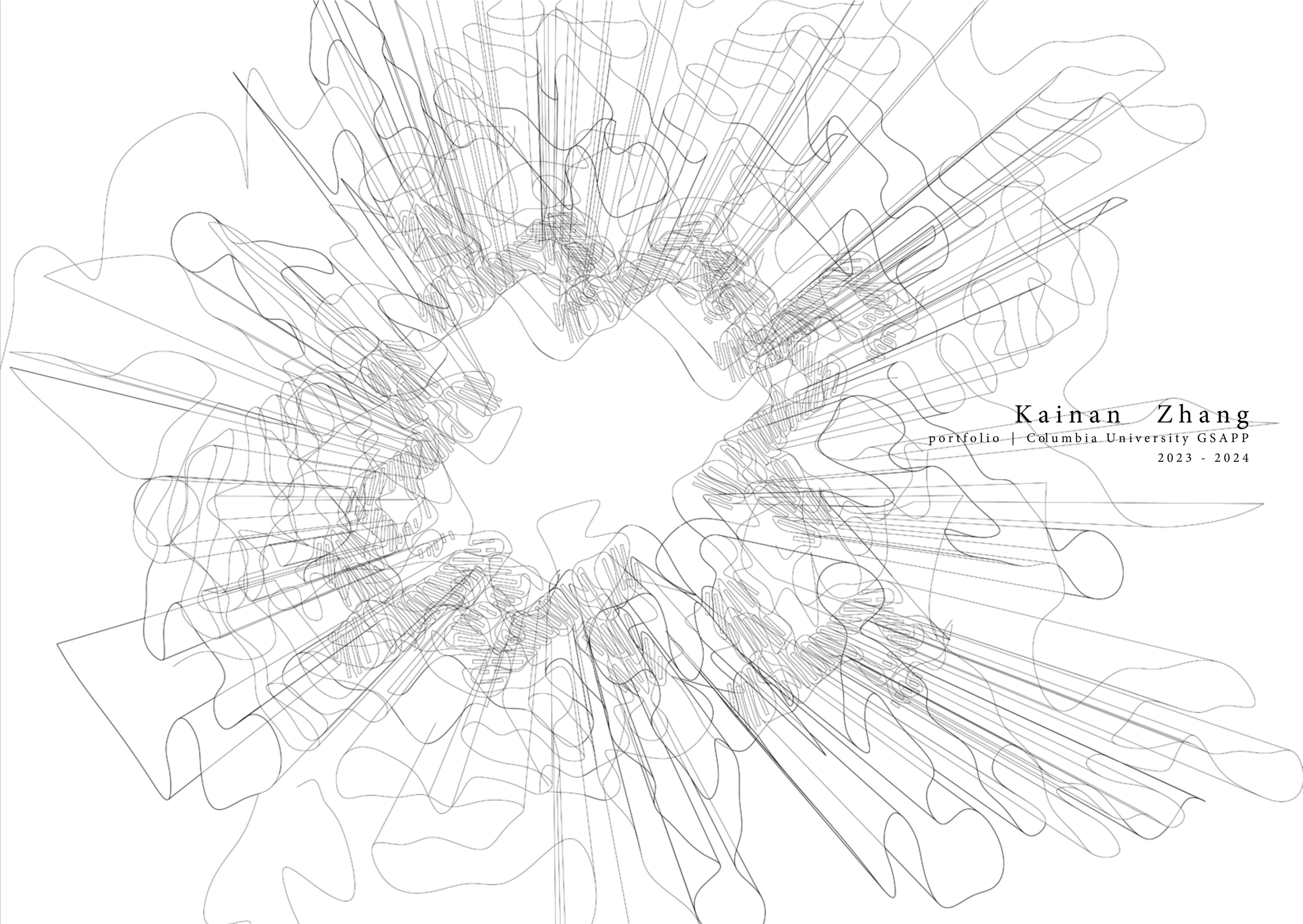
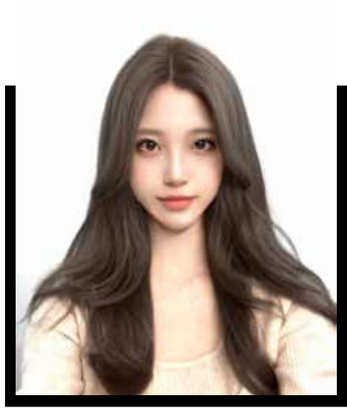


Kainan Zhang

portfolio | Columbia University GSAPP

2023 - 2024

About me



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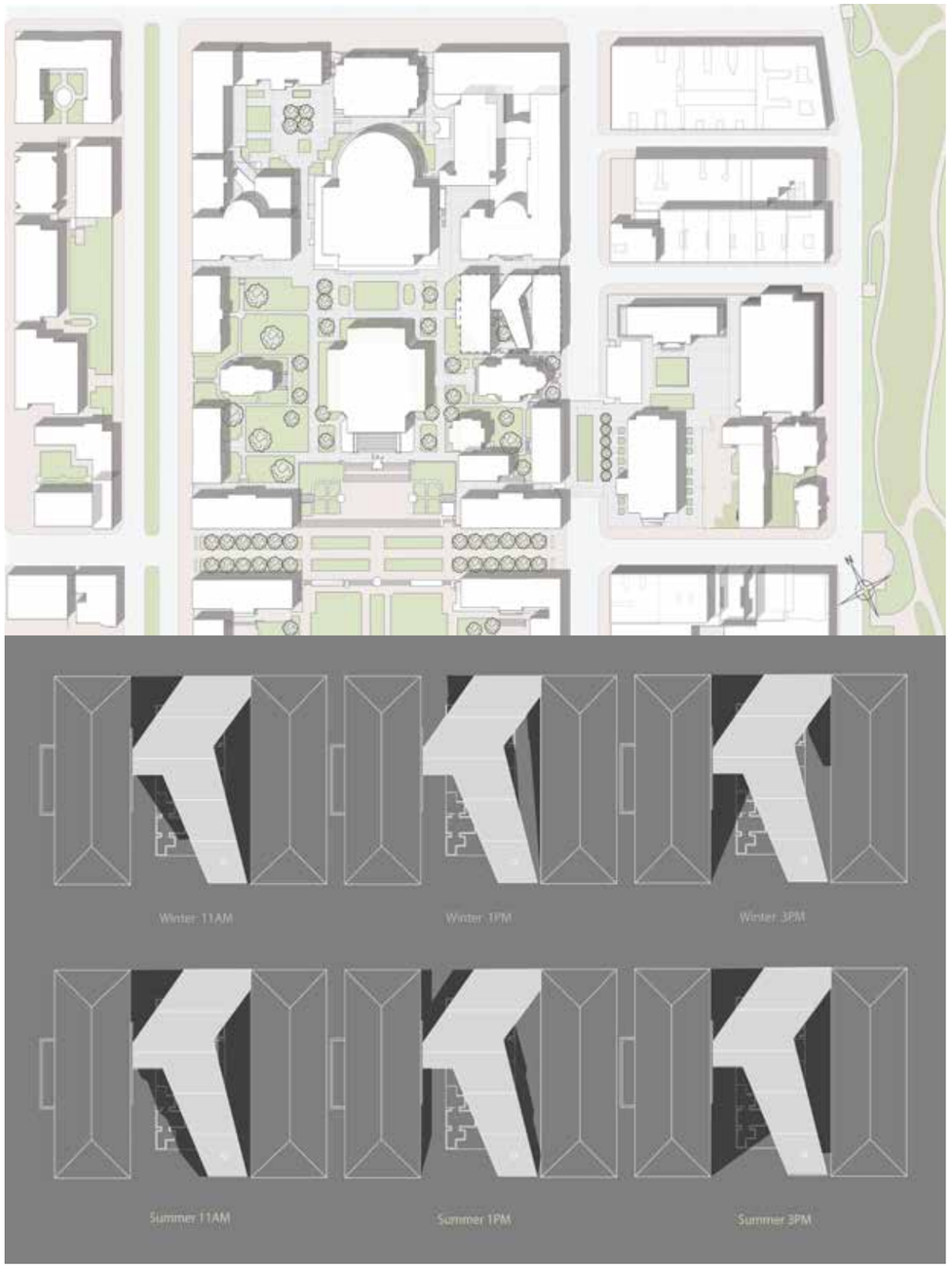
Contents

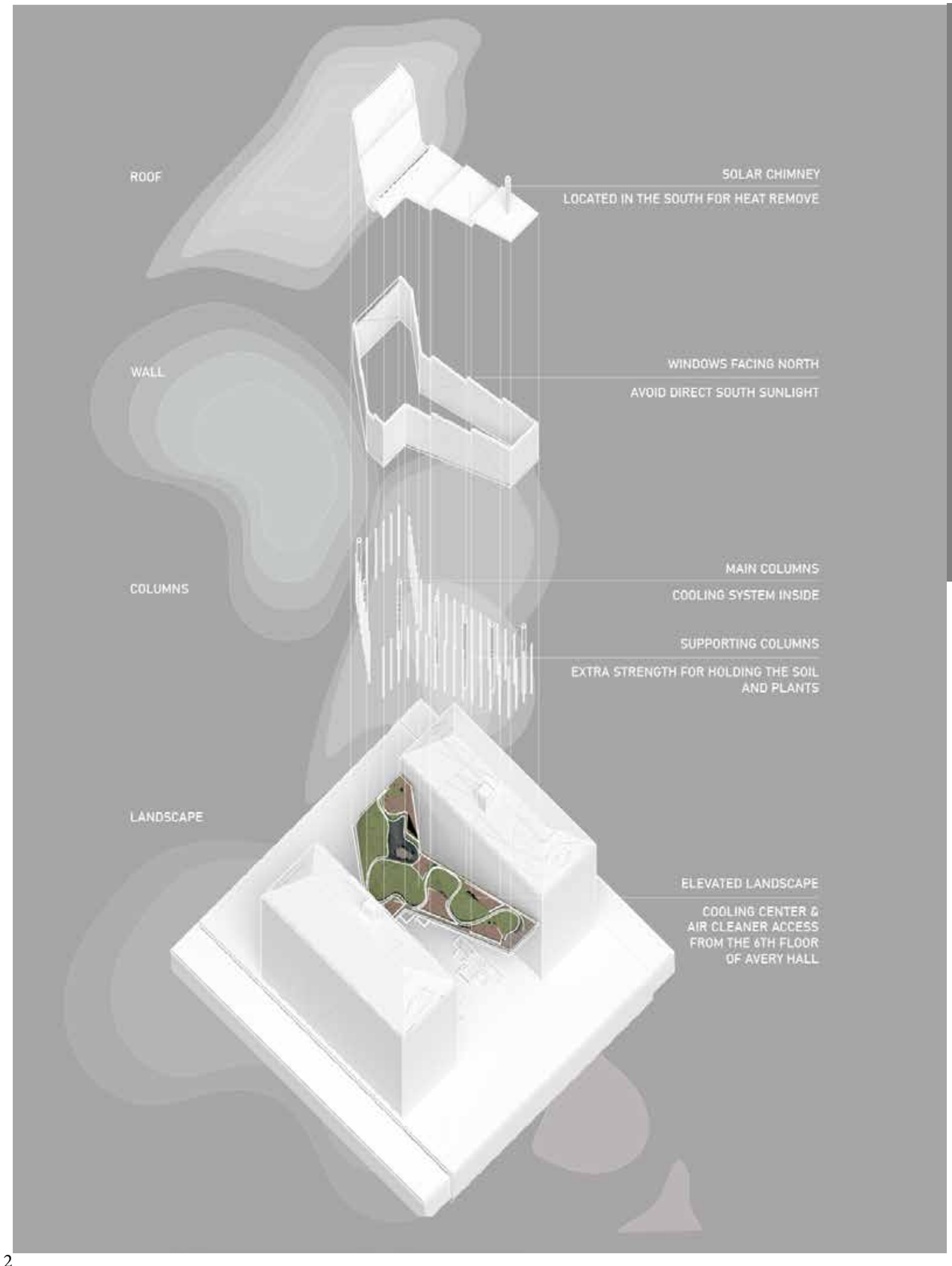
ACADEMIA

Fall 2023 | MOUNTAIN AVEN HOUSE PROJECT

GSAPP | Philippe Rahm & Mariami Maghlakelidze

The mountain aven house project is an elevated up cold house that is connected to the 6th floor of the existing Avery Hall. This cold greenhouse not only provides a cool space for both humans and plants, but also functions as an air cleaner for the high population density studio of Avery on the 6th and 7th floor. The project is using a thermal cooling system that grabs the cold air from underground and uses the solar chimney to remove the heat inside the space, with the special design of receiving light, the system is generated with solar energy.

