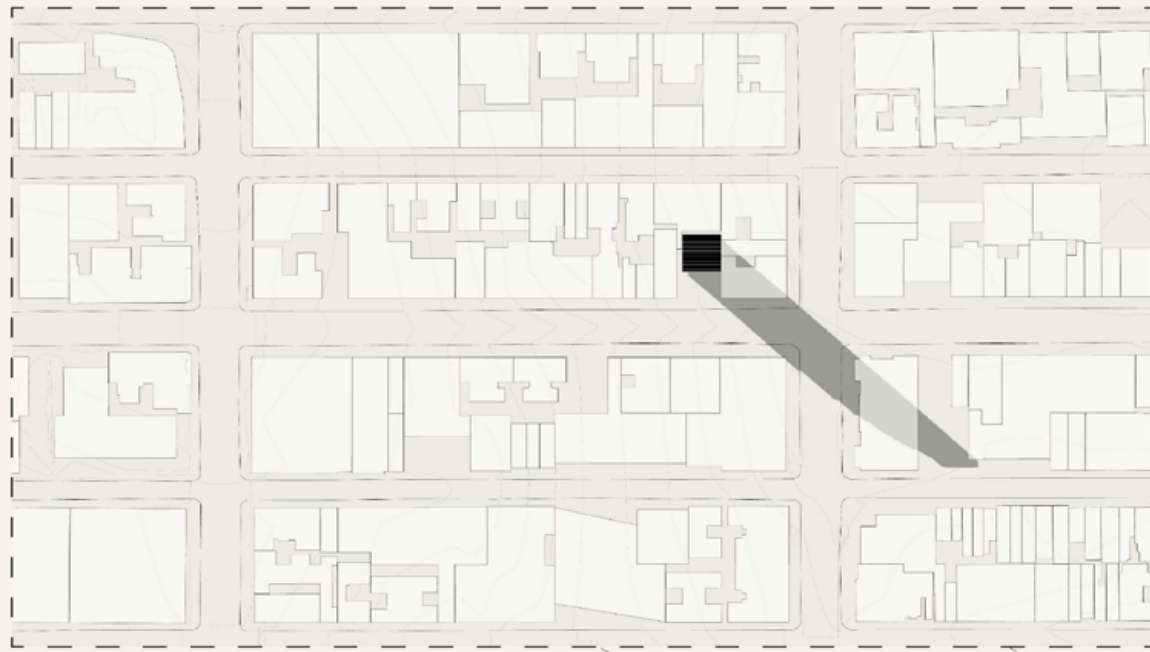
New York weather data was combined with sun study analysis, generative shape optimization, and interconnections between Rhinoceros, Grasshopper, and Revit to create a series of finalized geometries.



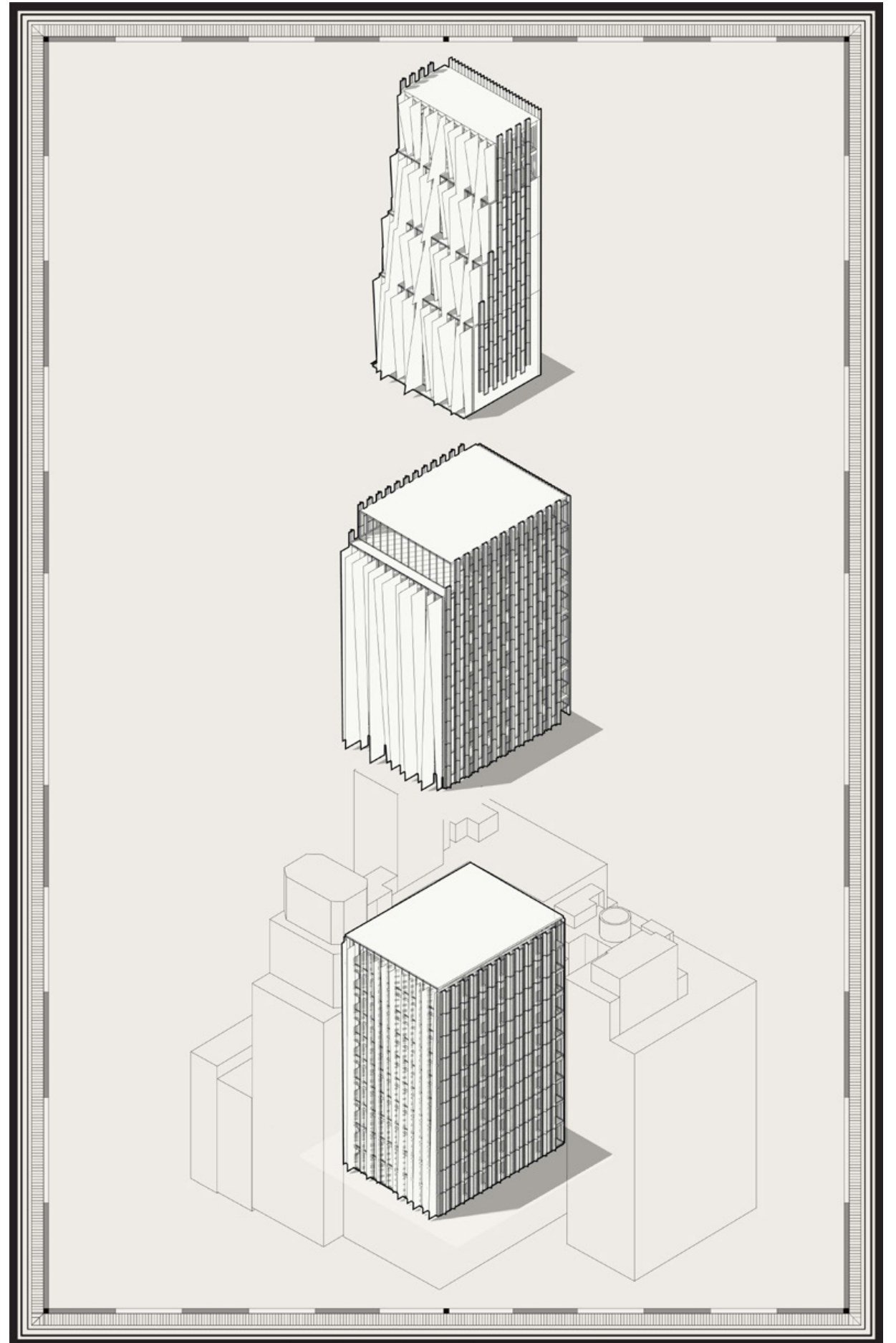
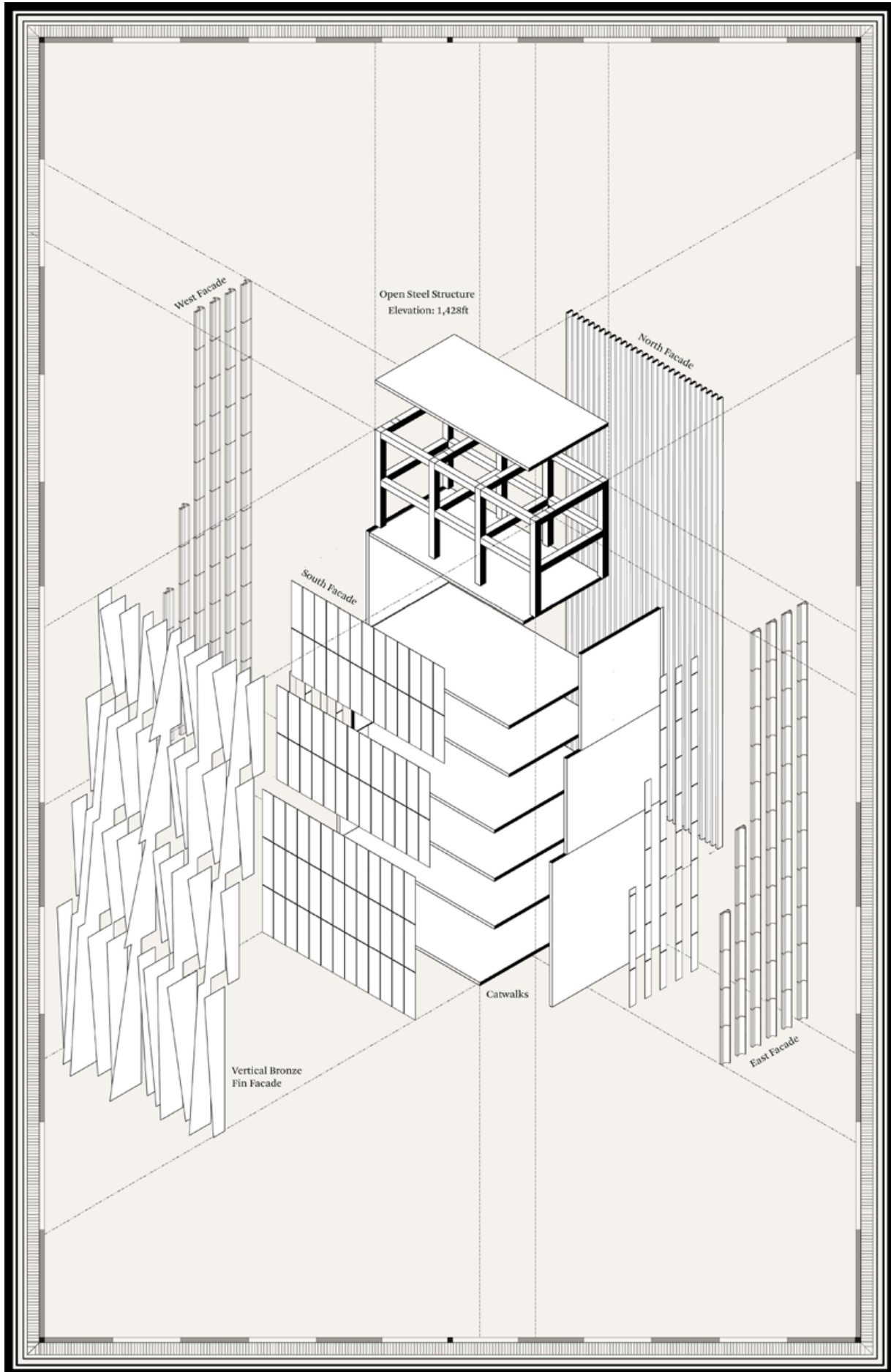
111 West 57th
Residential Tower
60 condominiums