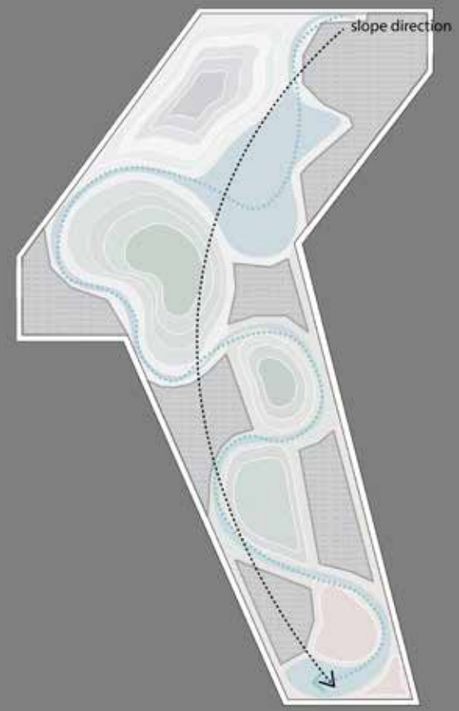




Arctic plants
locate at the highest altitude with small stones formed a natural arctic mountain landscape.

Arctic plants + Perennial plants
mix of both arctic and small local trees and plants at a slightly lower altitude landscape

Perennial plants + Largrer trees
local plants and trees locate at the lowest tropical area, an end of the flowing water provides more water for plants in the tropical area



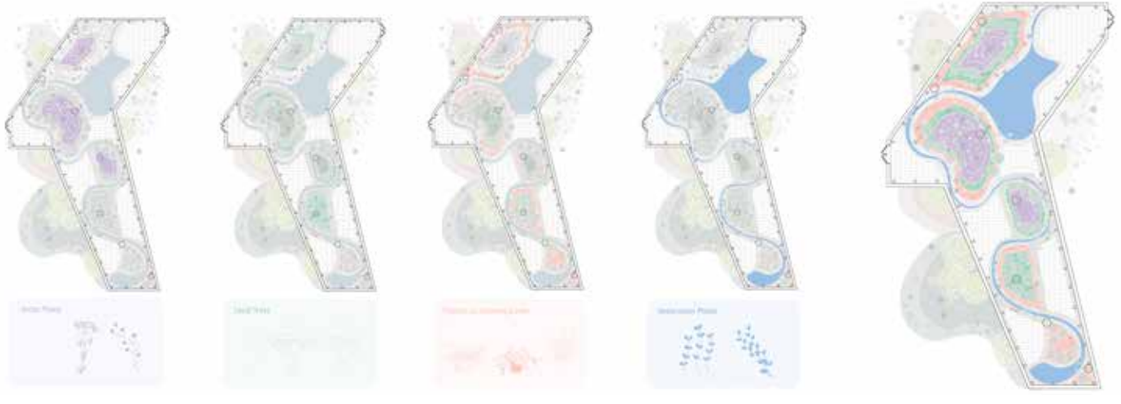
A main canel connecting all the plating area together , floating from top of the arctic hill towards the lowest point in the tropical area.

- As a main watering system that covers all the planting area
- The sloped ground support the natural flowing motion
- Provides rich water access for lower tropical area
- Easily crossing, no bridges needed
- As a string, joining and merging all the area together as a whole.

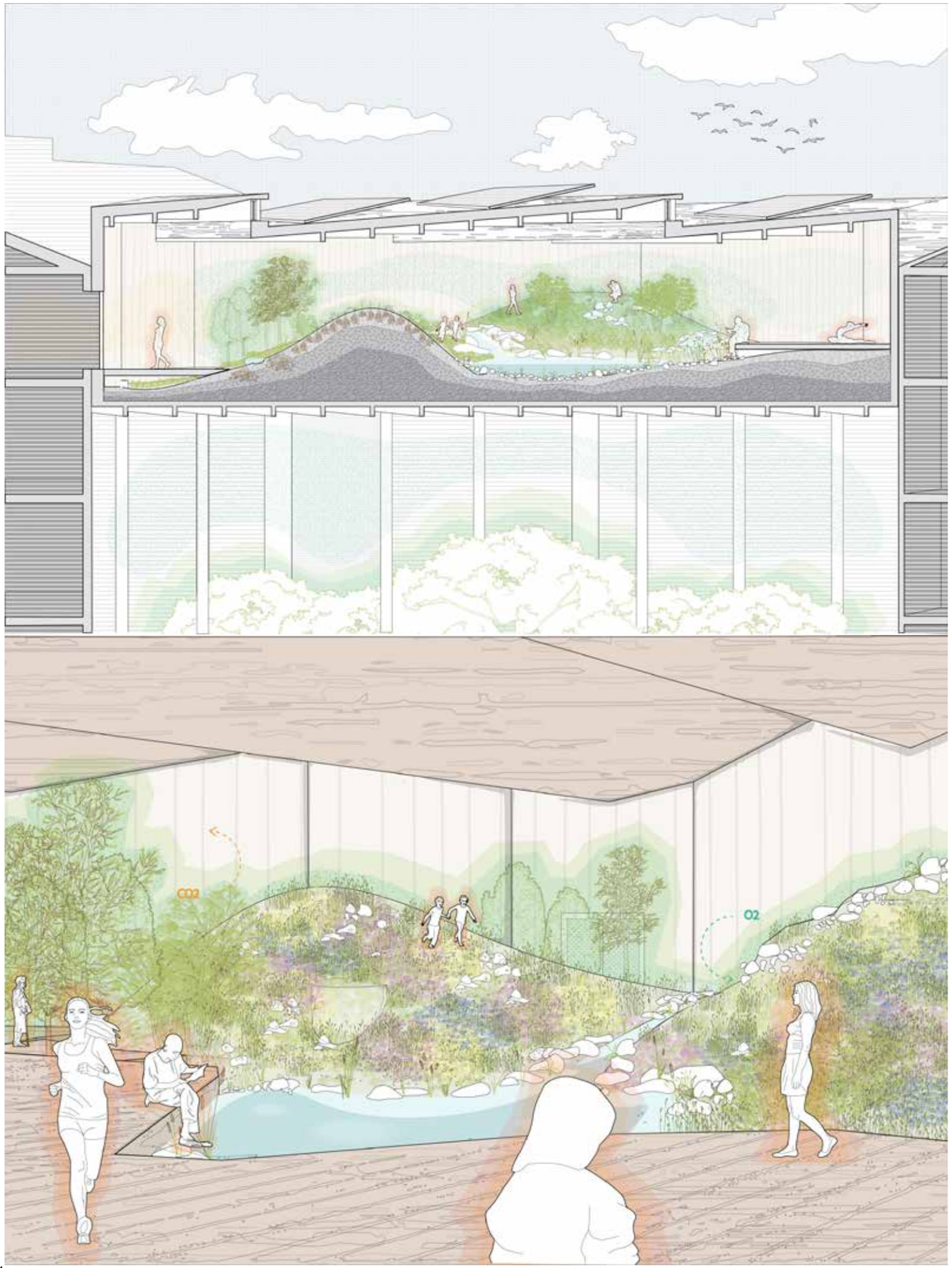
Wooden decks are also being locate around the natural planting landscape to provide some flat surfaces for human activities and furnitures

wooden planks not only give more access for human activities abut also naturally blended with the surrounding landscape

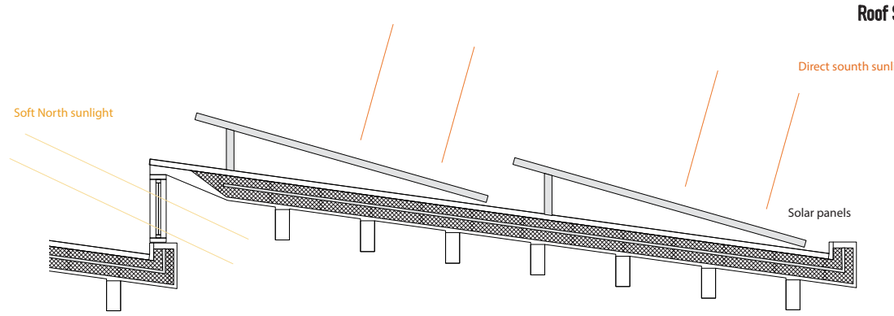
The interior of the project is being separated into planting landscape and flat surfaces for human activities. The planting landscape is also assigned for different plants, Arctic plants are located at the highest altitude with small stones forming a natural arctic mountain landscape. The middel landscape are for both Arctic plants + Perennial plants, and the mix of both arctic and small local trees and plants at a slightly lower altitude landscape. At the very south of the project, is Perennial plants + Larger trees, these local plants and trees located at the lowest tropical area, an end of the flowing water provides more water for plants in the tropical area.
There is a main canal connecting all the plating areas together, and the water is floating from top of the arctic hill towards the lowest point in the tropical area. This stream system is used as a main watering system that covers all the planting area, and The sloped ground supports the natural flowing motion without more electricity use. This canal also provides rich water access for lower tropical areas, and for humans to easily cross, no bridges needed for the landscape.



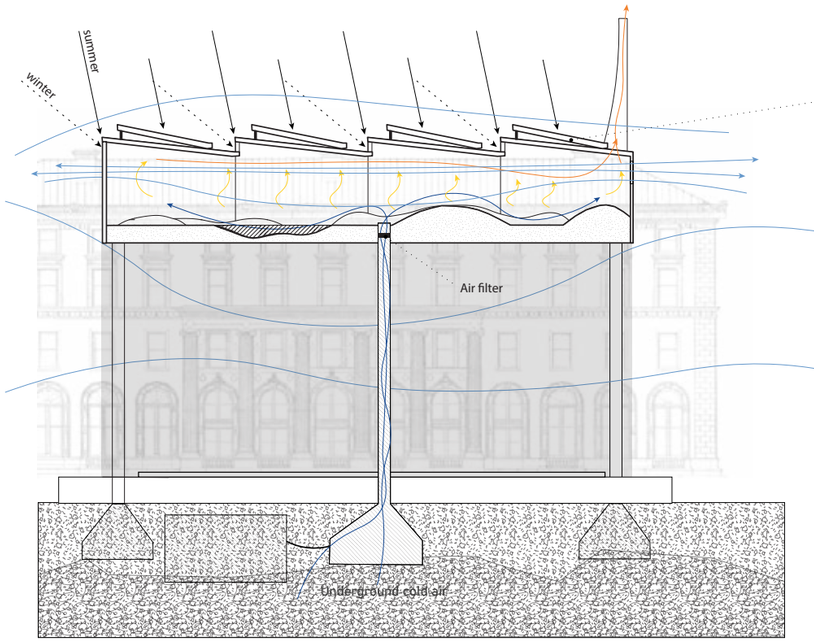
The structure of the project is mainly a wood and column structure, the main columns are located at the centerline of the whole building, and these large columns are not only supporting the structure but also having the cooling system inside with a filter to grab cold air from underground for the upper level project space. And the secondary supporting columns are thin columns located 5 ft apart from each other under the wall of the above project. The roof and walls are both insulated wooden structures with a vapor barrier to prevent temperature change in the exterior, and facade with only wood finish to prevent extra weight for the structure system.



Roof Section



Thermal cooling system



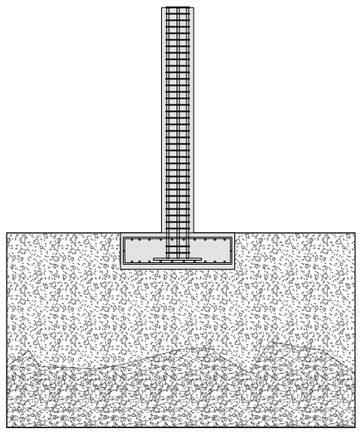
All windows are facing north for soft sunlight access. Solar panels are placing facing south re-civing direct south sun-light for more energy.

The whole project is using a thermal cooling system that have a solar chimny on the south side to remove the heat nor-mally on the upper space. At the sametime grabing the underground cold air to the space by the tube inside the main columns with air filter inserted.

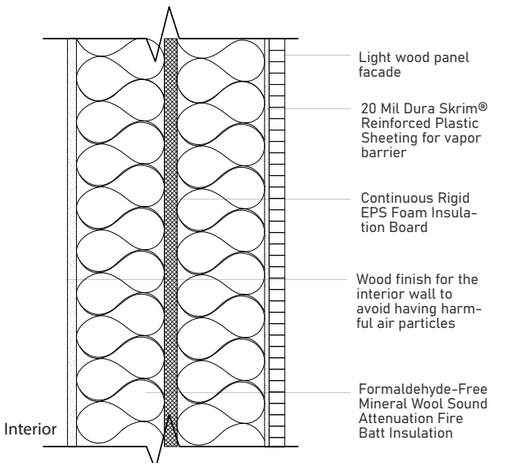
The garden below is par-tially shaded and prevent the direct south sunlight at sametime not blocking the ventilation and light access for the existing buildings

All water generating col-lecting system and me-chanical equipnments are locate underground and connect to the proj-ect space inside every columns

Supporting Column Section



Insulated Wall Section



A AIR QUALITY AND PLANTS | THE ATMOSPHERIC AND SOIL ENVIORMENT OF COLD PLANTS

PLANT CARBON EMISSIONS CAPTURED CATALOG

Plants form the backbone of natural ecosystems, and they absorb about 30 percent of all the carbon dioxide emitted by humans each year.

Common Tree Species in NY

RED MAPLE

Carbon Emissions Captured in Pounds of CO2 2,200 to 3,000

English Oak

Carbon Emissions Captured in Pounds of CO2 14,400

Eastern White Pine

Carbon Emissions Captured in Pounds of CO2 2,500

Basswood Trees

Carbon Emissions Captured in Pounds of CO2 9,600

Arctic Plant Species in NY

Dandelion

The increased CO2 caused the plants to produce more flowers and more seeds.

Draba

Protecting the ground and holding in moisture in dry periods, and offering a barrier between the soil and the air's temperature changes.

White Clover

Nitrogen Fixation
Holds moisture close to the ground and helps retain carbon dioxide (increasing photosynthetic efficiency)

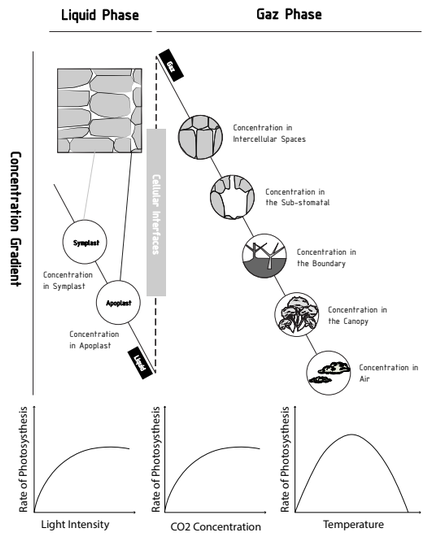
Underwater Plant Species in NY

Water Celery

Absorbing carbon dioxide (CO2) and ammonia (NH3) under water

Potamogeton Perfoliatus

The leaves are surrounded by thin porous cuticles, through which carbon dioxide enters into plants.



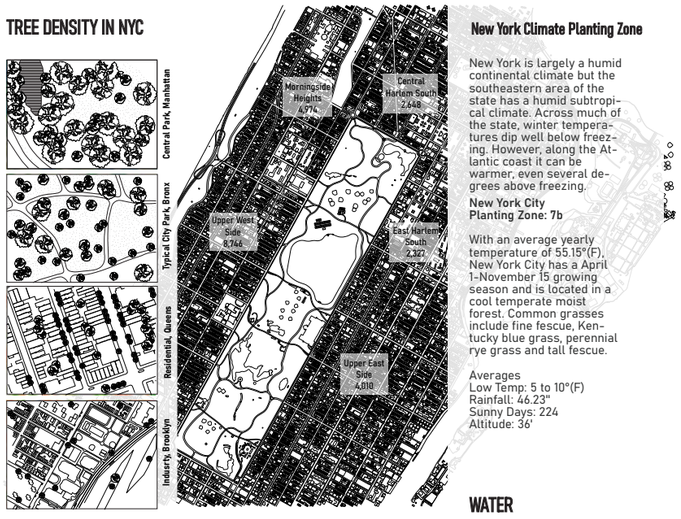
PHOTOSYNTHESIS

Absorption of Carbon Dioxide
Carbon Dioxide is absorbed through the stomata present in the lower epidermis of the leaves. This Carbon Dioxide enters through stomata and diffuses through air spaces between the mesophyll cells present in the leaves.

Absorption of Water
Water enters leaves through xylem vessels. This water moves up to the leaves from the soil in a chain of water molecules. The level of water uptake is determined by the rate of Photosynthesis and the rate of transpiration in the leaves.

Absorption of Sunlight
Light energy coming from the sun is absorbed by the chlorophyll molecules present in the chloroplast present in the leaves. Only 1% of the sunlight that falls on the surface of leaves is absorbed; the rest is reflected.

TREE DENSITY IN NYC



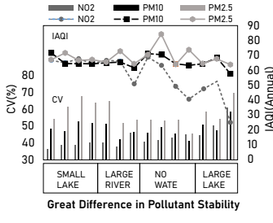
New York Climate Planting Zone

New York is largely a humid continental climate but the southeastern area of the state has a humid subtropical climate. Across much of the state, winter temperatures dip well below freezing. However, along the Atlantic coast it can be warmer, even several degrees above freezing.

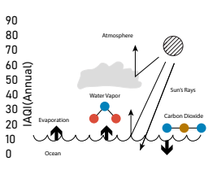
New York City
Planting Zone: 7b

With an average yearly temperature of 55.15°(F), New York City has a April 1-November 15 growing season and is located in a cool temperate moist forest. Common grasses include fine fescue, Kentucky blue grass, perennial rye grass and tall fescue.

Averages
Low Temp: 5 to 10°(F)
Rainfall: 46.23"
Sunny Days: 224
Altitude: 36'

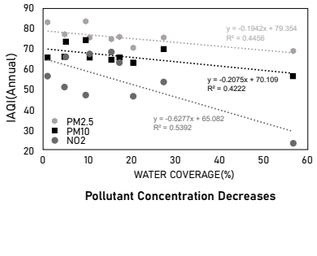


Great Difference in Pollutant Stability

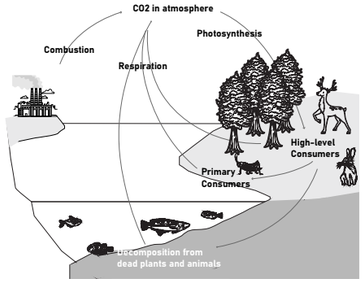


WATER

Water is one of the primary reactants involved in Photosynthesis, so water concentration in the plant dramatically affects the rate of Photosynthesis.
Higher water concentration will surely increase the rate of Photosynthesis.
The rate of Photosynthesis drops in dry seasons because less water is available for the plant.

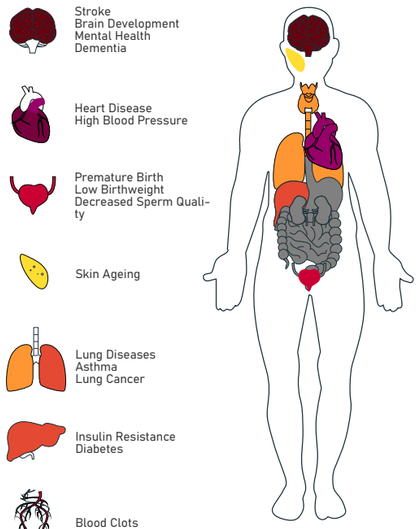


Pollutant Concentration Decreases

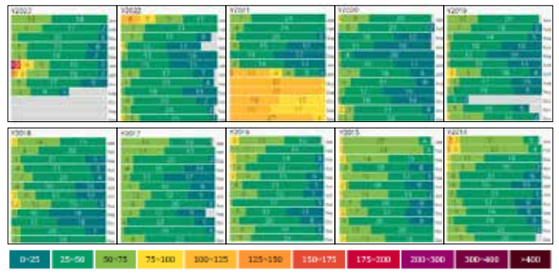


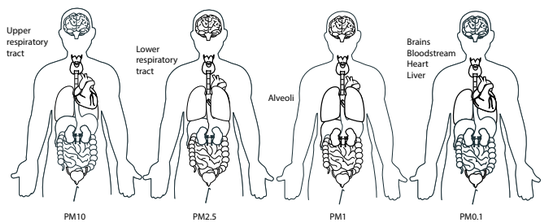
B OUTDOOR AND INDOOR AIR QUALITY AND HUMANS | THE ATMOSPHERIC ENVIORMENT OF HUMANS

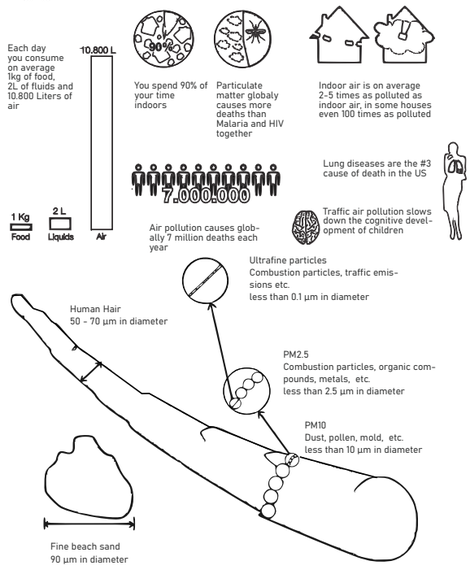
THE HEALTH HARMS OF BAD AIR QUALITY



Past 8 years NYC Air Pollution Level







Indoor Living Spaces Air Quality

- Pollutant Sources
- Fuel-burning combustion appliances
- Tobacco products
- Building materials and furnishings as diverse as:
- Deteriorated asbestos-containing insulation
- Newly installed flooring, upholstery or carpet
- Cabinetry or furniture made of certain pressed wood products

- Central heating and cooling systems and humidification devices
- Excess moisture
- Outdoor sources such as:
- Radon
- Pesticides
- Outdoor air pollution.

According to a study, air quality improves once you reach the 4th floor. Beyond this, the differences are just minimal. This means that you only need to be at least on the 4th floor to get good air quality, and you only get a tiny improvement every time you go a floor higher.

PM10

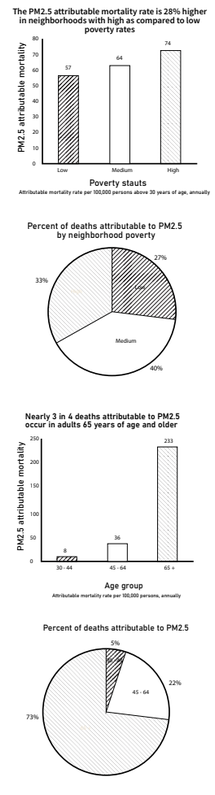
PM10 are particles which are smaller than 10 micrometer (µm), 1 micrometer = 0,001 milimeter. Because these particles are easily inhaled, they will reach your lungs and cause health issues.

PM2.5

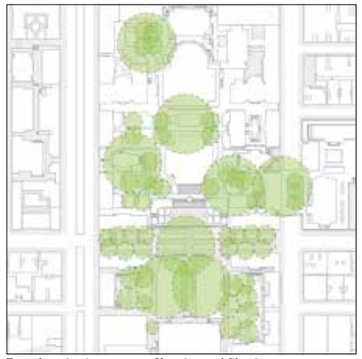
PM2.5 are particles which are smaller than 2.5 micrometer (µm). These PM2.5 particles are so small they can penetrate the respiratory and cardiovascular system and cause health issues.

Ultrafine particles

Ultrafine particles are all particles smaller than 0.1 µm (micrometer). These particles are so small they can penetrate into your bloodstream and be transported everywhere in your body, for example to your brains. Exposure to ultrafine particles can cause various health risks.