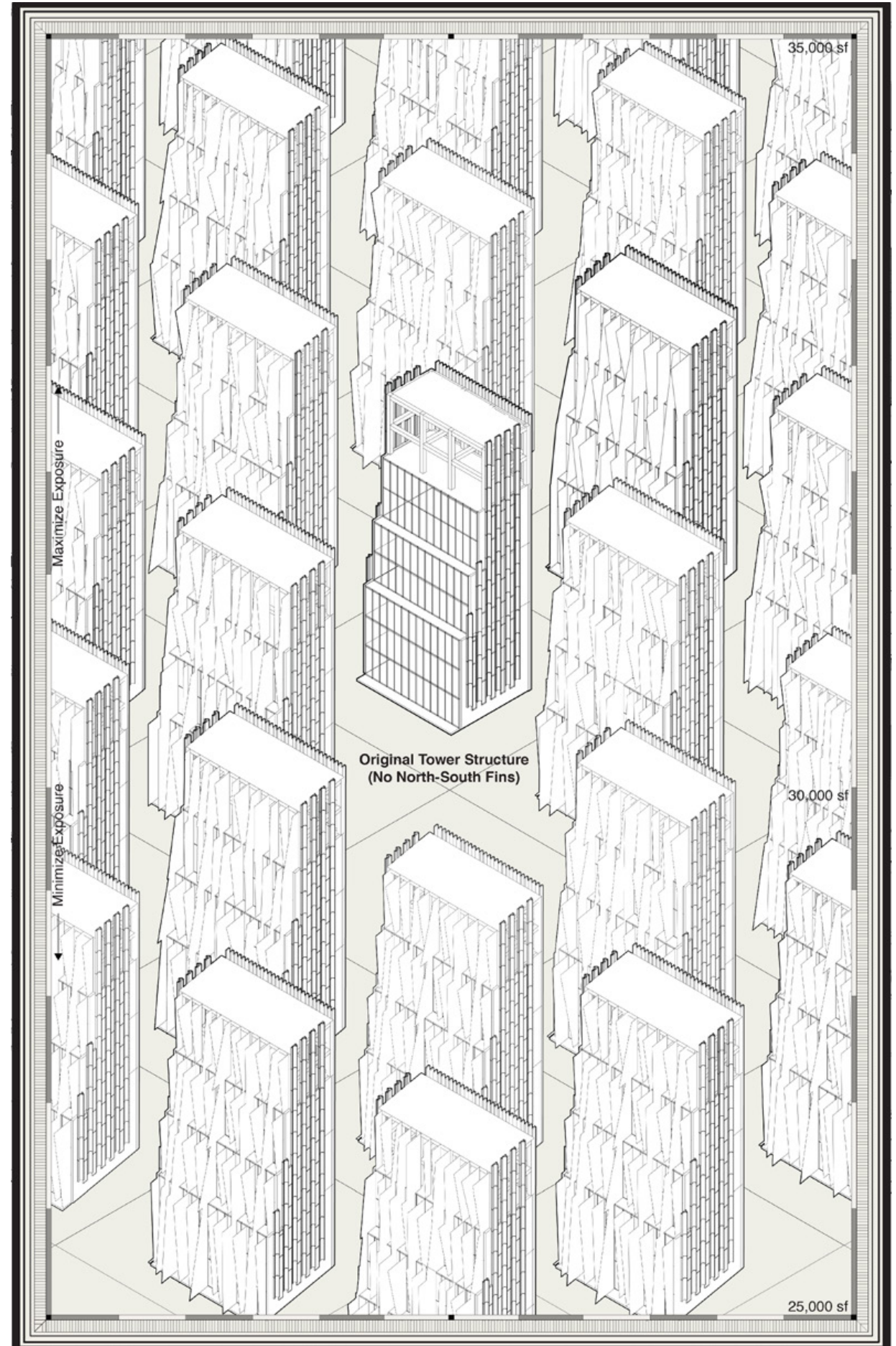
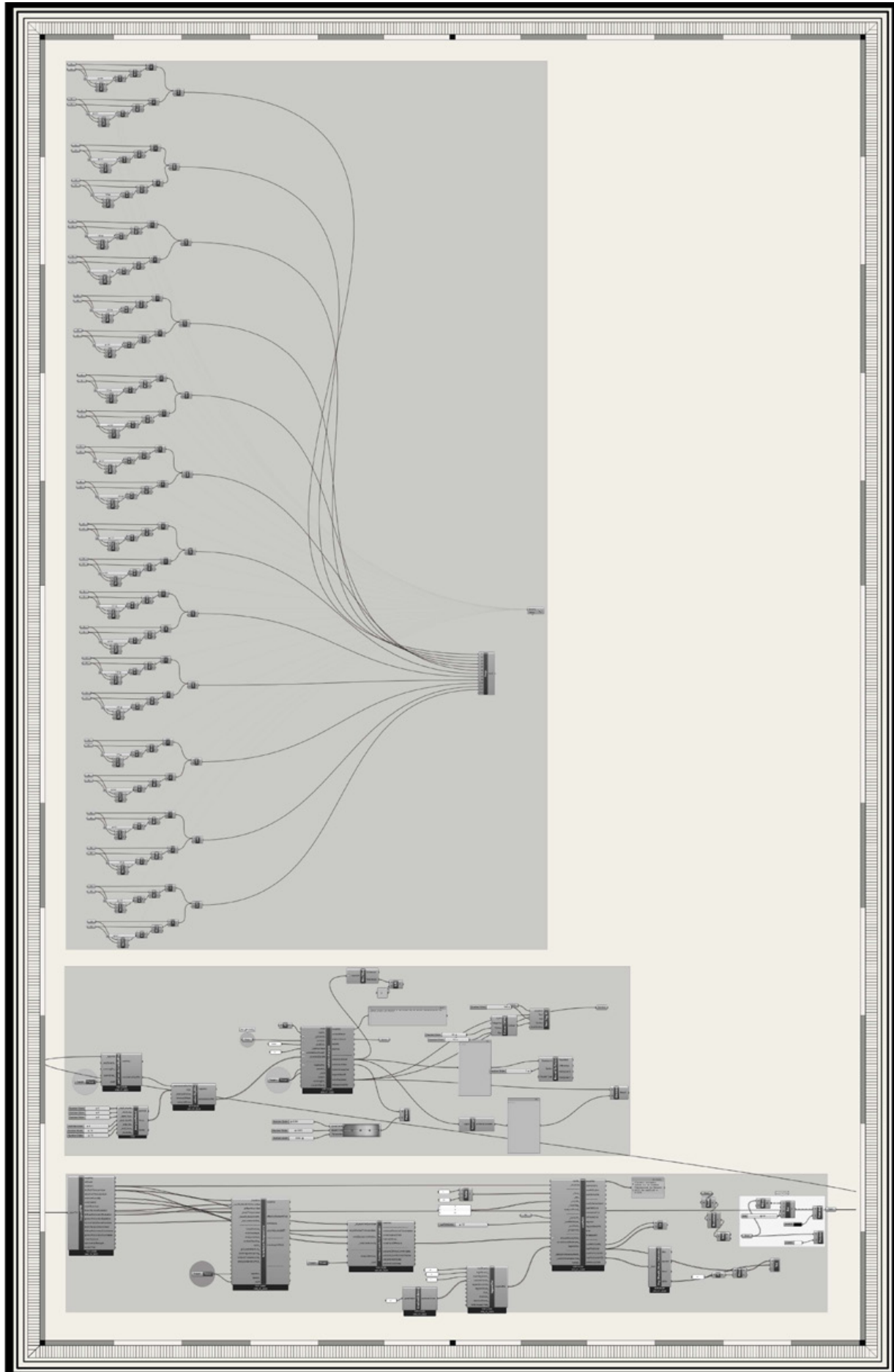
1,428 feet tall
Height-to-width ratio of 24:1

Designed by SHoP Architects
Developed by JDS Development, Property Markets Group
and Spruce Capital Partners
Interiors designed by Studio Sofield
Marketed by Douglas Elliman Development Marketing



In May 2012, JDS Development Group and Property Markets Group acquired the site for some \$40 million. They also purchased neighboring Steinway Hall for \$46.3 million, its 45,000 square feet of air rights for \$46 million, and its land lease for \$131.5 million.





“Speculative City”

Columbia GSAPP Design Seminar - Speculative City
Professor David Eugin Moon
Site: Atlanta, GA

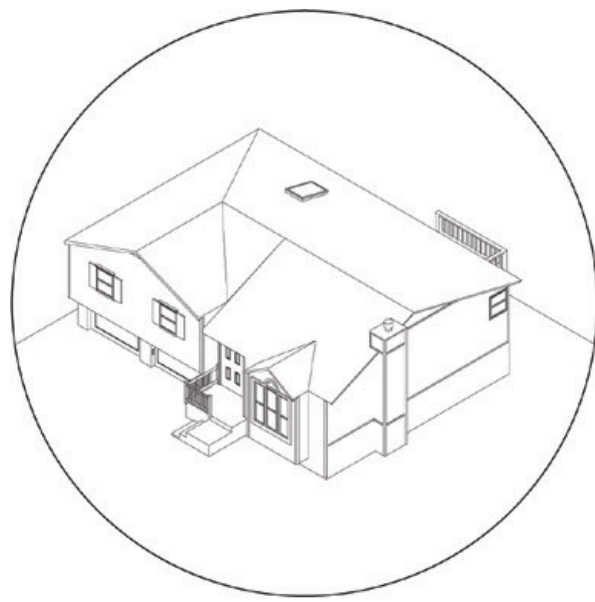
Throughout history, construction has been used as a means to separate and segregate populations. Varying from the smallest building to infrastructure, designers and planners' creations effectively select the users that are allowed access. As a result of car-centric design, many of the United States' cities experienced rapid development of highway infrastructure. This infrastructure provided transportation routes across the nation, but also cut through existing cities' transportation routes. Intentionally or unintentionally, these infrastructure projects created hard borders through the routes they traveled.

In some neighborhoods of the country, these roads cut through or between existing wealth, educational, and racial boundaries, cementing inequality in the region through a physical divide. These divisions, some created a century ago, still affect populations today. A crisis of seemingly permanent population division seems to be an inherent part of cities in America today. This project is an intervention that seeks to lessen the crisis of wealth inequality, which has been strengthened by physical boundaries as a result of transportation infrastructure.

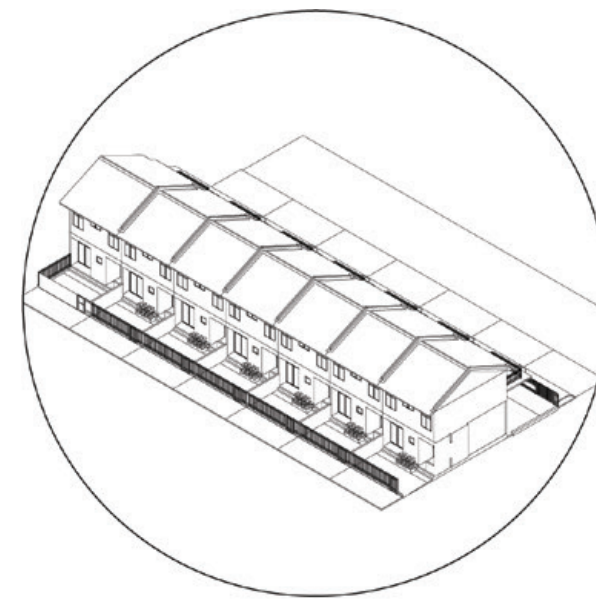
Further established by numerous highways and intersections, Atlanta ranks among the top cities in America for inequality. Attempts to lessen the “flight” from the cities were unsuccessful and only increased the car-centric design of cities. In addition, “Urban Renewal” projects only brought in further displacement and segregation. What if a city could reclaim land scarred from roads and highways?

What would a new Atlanta cityscape look like? The analysis of the current conditions of Atlanta and the speculation of solutions to this crisis are the goals of this project. Crisis and uncertainty are explored in the city of Atlanta, through the lens of social, political, and economic factors. Through this analysis, hierarchies in public and private realms were revealed and modified in hopes of healing disrupted economies and contested political grounds.