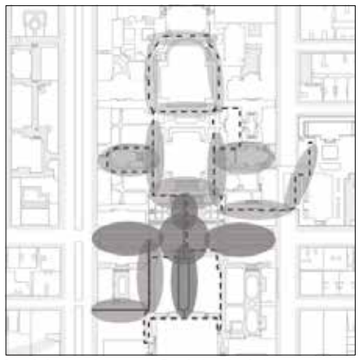


C AIR QUALITY | ENVIRONMENTAL ANALYSIS OF COLUMBIA UNIVERSITY CAMPUS



Trees location in campus - Cleaning and filtering

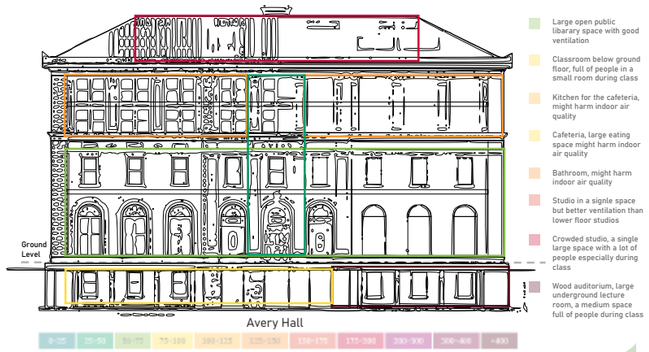
Elevation difference in campus - Raised platform



Crowded spaces in campus - Population circulation

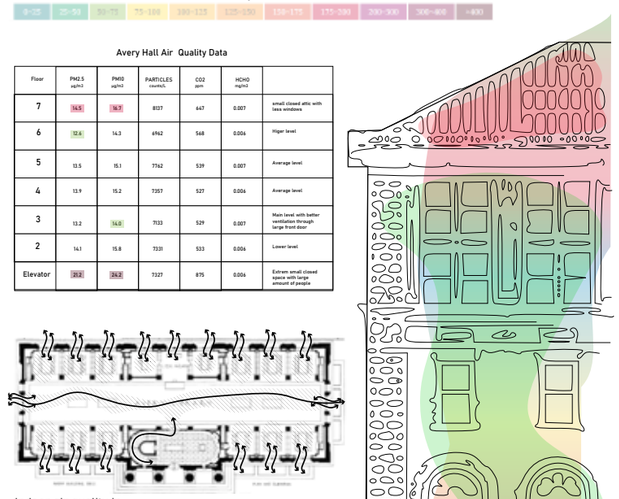
Major streets surrounding campus - Traffic pollution

AIR QUALITY OF AVERY HALL IN COLUMBIA UNIVERSITY CAMPUS

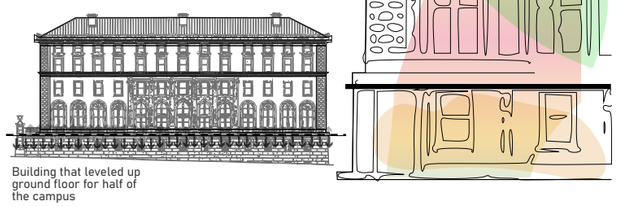


Avery Hall Air Quality Data

Floor	PM2.5 ug/m3	PM10 ug/m3	PARTICLES counts	CO2 ppm	HCHO mg/m3	
7	14.5	14.7	8127	647	0.007	small closed attic with less windows
6	12.6	14.3	6962	568	0.006	Higer level
5	13.5	15.1	7762	539	0.007	Average level
4	13.9	15.2	7357	527	0.006	Average level
3	13.2	14.0	7133	529	0.007	Main level with better ventilation through large front door
2	14.1	15.8	7331	533	0.006	Lower level
Elevator	21.2	24.2	7327	875	0.006	Extrem small closed space with large amount of people

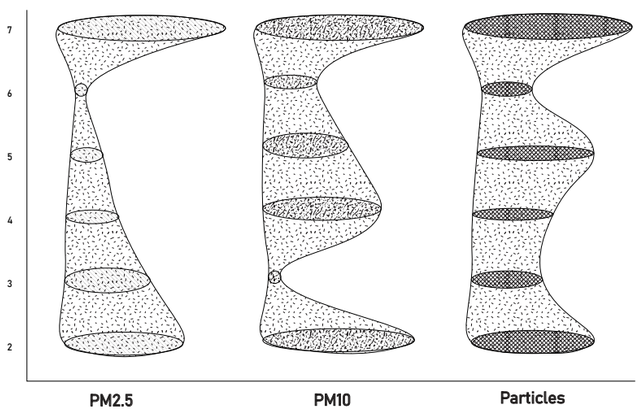


Indoor air quality in public libarary space



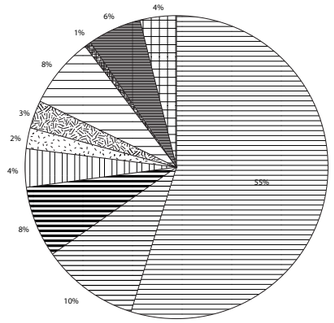
Building that leveled up ground floor for half of the campus

Particle Amount on Each Floor in Avery Hall



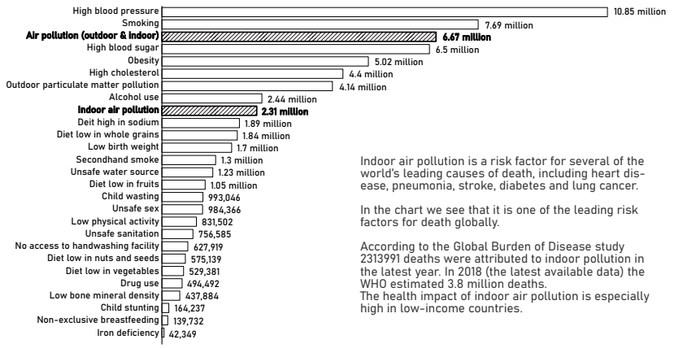
A INDOOR POLLUTION | RESEARCH INTO THE CLIMATIC PRINCIPLES OF ARCHITECTURE

HEALTH SYMPTOMS LINKED TO POOR INDOOR AIR QUALITY



- 10% Eye irritation
- 8% Fatigue
- 4% Dizziness
- 2% Skin irritation/itchy skin/dry skin
- 3% Difficulty breathing/shortness of breath
- 8% Coughing/irritation of airways
- 1% Asthma
- 6% Nose irritation/frequent sneezing/runny nose
- 4% Trouble concentrating
- 55% Chronic bronchitis

World's deaths by risk factor



Indoor air pollution is a risk factor for several of the world's leading causes of death, including heart disease, pneumonia, stroke, diabetes and lung cancer.

In the chart we see that it is one of the leading risk factors for death globally.

According to the Global Burden of Disease study 2313991 deaths were attributed to indoor pollution in the latest year. In 2018 (the latest available data) the WHO estimated 3.8 million deaths.
The health impact of indoor air pollution is especially high in low-income countries.

Best Plants Help Remove Indoor Toxins

Spathiphyllum

The NASA study found spathlphyllum to be the most effective houseplant for removing TCE from indoor air pollution, removing **23% over 24 hours**, also removing formaldehyde, trichloroethylene and benzene from the air (particles that get released from carpet and furniture, too)

Chlorophytum comosum

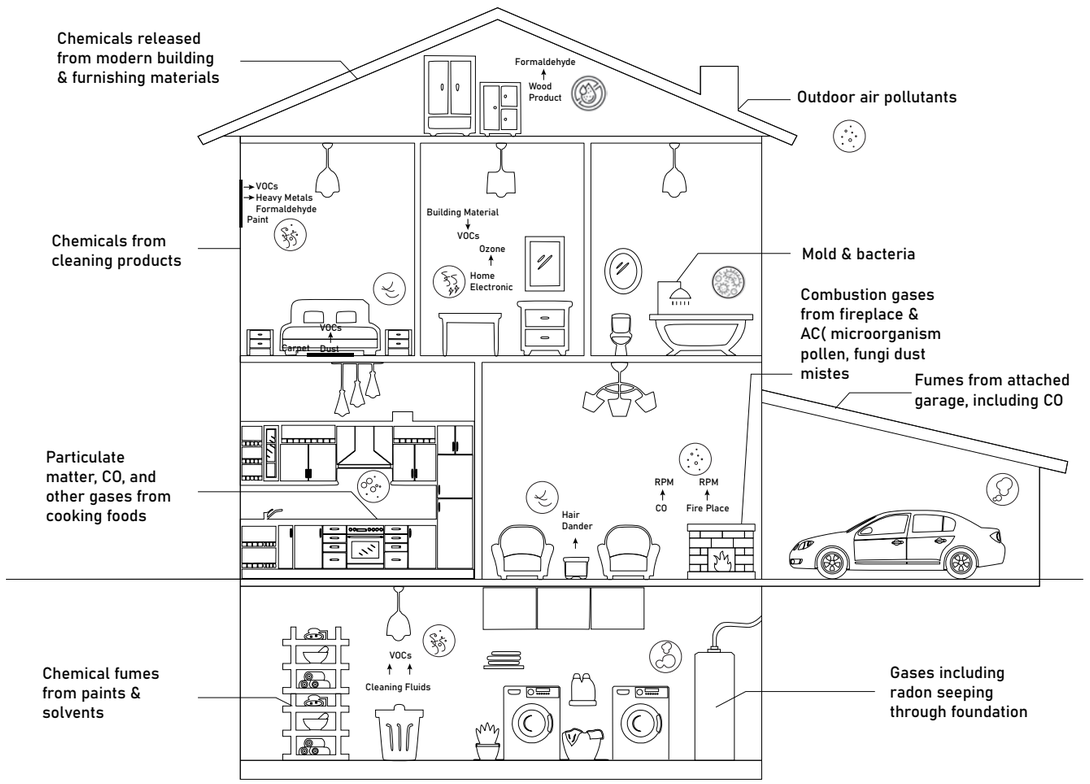
The NASA, which tested the abilities of three common houseplants to remove formaldehyde from the air, found in preliminary tests that spider plants were the champs, removing **95% of the toxic** substance from a sealed Plexiglas chamber in 24 hours.

Aloe Vera

Aloe Vera works by releasing oxygen and absorbing carbon dioxide during the night The CO2 concentration can be decreased **487, 276, and 185 ppm for a period of 8 hours** using a plant of Aloe vera

Hedera helix

According to researchers at the American College of Allergy, Asthma & Immunology, this plant can remove **78% of airborne mold in just 12 hours**. It also battles benzene, formaldehyde, trichloroethylene, xylene and toluene in the air.



GSAPP | Youssef Anastas & Elias Anastas
Partner | Zhihan Guo

REUSE STONE WASTE

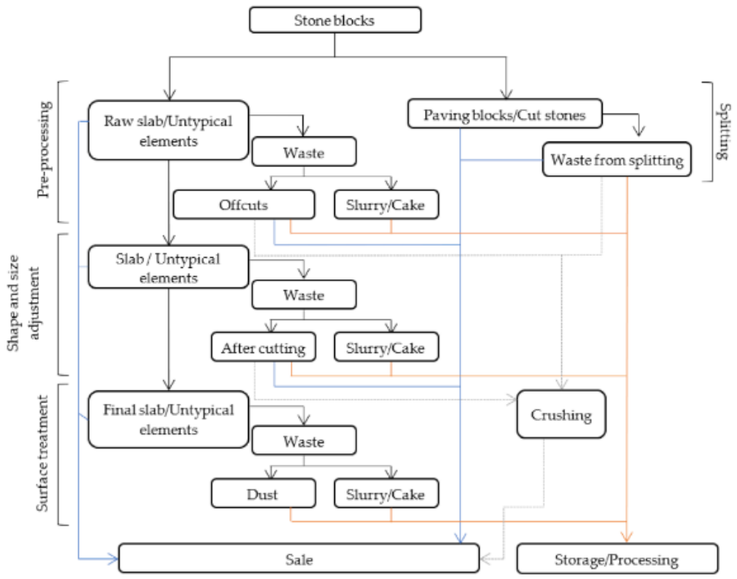


Diagram representing waste production in the processing of natural stone

(**a**) crushed slabs (different waste size)