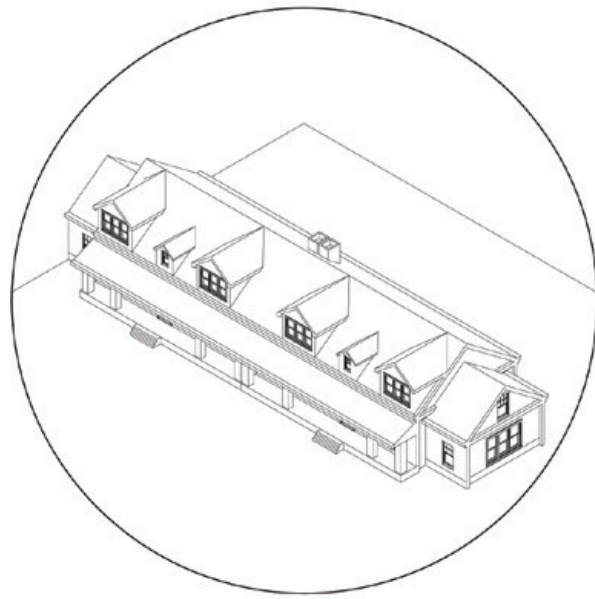




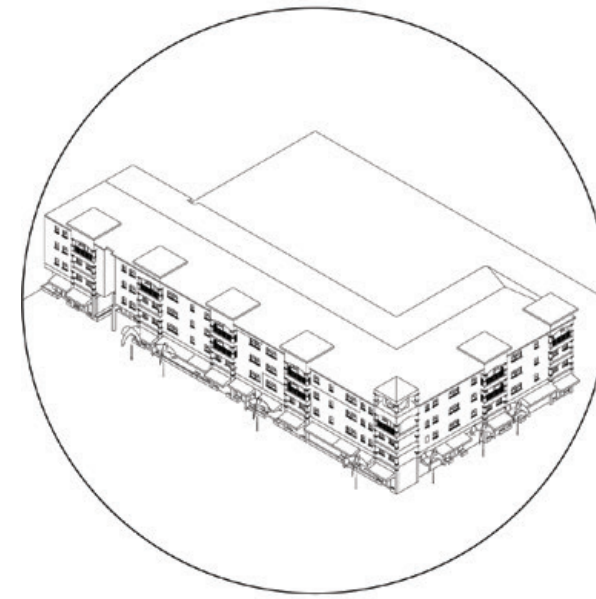
Single Family Detached



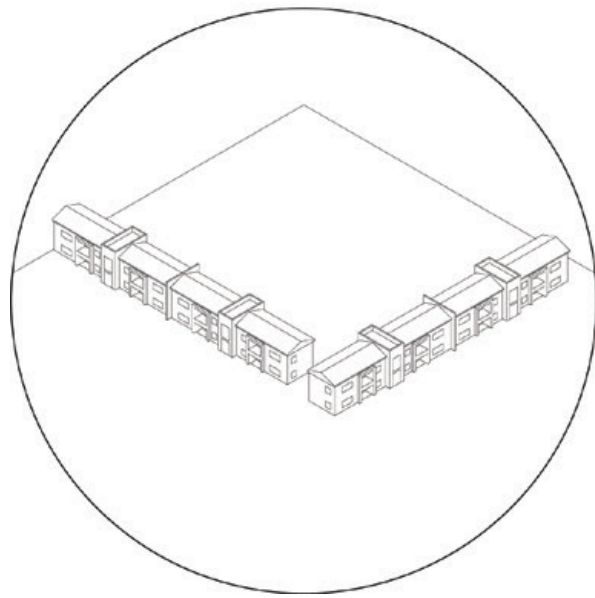
Townhomes



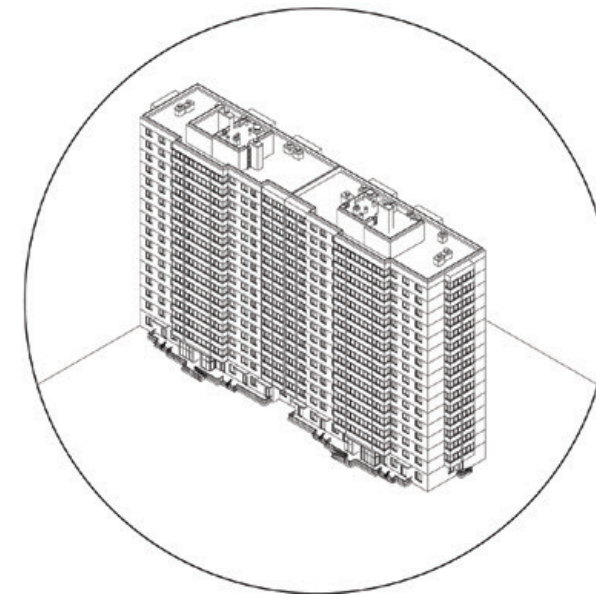
Duplex



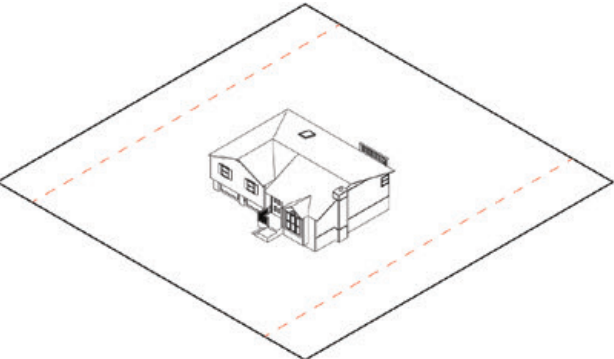
Mixed - Use



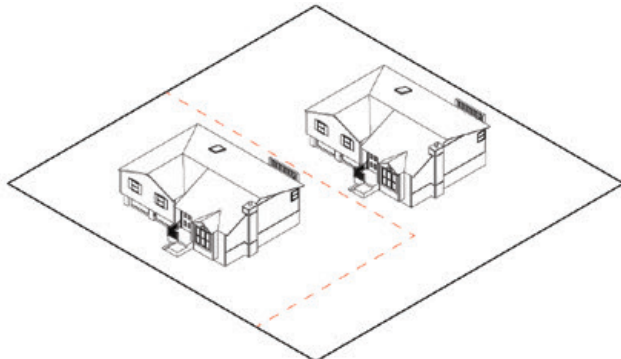
Courtyard Apartment



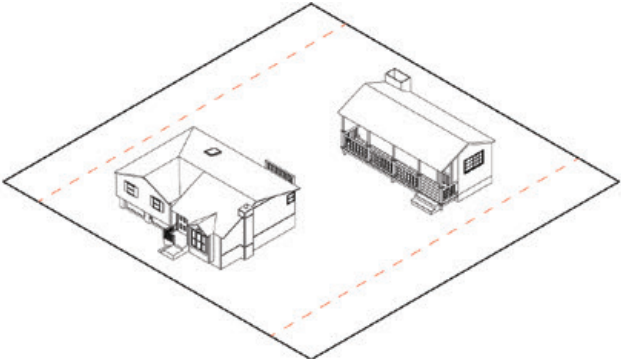
High - Rise



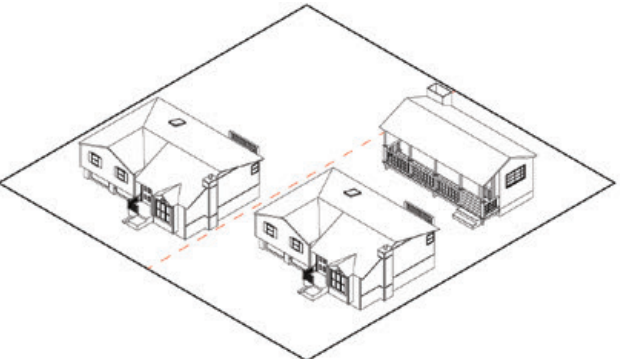
Single Lot



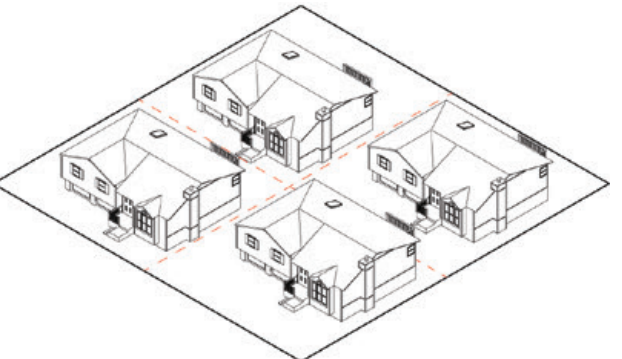
Flagged Lot



Single Lot + ADU



Corner Condition + ADU



Increased Lot Density



“Drawing & Representation”

Columbia GSAPP Visual Tech - ADR I & II
Professor Josh Uhl & Dan Taeyoung

These works were completed as part of the first-year training courses intended to familiarize students with conventional drawing tools used in architecture school. Rhinoceros, Grasshopper, Adobe Creative Suite, and other programs were introduced as part of fundamental training for new students.

The explorations done in this course would serve as a foundation for study further along in the GSAPP coursework. Modeling techniques would be used for the remainder of the program.