(**b**) sludge

NEW MATERIAL | Reference

Application of Stone Scrap	Type of Stone Scrap	Material	References
Building materials (mortar/concrete/brick)	powder/fine aggregate	granite	[23,24,25,26,27,28,29,30,31,32,33]
		marble	[34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55]
		limestone	[56,57,58,59,60,61]
	powder/fine aggregate	basalt	[62,63,64,65]
	coarse/fine aggregate	sandstone	[66,67,68,69,70,71]
	powder	mix/unidentified	[72,73,74,75,76,77]
Ceramic materials	fine grained waste/powder	granite	[78,79,80]
		marble	[81,82,83,84,85]
	powder	gneiss	[86,87,88]
		serpentinite	[89,90]
		mix/unidentified	[91,92]
Stabilised clay soil	powder	marble	[93]
		limestone	[94,95,96,97]
		mix/unidentified	[98,99]
Fertilisation	unidentified	marble	[100]
		basalt	[101,102]
	powder	gneiss	[103,104,105,106]
Various composite materials	powder	granite	[107]
		marble	[108,109,110,111]
		sandstone	[112]
		basalt	[113,114]
Other applications	powder	granite	[115]
		marble	[116,117,118,119]

Table: Literature research on the possibilities of application of stone waste

LIME
Hydraulic Lime

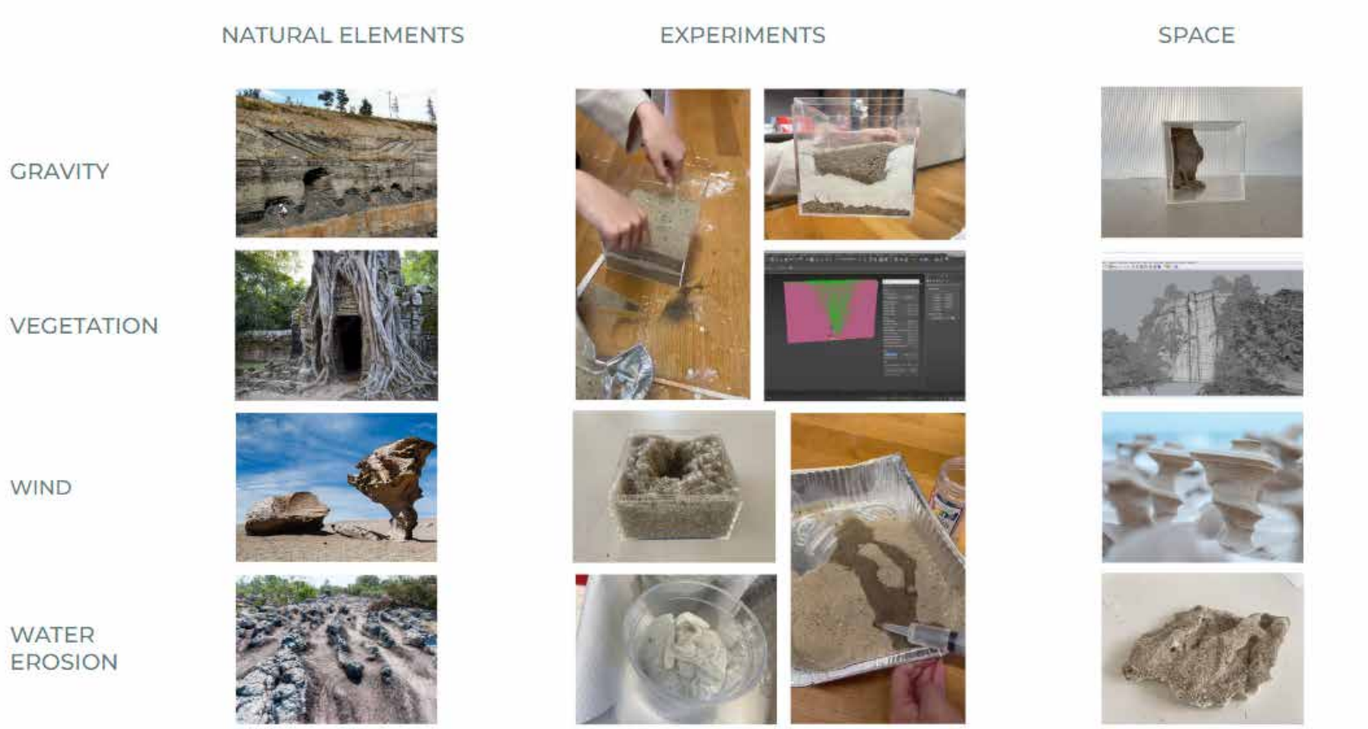
NEW MATERIAL | Composition

	BINDER	AGGREGATES	OTHER
CONCRETE	Portland Cement	• Rock • Sand • Gravel	Admixtures
VS			• Waste Marble Powder • Wood Sawdust • Paper Waste Sludge • Iron Wire Segments • Stone Strengthening Fiber
LIMECRETE	Hydraulic Lime	• Crushed Limestone • Fine Sand • Coarse Sand	

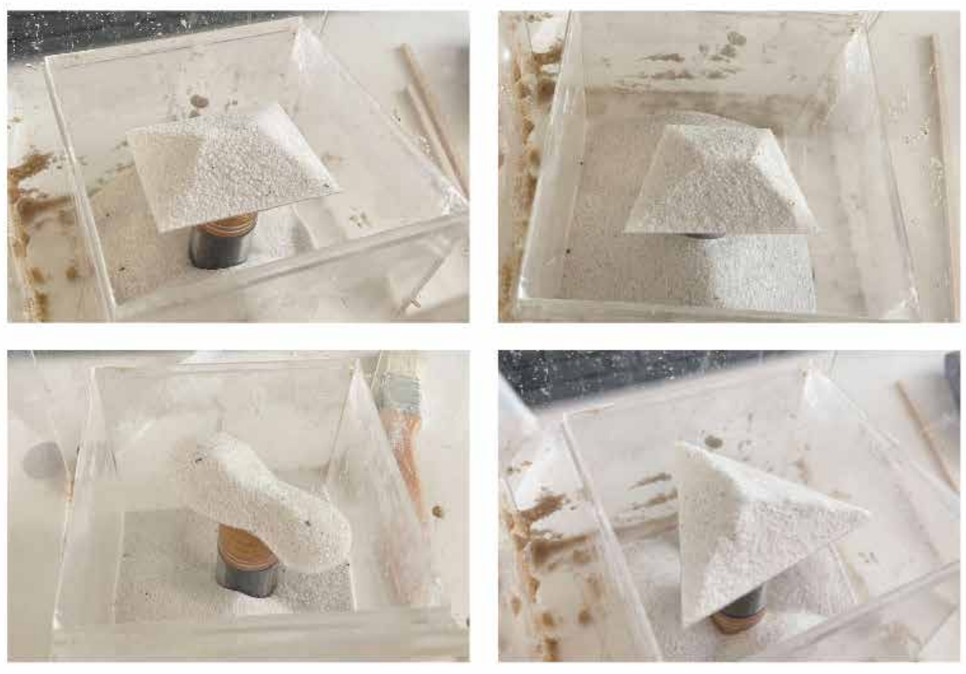
NEW MATERIAL | Experiments

For this project, we pay attention to a lot of waste production in natural stone processing, which has been a severe environmental problem. Therefore, we attempted to create new materials with different types of waste to alleviate this problem. After a series of studies, we found that lime, especially hydraulic lime, is an excellent material to glue all the waste. It is more sustainable than cement, and it is more stable, stronger, easier to handle, and sets more quickly than other kinds of lime. We learned from the composition of concrete to make our new limecrete.

FORM FINDING | Experiments



FORM FINDING | Experiment



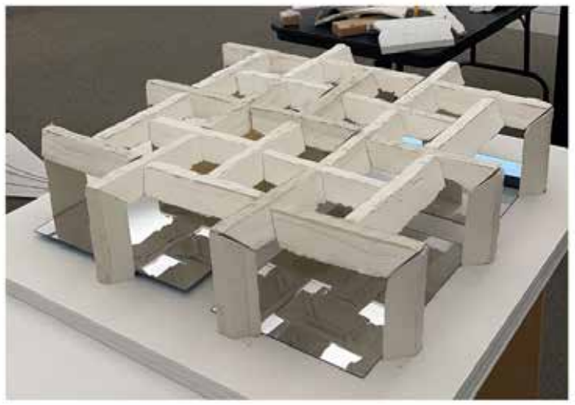
Erosion In The Right Place

We used waste crushed limestone to replace the aggregates, marble dust to improve its adhesion, wood sawdust or steel wire pieces to increase its tensile strength, paper sludge, and other waste materials to improve the various properties of materials. After that, we chose sand to cast this new material because of its affordability and accessibility.