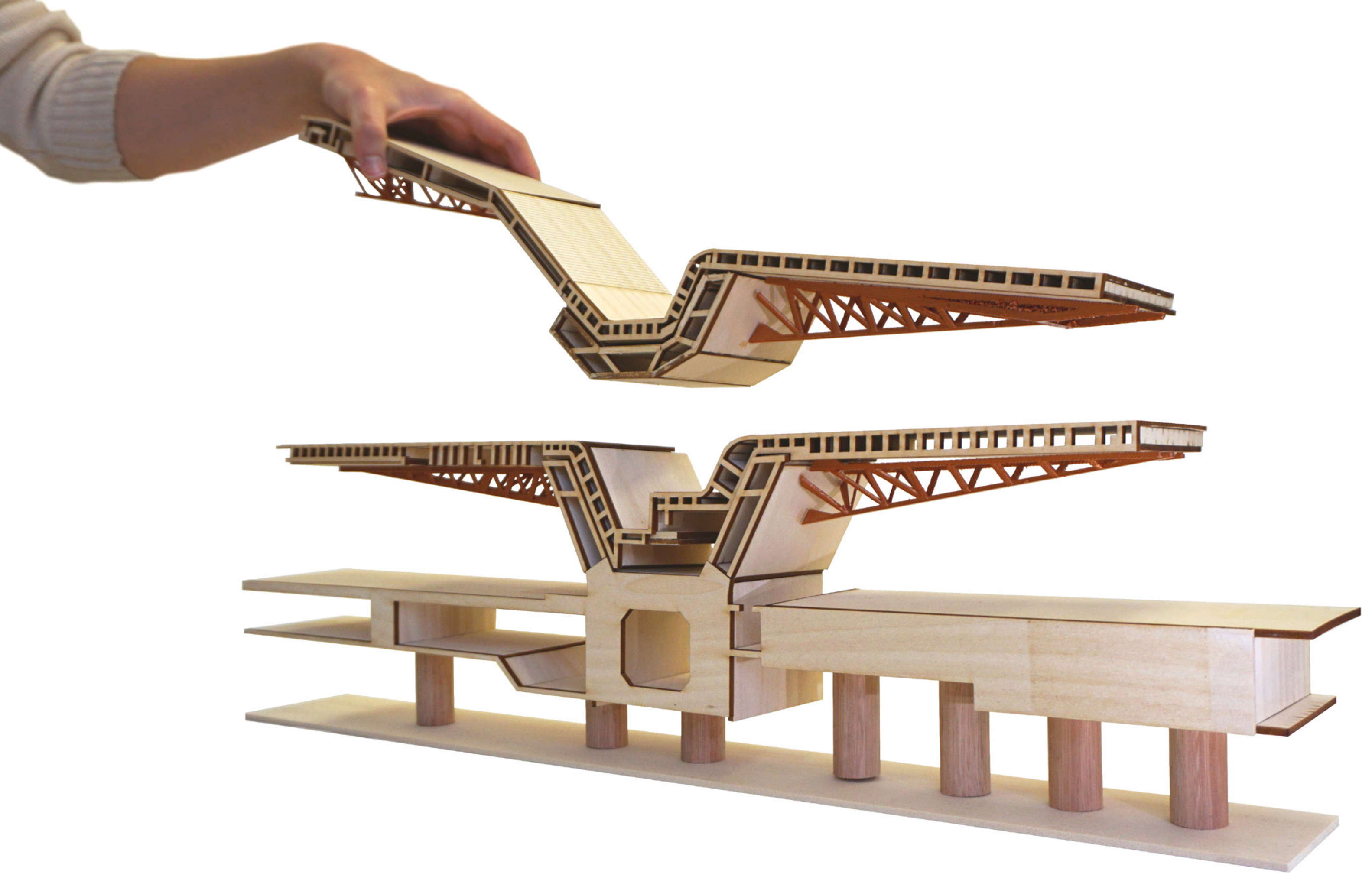
What is a drawing? What is the purpose of drawing? Is a drawing really a drawing? Do these letters form a drawing? What else could a drawing be?

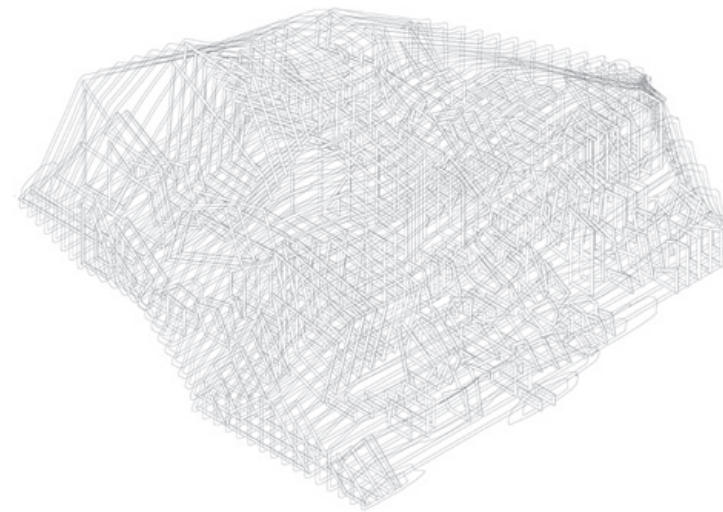
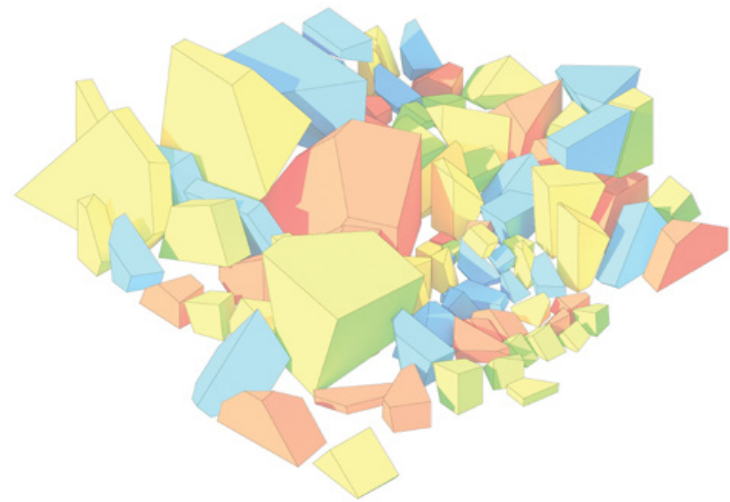
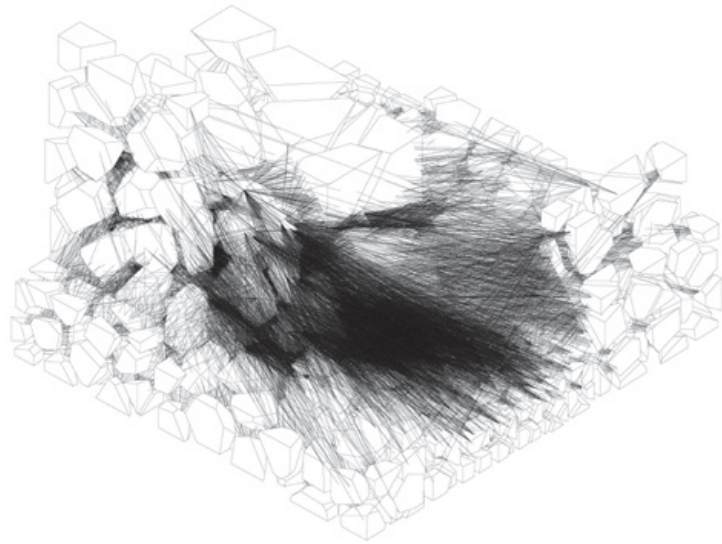
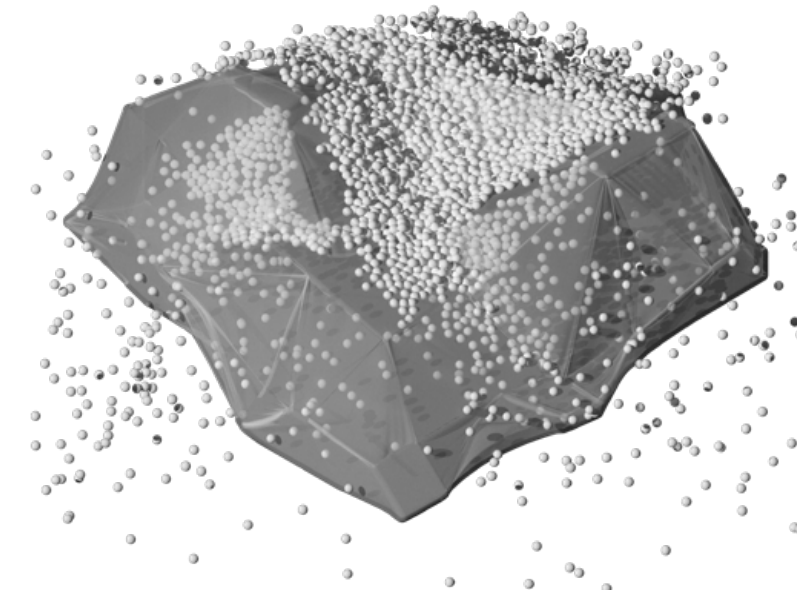
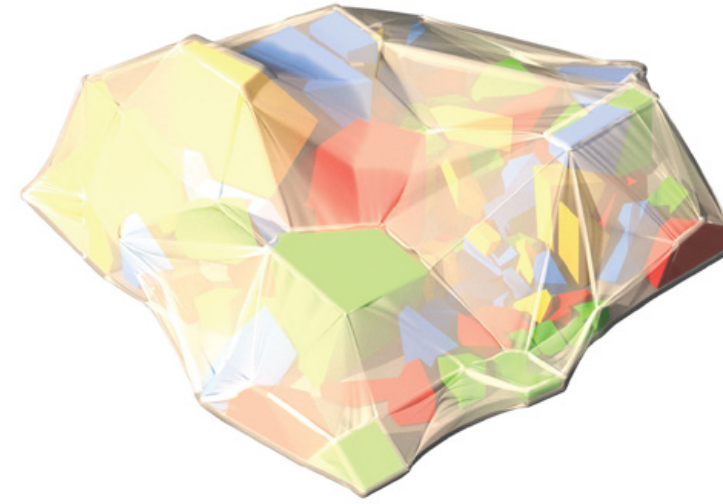
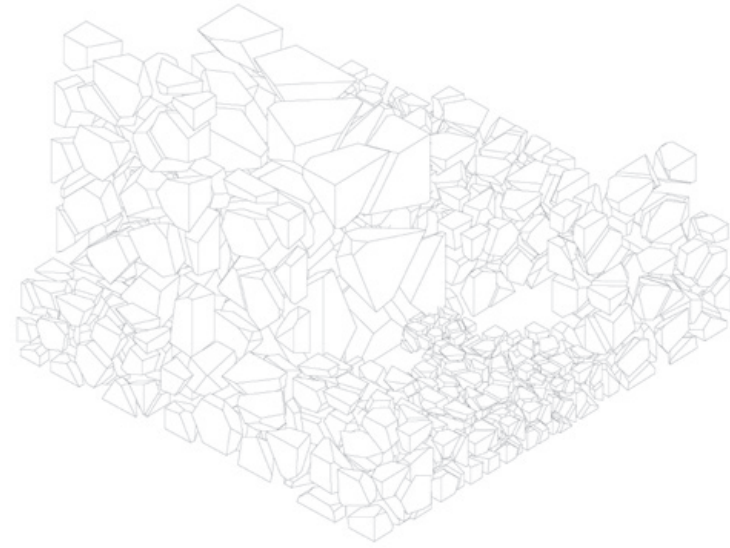
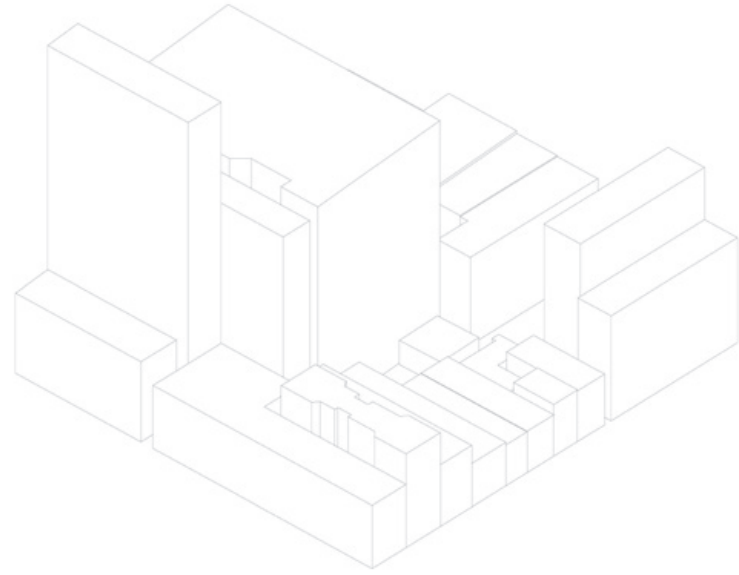
A drawing is a group of symbols on a page that convey as much information as possible in every dimension possible. Markings on the page are required to evoke emotion in the reader; without emotion, there is no memory. Without a memory, the drawing does not exist.

A drawing appeals to all emotions, all senses, and all dimensions. A drawing exists to be remembered.

Consequently, a drawing should to portray conventional portrayals of the unconventional or unconventional presentations of conventional portrayals.







“The Tri Elliptical Pyre”

Columbia GSAPP Visual Tech - Generative Design
In collaboration with Shuang Bi, Anirudh Chandar, & Jacob Li
Professor Danil Nagy

The project seeks to demystify the design process for a pavilion by operating through a legible methodology and generative process. The goal is to achieve certain qualitative and quantitative goals within the structure while optimizing them as variables balanced against one another. The process allows this system to be adapted to any pavilion composed of beam elements.

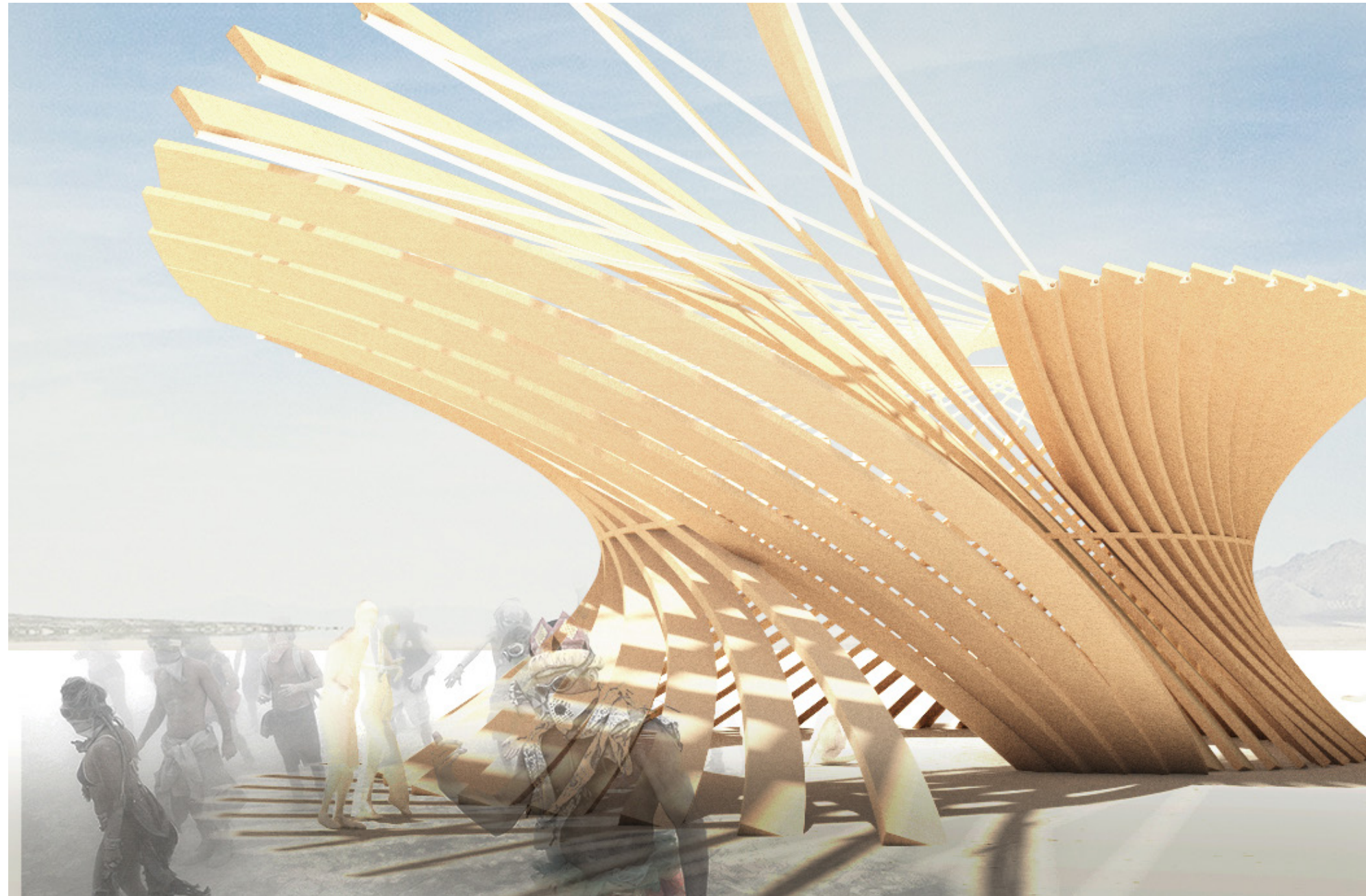
Architecturally fundamental metrics of shading, material weight/displacement are measured which are ubiquitous to any pavilion's goals. This paper iterates on this process through an exemplary design of a pavilion for the annual Burning Man event in the Black Rock Desert.