FORM FINDING | Experiment

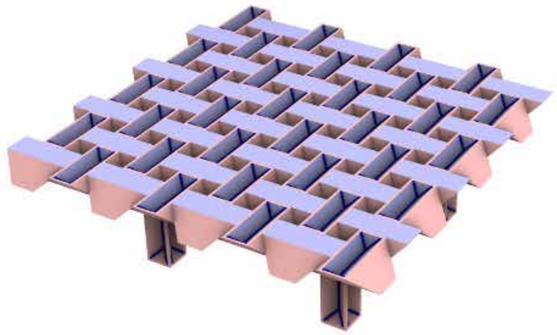
Erosion In The Right Place

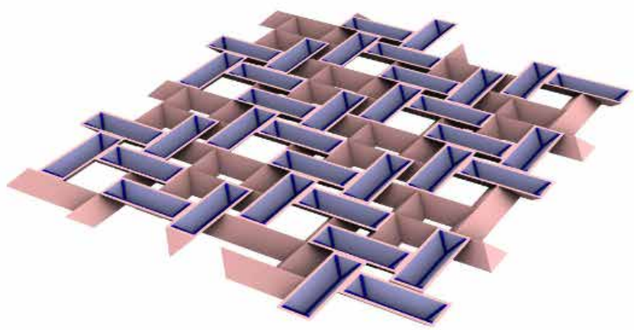
ASSEMBLE | Final Model

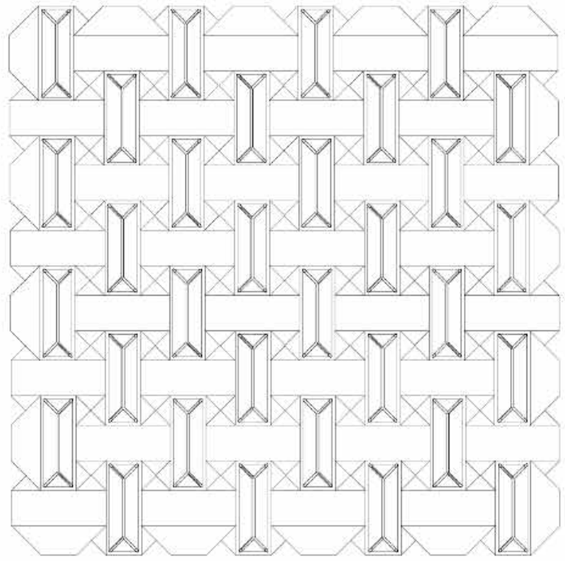


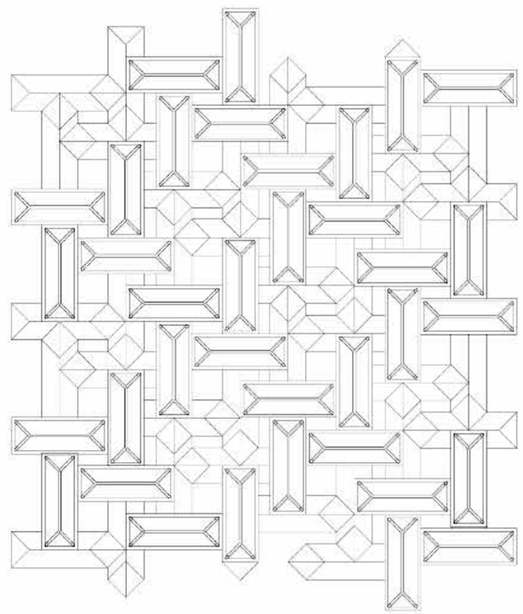
FORM FINDING | Midterm

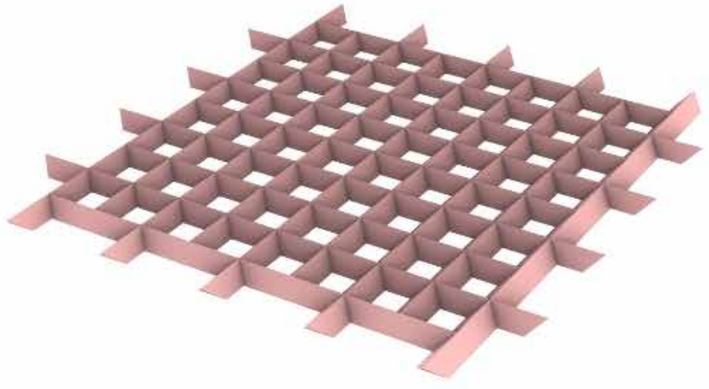
ASSEMBLE | Geometry

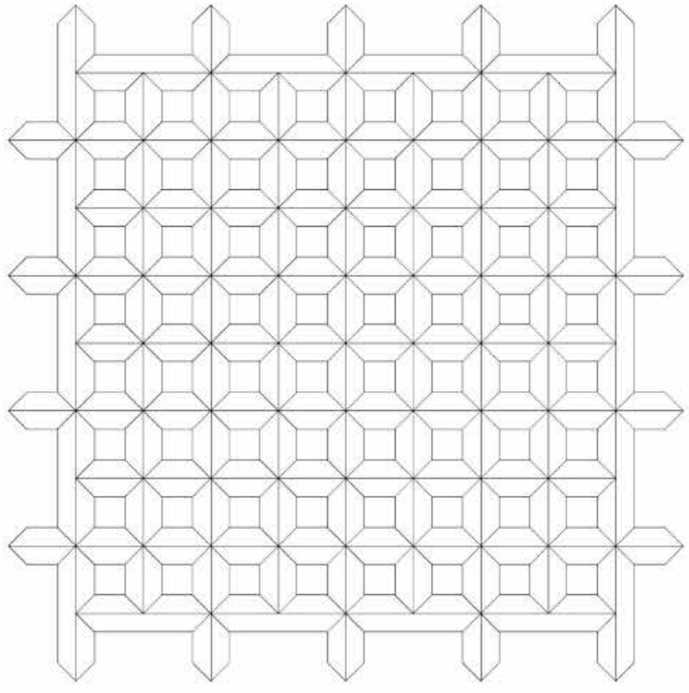




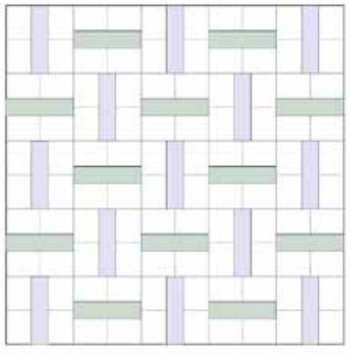








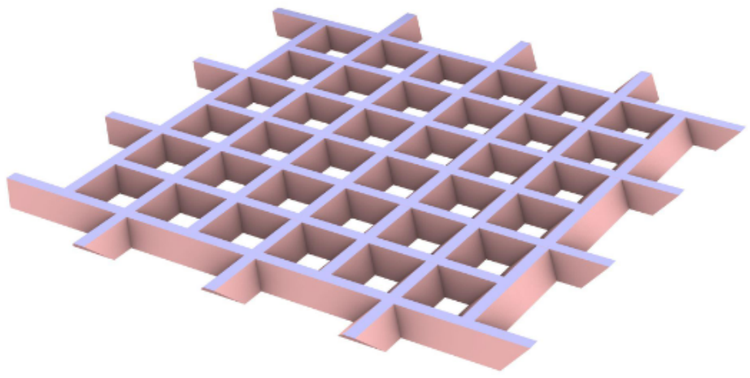
ASSEMBLE | Grid

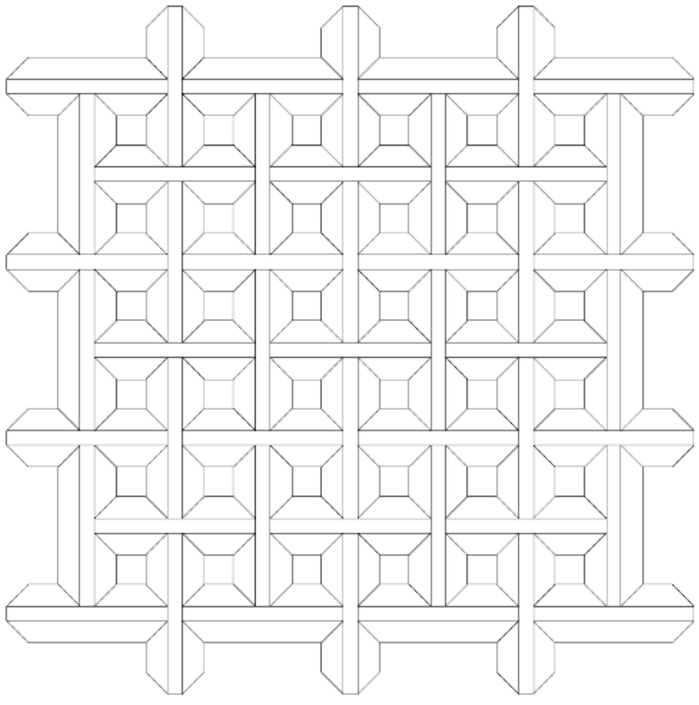


STATISTICS | Reuse

53 tons Waste Limestone
10 tons Marble Dust
12 tons Wood Sawdust

Material
(Every 1000㎡ Structure)





STATISTICS | Carbon Emission

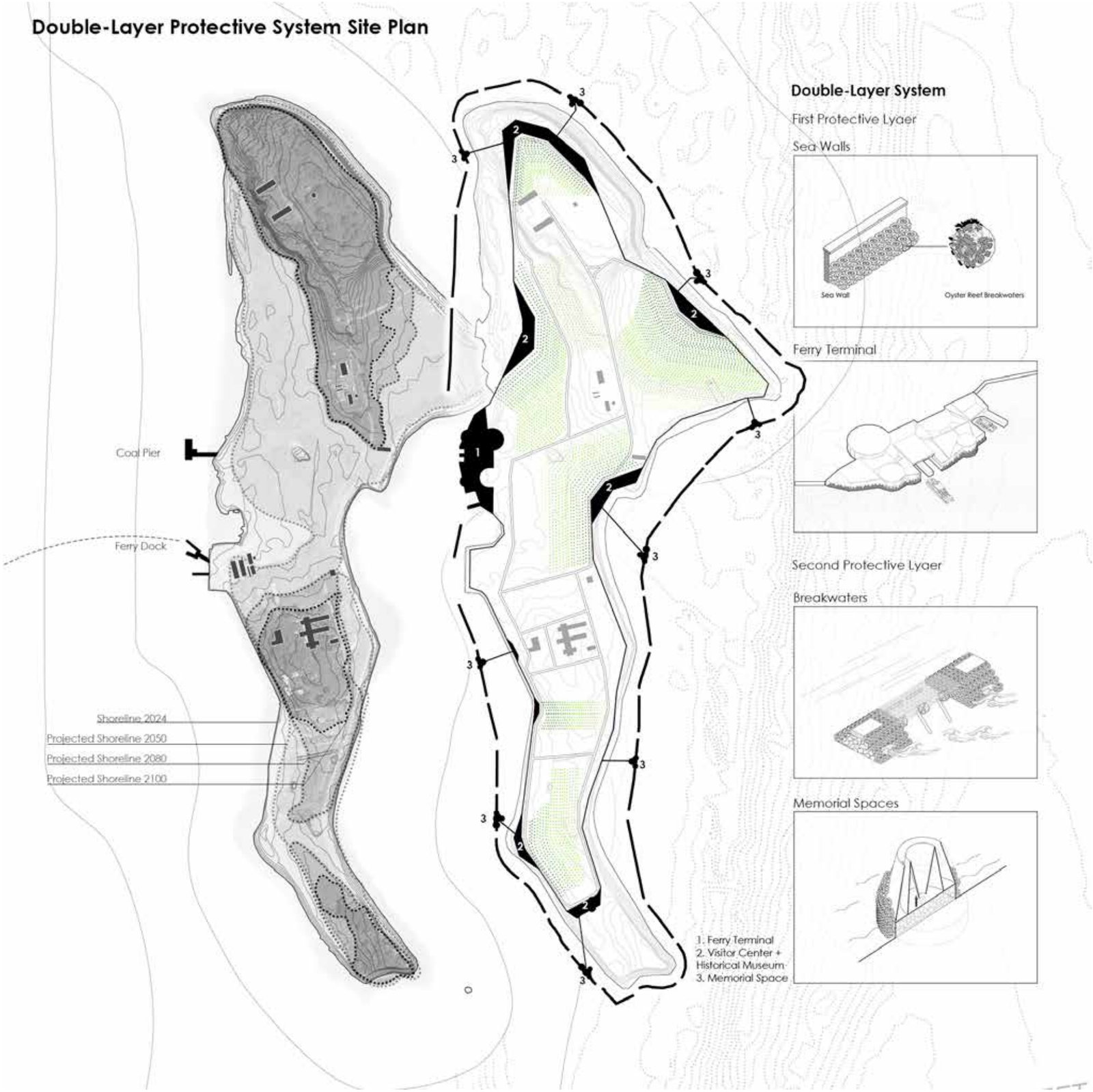
Material
(Compared to Portland Cement Concrete)

-33% Embodied Energy
-64% Embodied CO2

STATISTICS | Save

Structure

-45% Material



Spring 2024 | IMPERMANENT ARCHIVES
Memorial on Hart Island

GSAPP | Karla Rothstein

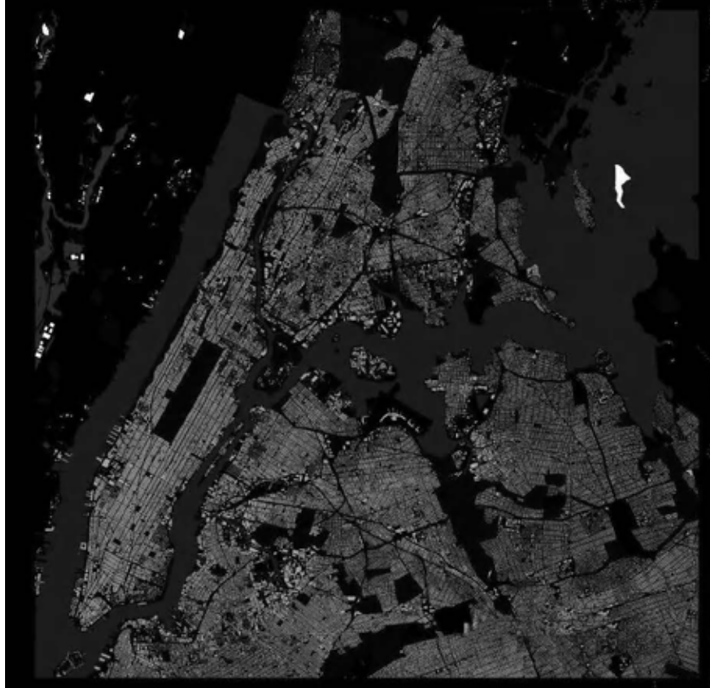
Partner | Yao Xiao

Our project is guided by a theoretical and political commitment to redefining the relationships among forgotten spaces, memory, and urban development. Recognizing marginalized sites like Hart Island as vital components of the urban landscape, we aim to reframe prevailing attitudes of neglect and erasure. At stake are honoring collective memory, acknowledgment of historical injustices, and the creation of inclusive and equitable spaces within the city. The future of this site will be informed by fundamental values of justice, compassion, and sustainability in urban planning, building upon the history of Hart Island as a burial ground for the marginalized and disenfranchised, while also envisioning its potential as a site of renewal and reconciliation for all New Yorkers.

To address the challenges of environmental degradation and accessibility, our project employs a dual-layered approach to protect Hart Island. An inner protective layer consists of sea walls and a ferry terminal, serving both as a barrier against sea water flooding and as a multifunctional space for exhibitions and memorials. The project safeguards the island while fostering meaningful connections between visitors and its historical and cultural heritage, catalyzing awareness and engagement. Additionally, the provision of shelter within our terminal design responds to the harsh environmental conditions experienced during our site visit.

In parallel, an outer protective layer comprises breakwaters and memorial spaces, strategically positioned to reduce sea wave energy and prevent erosion along the island's edges. By integrating these protective measures with commemorative elements, we both safeguard the physical integrity of Hart Island and honor its significance as a place of remembrance and reflection. We understand the site as an Impermanent Archive—a dynamic space that collects, organizes, and disseminates shared knowledge and memory, continuously reconfiguring over time. Through actions of reclamation and revitalization, we challenge conventional understandings of forgotten marginalized spaces and assert their agency within the urban fabric, prioritizing inclusivity and resilience.