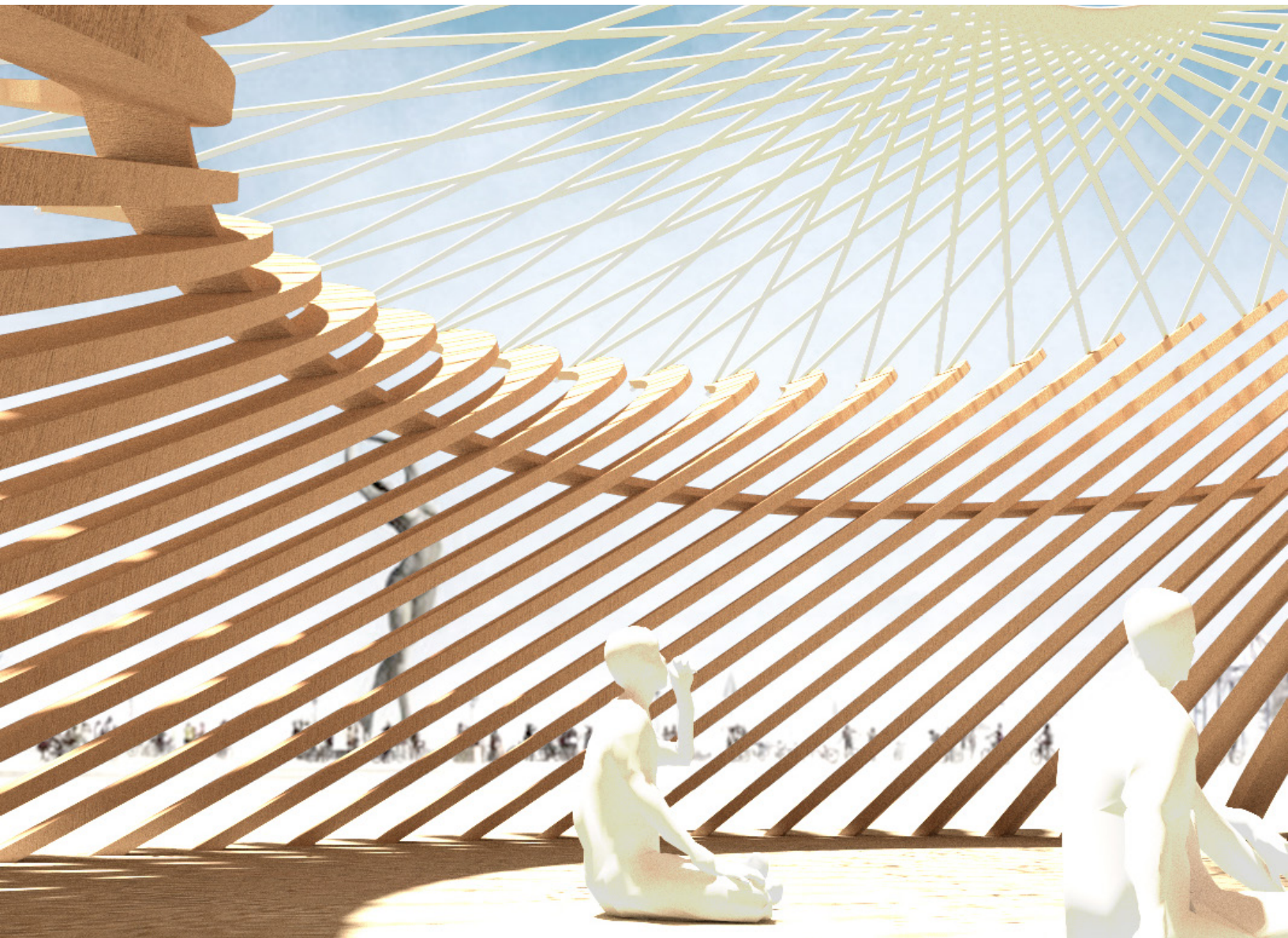
The design of the pavilion is crafted by picking key parameters that control proportions, number of members, and their cross-sections. A heuristic approach to the problem would traditionally be a back and forth between the design team's goals and a structural consultant's input on feasibility leading to an iterative and slow process.

By compressing these steps, the generative method allows for design goals to be weighed against structural capabilities in real-time and a wide range of outputs within the feasible sample space.

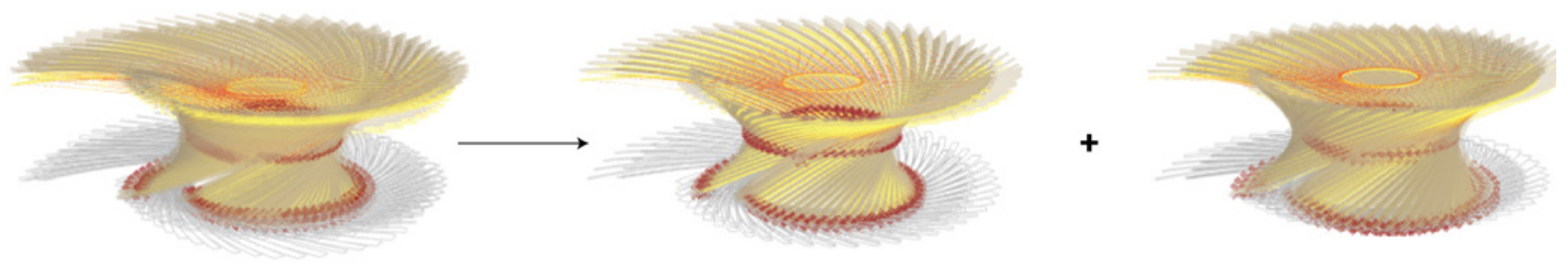
The pavilion seeks to maximize its shading (through overhang) while minimizing material usage and member deflection giving us clear constraints that need to be balanced. The design was composed of three vertically stacked ellipses that control the shape of the pavilion at three fixed heights. The pavilion, composed of beam elements, would be the form resulting from the interpolation of points on these 3 ellipses.

The cross section of each beam is assigned in increments based on industry standards in response to the amount of stress applied on each beam which in turn depends on its length and overhang. The interior of the pavilion is designed to allow for human occupation, creating fixed constraints.





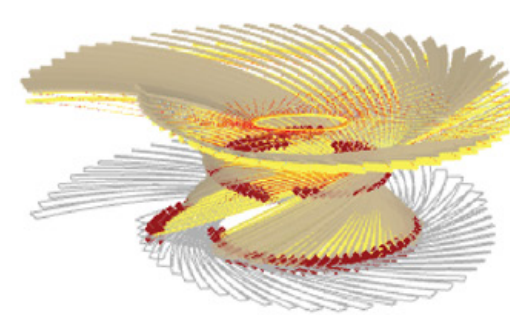
Evaluation metrics



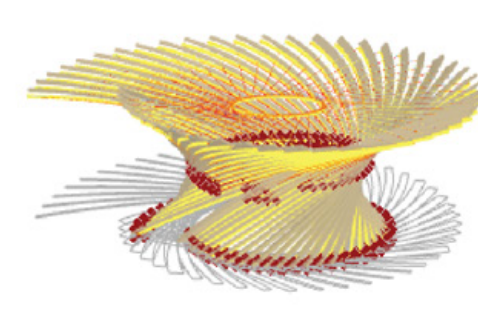
1. Scatter Plot
shadow (y-axis), material cost (x-axis)
Optimized Result:
 Beam numbers: 40 - 60
 Top ring size: 20' - 28'
 Bottom ring size: 10' - 14'
 Shadow/cost = 1.45 - 2.06
 Shadow /Displacement: 42 - 134

2. Shadow/Cost Value
Optimized Result:
 Beam numbers: 50 - 54
 Top ring size: 20' - 26'
 Bottom ring size: 10' - 14'
 Shadow/cost = 2.16 - 2.23
 Shadow /Displacement: 42 - 67

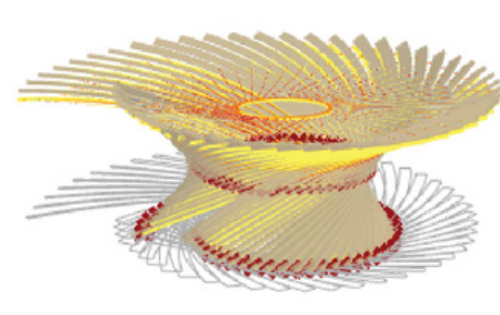
3. Shadow/Displacement Value
Optimized Result:
 Beam numbers: 47-60
 Top ring size: 20' - 22'
 Bottom ring size: 11' - 14'
 Shadow/cost = 1.41 - 1.57
 Shadow /Displacement: 132 - 152