Location



Functions

While Hart Island is currently only used for **CITY BURIALS**

The island has served many uses since the 19th Century,

A Quarantine Station
A Phychiatric Hospital
A Tuberculosis Ward
A Reform School
A Homeless Shelter
A Rehabilitation Facility
A Military Base
A Jail

Shoreline Map

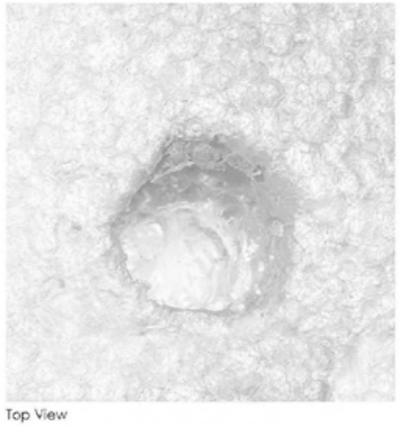
Dock 1

Ferry Dock
Material: Concrete, Steel and Timber
Status: In Use

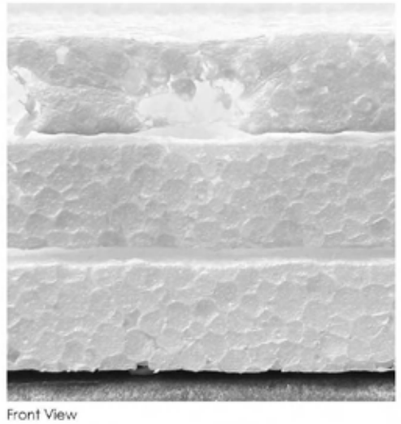
Dock 2

Coal Pier
Material: Concrete and Timber
Status: Not In Use

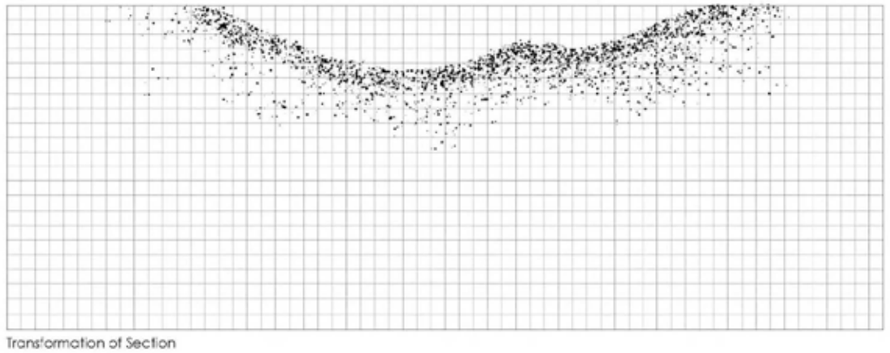
5 Drops



Top View



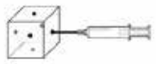
Front View



Transformation of Section

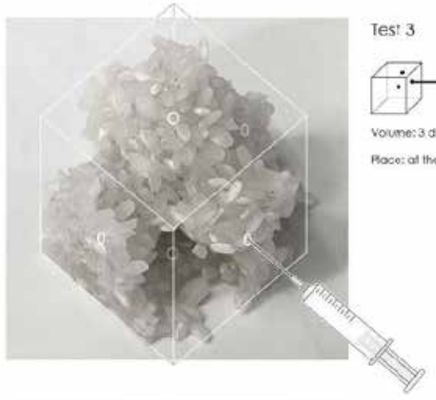
To safeguard against flooding for at least the next 100 years, we've devised a protection system inspired by our material studies. Our material study involves utilizing a superglue that corrodes the foam, creating denser and harder edges within the void. Additionally, we've developed a cohesion system using resin that permeates the grain structure in various directions, uniting separate particles into a cohesive whole.
Here is a diagram illustrating these systems in relation to the decay and renewal processes. Combining these two systems, we've introduced a double-layer approach to protect the island.

Test 1

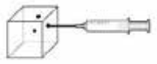


Volume: 6 doses (5ml/dose)

Place: In the center of each sides

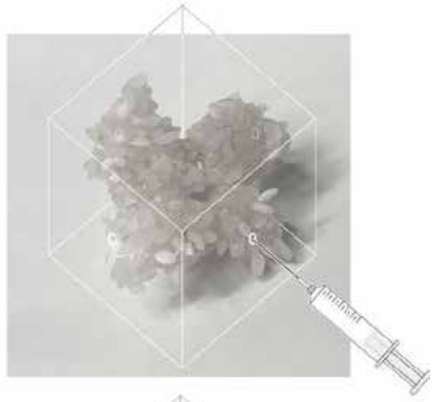


Test 3

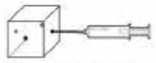


Volume: 3 doses (5ml/dose)

Place: at the corner of 3 sides

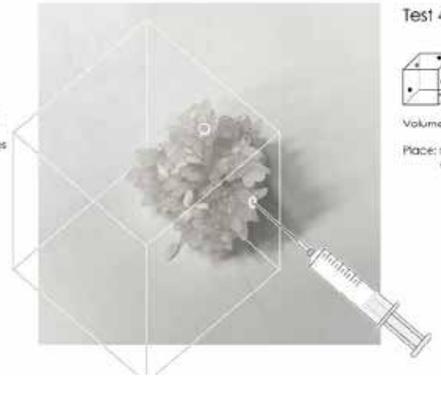


Test 2

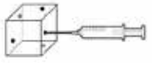


Volume: 4 doses (5ml/dose)

Place: In the center of 4 sides

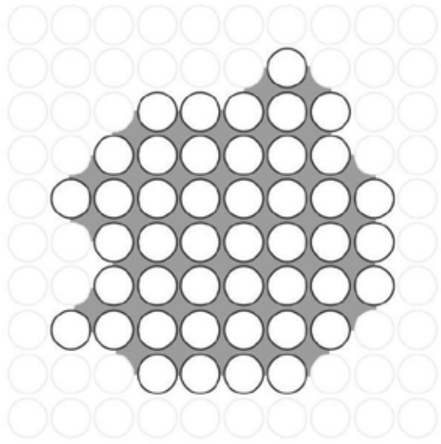


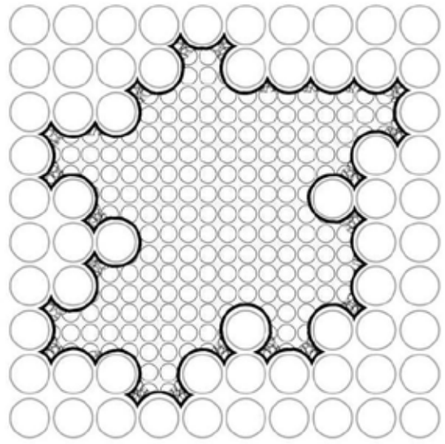
Test 4



Volume: 6 doses (5ml/dose)

Place: randomly injected of each sides





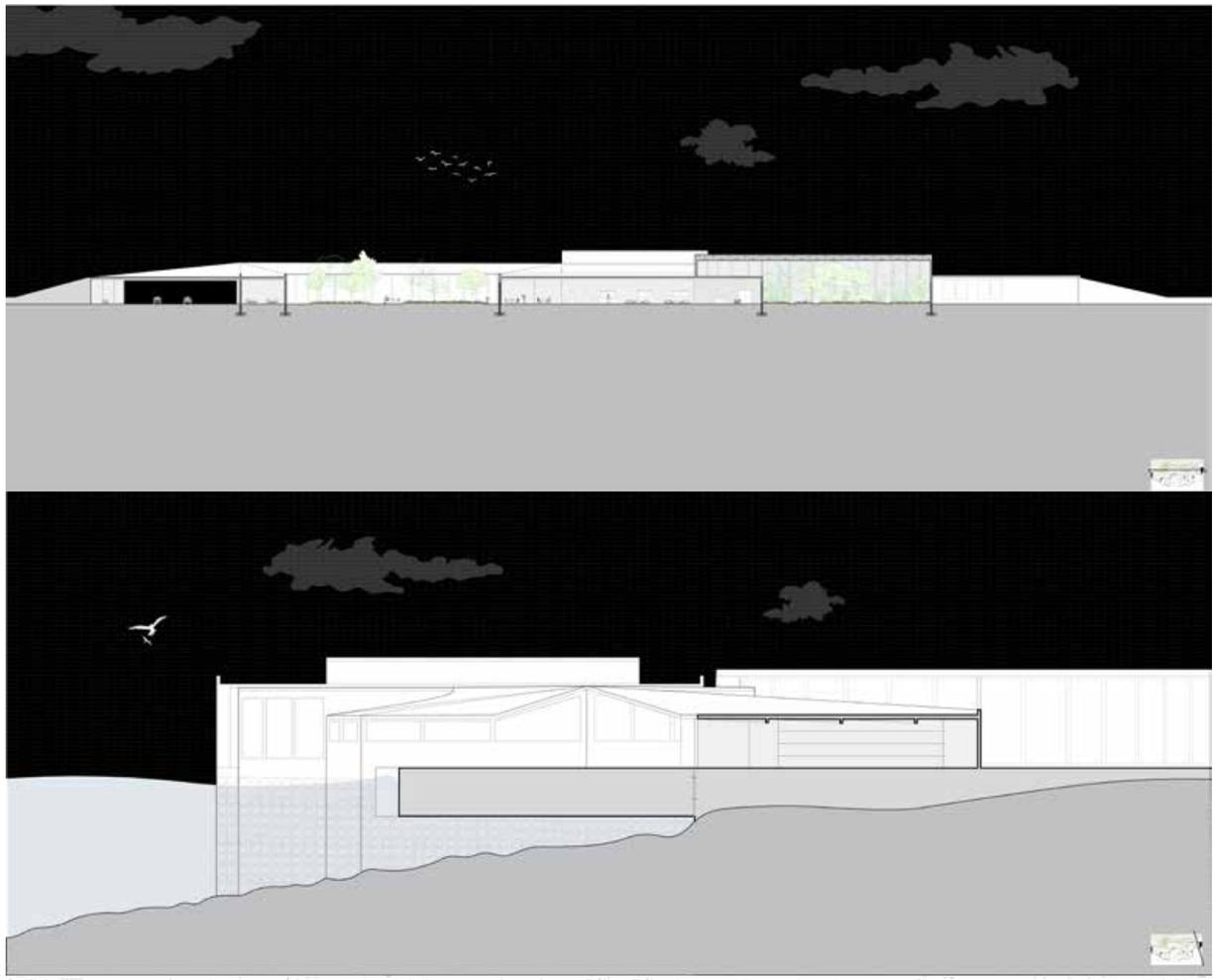
1. Ferry Dock
2. Waiting Area
3. Information Center
4. Office-1
5. Office-2
6. Restroom
7. Greenhouse
8. Cafe
9. Kitchen
10. Office-3
11. Cargo Ferry Dock