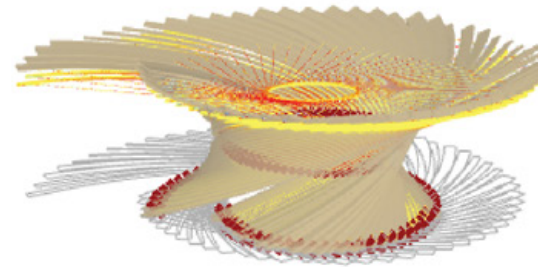
Gen 8-15



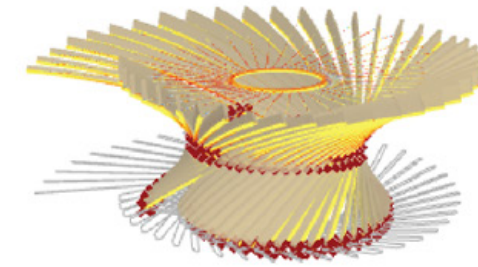
Gen 9-25



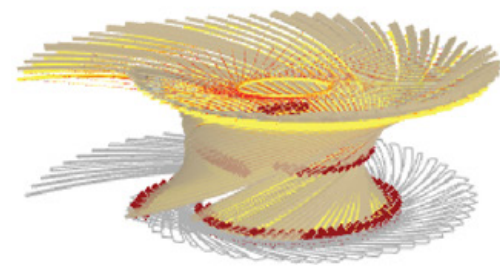
Gen 11-35



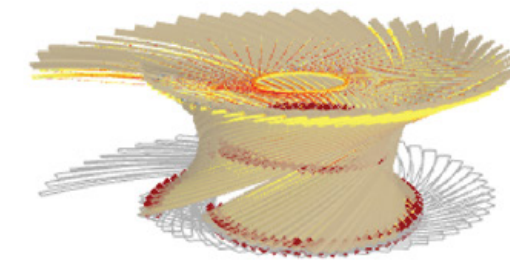
Gen 18-4



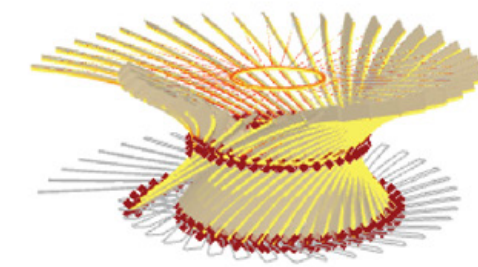
Gen 22-28



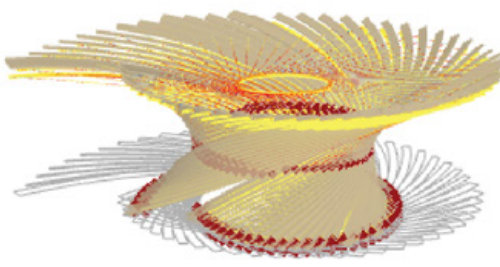
Gen 24-17



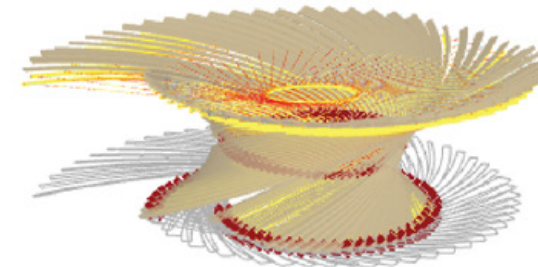
Gen 29-8



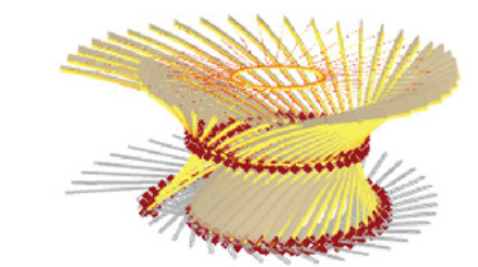
Gen 30-28



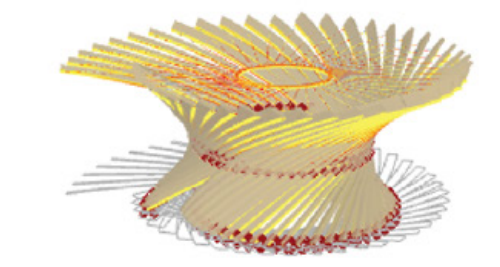
Gen 30-35



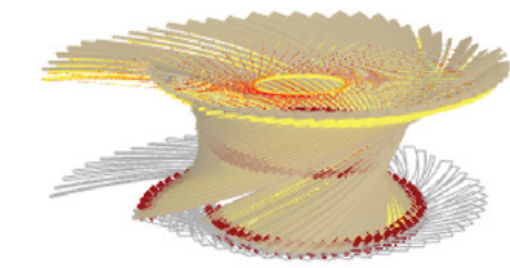
Gen 32-27



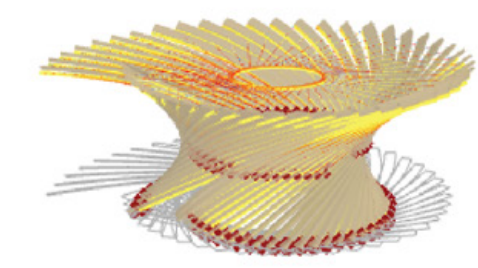
Gen 36-12



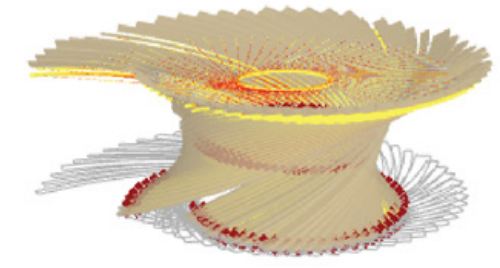
Gen 39-16



Gen 42-2



Gen 48-17



Gen 48-31

The first set of parameters that control the form include the radii (continuous) of the top and bottom tier ellipses. The second includes the density of points (categorical - natural numbers) on each ellipse which alters the number of consequent beams. This simple set of variables gives rise to an infinite field of possibility.

Karamba 3D enables the structural analysis and tests the feasibility of options with a yield stress of the material chosen (Laminated Veneer Lumber). The beams are first assigned a standard cross-section to extract material volume and estimated stress. These values help assign varying cross-sections to member groups with similar stress. The optimization occurs in identifying a few solutions that alter radii of the ellipses and beam count to achieve an optimal balance of maximizing overhang while minimizing deflection and material volume.

From the scatter plot that includes all the designs generated, we can see that the optimization process was able to keep on reducing structural displacement. However, due to the equal emphasis on cost and shade area, the algorithm was still producing a wide range of options across all numbers of beams towards later generations.

Among the 1750 designs from the optimization process, we selected 15 that were equally high-performing based on tradeoffs between the shadow area and the material cost. We added two more evaluation metrics to further differentiate the results: the shadow area per material cost and shadow area per deformation distance. By comparing the results based on these 2 metrics, we found that designs of high values of shadow/cost tend to have 50-54 beams, while those of high values of shadow/displacement tend to have a top ring size within 20' to 22'.

Three examples of different strengths are shown next to the scatter plot. The middle has both high values of shadow/cost and shadow/displacement but not high shadow area; the bottom one has a high shadow area, low relative cost, but also high relative displacement; the top one is between the two. The design space provides us a range of optimized options that can be selected based on a priority of either shadow area or the material cost. Further decisions could be made based on more specific design requirements.

The complexity of the design space increases with the increase in range and categories of input parameters. In order to keep the project continuous and searchable, we limited the variables to three types. Although we were originally interested in manipulating more variables such as beam shapes, spiral patterns, and different support strategies, it was ultimately more productive to focus on a reasonably complex set of variables that would produce constructive and measurable results.

Although setting immovable support and variables at our pavilion's ground level introduced a certain level of bias in our results, it was necessary to narrow the variance of the project. While our exploration employed finite element analysis of a designed pavilion, we included variables that would test for different scenarios and conditions. Ideally, the project would have undergone another level of dynamic methods that would seek to find the best condition - the convergence of our intended design.

Some metrics we used in our investigation were the shade produced, material cost, and displacement of the structure. These were chosen because of our intention to use the pavilion at Burning Man. Of importance were the sheltering properties, ease of construction, and structural integrity of the structure. These metrics were directly related to our design goals of maximizing overhang, reducing mass, and staying upright.

The most intuitive solution in this project was to calculate the maximum overhang we can achieve within certain displacement. However, it would be hard to integrate cost and cross-section design during the process. The optimization process of the genetic algorithm narrowed our design solutions to the ones that have equally high performance based on our metrics. A priority among these metrics will finalize the design selecting process.