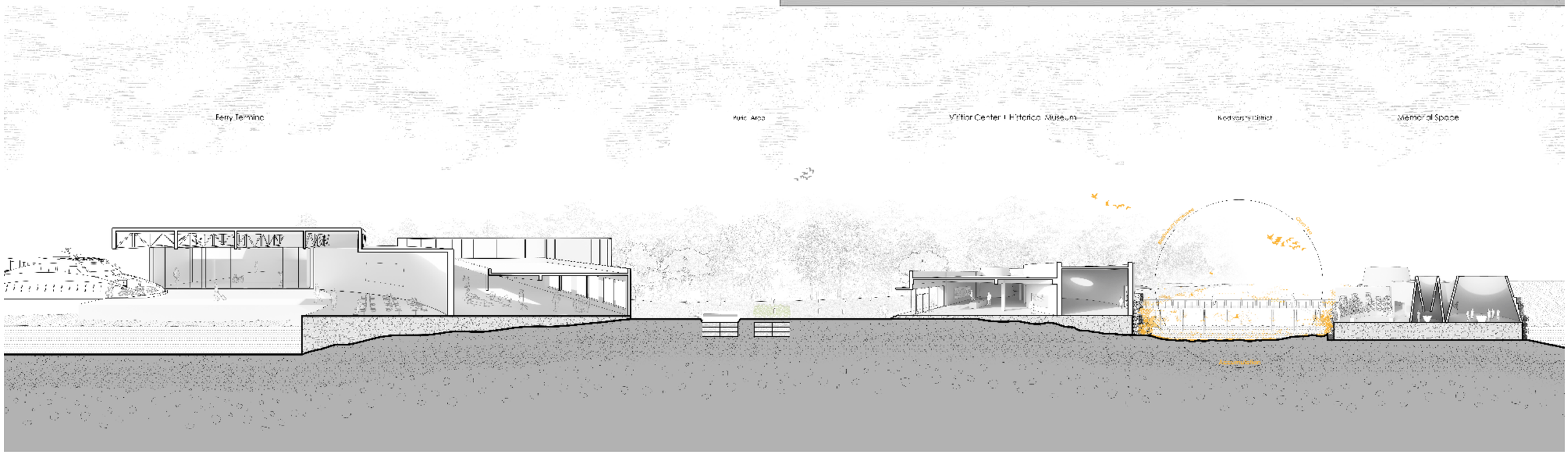
12. AIDS Historical Museum Exbition Hall
13. Gathering Space
14. Memorial Space-1
15. Memorial Space-2
16. Memorial Space-3
17. Memorial Space-4
18. Memorial Space-5
19. Restroom
20. Memorial Space with Breakwaters

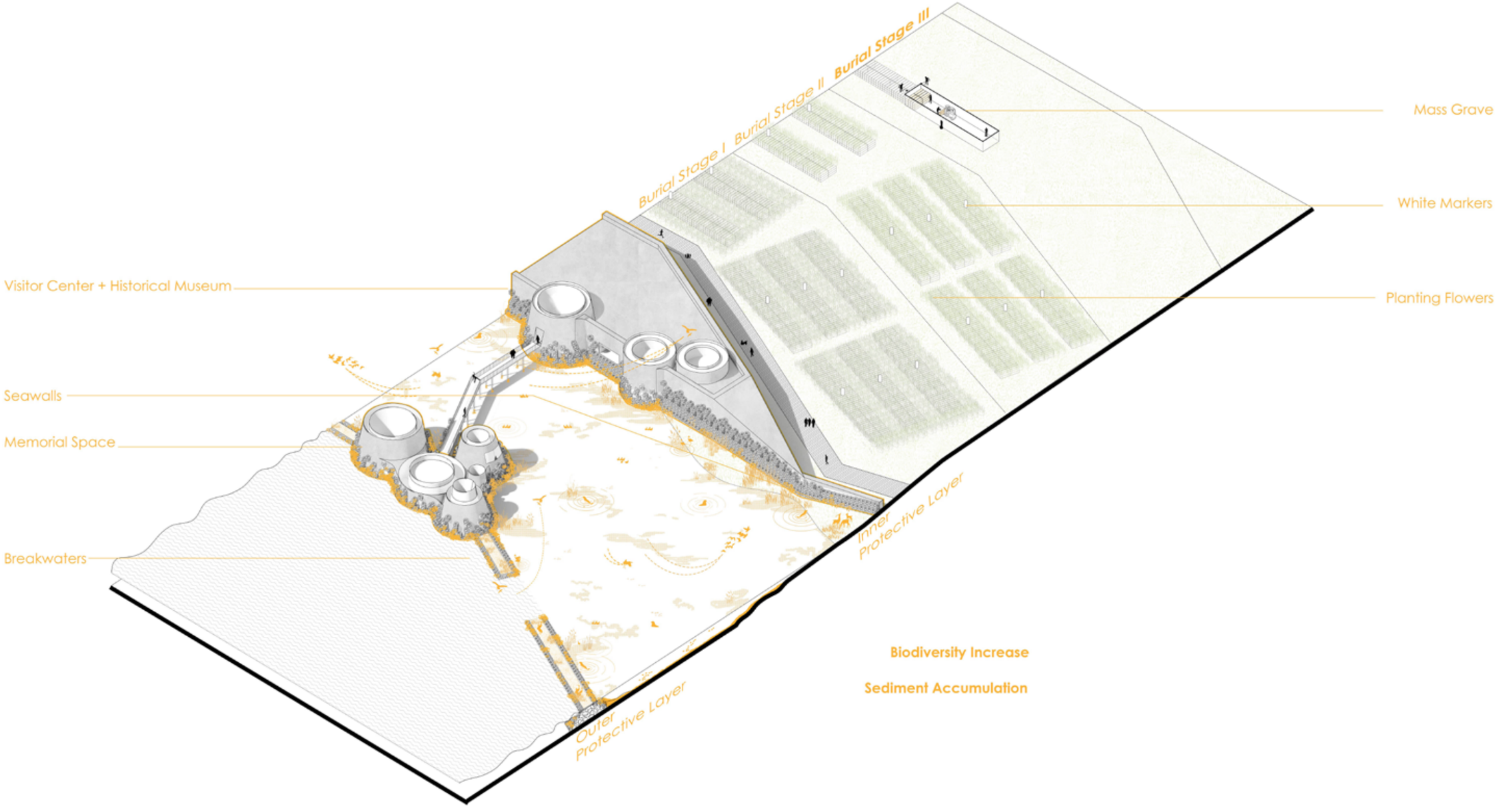
As we protect the island, we also aim to grow the island from three significant aspects: burying bodies in new areas, planting flowers, and increasing biodiversity.

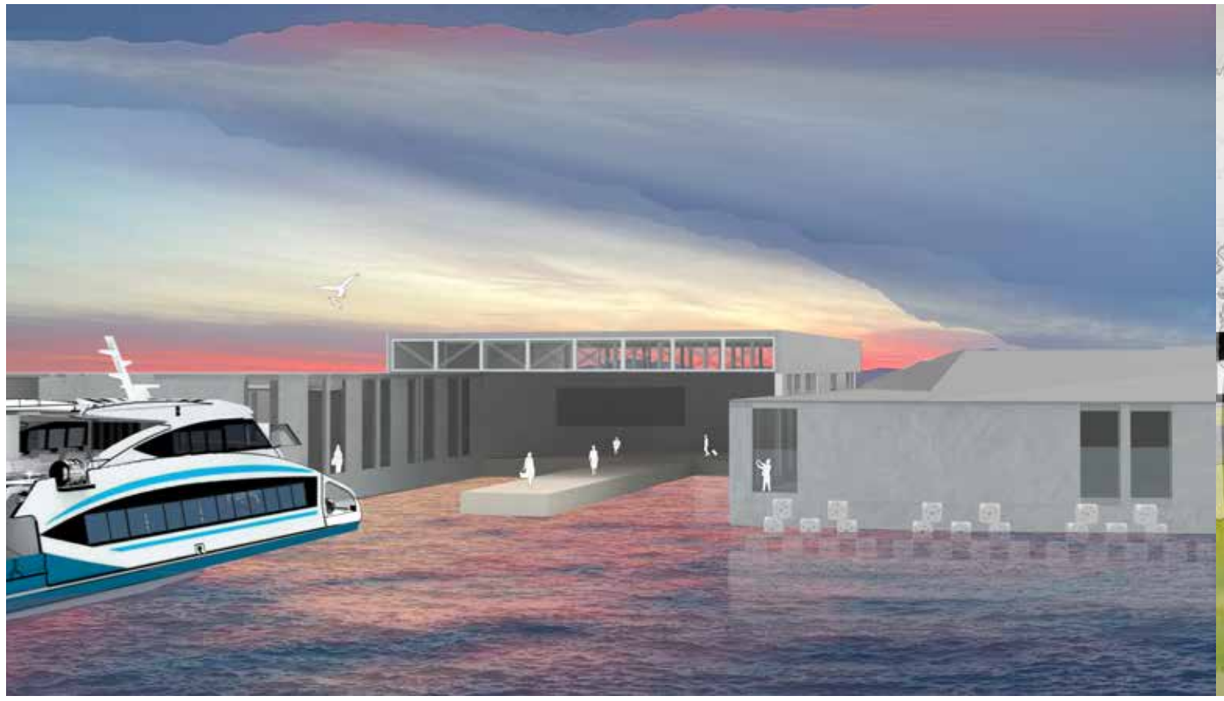
Also, here is a whole plan of the burial area, which is dispersed from every visitor center museum towards the center of the Island with different flowers planted on different burial time periods. At the same time, the visitor center museum is also becoming a memorial monument for the burial site in front of it.

On the other hand, every visitor center museum is also connected to a memorial space on the breakwaters, which these memorial spaces provide the most private space for people who want to calm and memorize their loved ones. The breakwater structure not only prevents large waves from the ocean and keeps more sand and soil to the Island, but also creates a calm and peaceful space for the species living on the island in between the two structures.



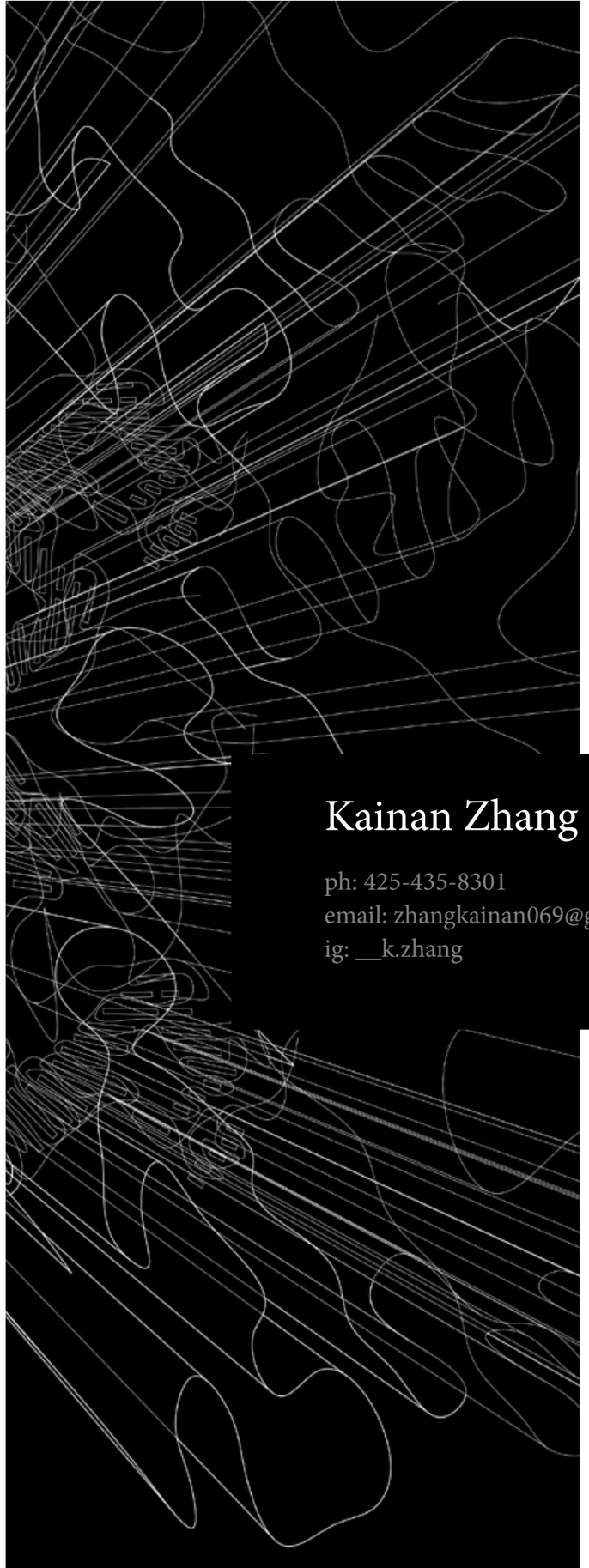



Burial Stage I
Burial Stage II
Burial Stage III
Mass Grave
White Markers
Planting Flowers
Visitor Center + Historical Museum
Seawalls
Memorial Space
Breakwaters
Inner Protective Layer
Outer Protective Layer
Biodiversity Increase
Sediment Accumulation



Here will be an experience of a person who visited the island, the first one is the terminal dock, and the second is the burial ground when you leave the terminal.

The visitor center museum that you can see the historical monument and also the burial site in front, the last one is the view when you are going to the private memorial spaces.



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Thank You