THE STRATEGIES OF FLOOD CONTROL

IN YANGSHUO, GUILIN, CHINA

CHEN QI / GUO LUWEI / LI XUANJING

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Politecnico di Milano
Scula di Architettura Urbanistica Ingegneria delle Costruzioni
M.S.C Architecture - Built Environment Interiors

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King Yu combating the flood 4000 years ago
(image: https://baike.sogou.com)

01 ABSTRACT

Among all kinds of natural disasters, flood is the most common and harmful one.The greatest harm caused by floods is to inundate houses and people, causing a large number of casualties. Floods can also take away everything in the human settlements, causing a lot of economic losses. In addition, flooding flooded farmland and destroyed crops, resulting in a substantial reduction in food production, resulting in famine. Not only that, but floods can also damage factories, factories, communications and transportation facilities, thus causing damage to the national economic sector. In addition, floods can also cause landslides, debris flows and epidemics.

Flood has been one of the greatest disasters in China since ancient times. According to incomplete statistics, in the 2225 years from the pre-Qin Dynasty to the present, there were 1097 major floods and more than tens of thousands of deaths.

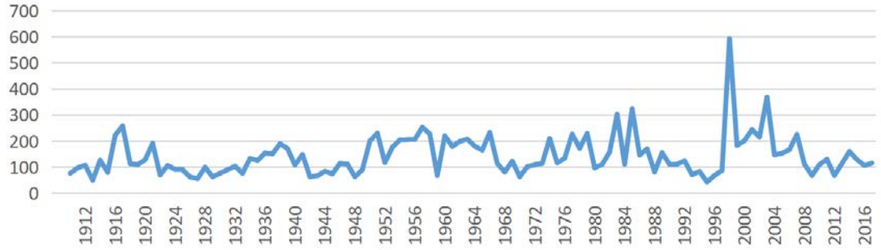
The main flood areas in China are located in the east of Daxing'an Mountains, Taihang Mountains and Wuling Mountains. According to the statistics of historical rainfall and waterlogging, the most serious areas are the southeast coastal area, Hunan-Jiangxi area and Huaihe River Basin. The second rainy areas are the middle and lower reaches of the Yangtze River, Nanling, Wuyishan area, Haihe and the lower reaches of the Yellow River, Sichuan Basin, Liaohe River and Songhua River area.

Except for deserts, extreme arid areas and alpine areas, about two-thirds of China's land area has different degrees and types of floods. The annual precipitation is large

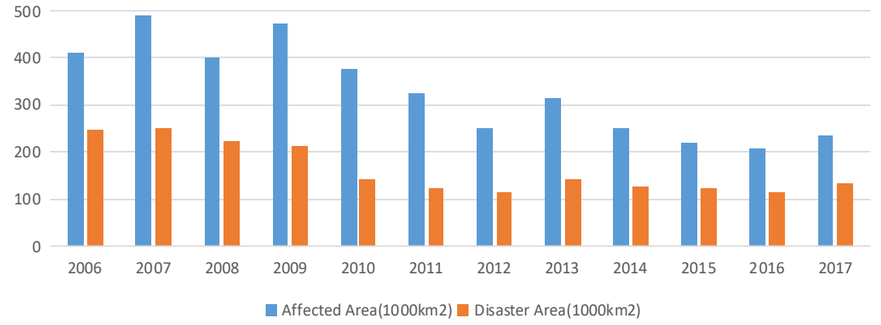
and 60-80% is concentrated in the eastern part of the flood season from June to September. Heavy rains and floods often occur.

Mountainous, hilly and plateau areas, which account for 70% of China's land area, are often attacked by torrential rains; some coastal provinces, autonomous regions and municipalities directly under the Central Government are attacked by floods caused by storm surges every year; rivers in northern China, such as the Yellow River and Songhua River, sometimes cause floods by ice; Xinjiang, Qinghai and Tibet. Snow melting floods occur every day in other places, as well as floods caused by dam collapse of reservoirs and man-made breaks of embankments. The eastern part of China often suffers from heavy rainstorms with large intensity and wide range, and the flood control capacity of rivers is low, so the sudden occurrence of flood disasters is strong.

Based on this situation, we hope that through the analysis and planning of case site, we can use parametric design way to explore flood control strategies which may more tailored to local conditions. We chose Yangshuo, Guiling as the object of research and design, where sufferred floods every year.



Amount of counties affected by floods, 1910-2017



Flood condition in China, 2006-2017

20 CNY banknote
(image: https://travel.qunar.com/youji)

02 INTRODUCTION

As one of the most frequent and serious flood disasters in the world, China has not only a wide range of floods, but also sudden and strong losses. Especially the eastern plains of China, where the terrain is low, and the poor drainage of rivers during the rainy season is the root cause of flood disasters.

Flood distribution in China

The areas with high flood risk mainly distribute in the eastern plain area. In the areas where floods occur frequently in the east, the degree of flood risk varies greatly. Seven high-risk areas are in turn from north to south: the middle and lower reaches of Liaohe River, the plain in the north of Haihe River, Tuhai Majiahe River in the north of Shandong Province, the west of Shandong Province and the lower reaches of Weihe River, Huaibei and Lixia River areas, the middle reaches of the Yangtze River (Jianghan Plain, Dongting Lake area, Poyang Lake area and the area along the Yangtze River), and the Pearl River Delta. These areas have a common geographic feature, they are located in low-lying areas around lakes, on both sides of rivers and in estuaries.

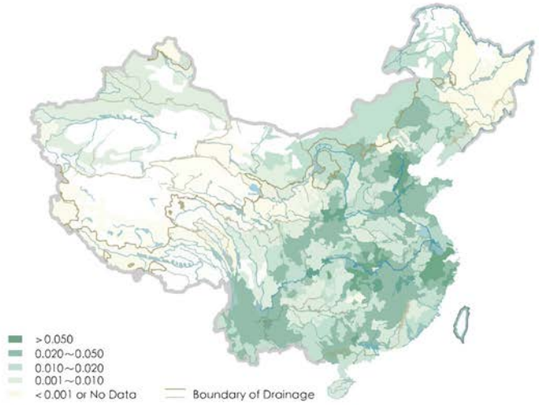
The flood risk areas are mainly located in the Liaohe River Basin, the lower reaches of the Yellow River Basin, the vast areas of Sichuan Basin, the southeastern coastal mountainous areas, the Sino-Indian and Sino-Vietnamese border areas, in addition to the buffer zones on both sides of the river. This part of the area may not be flooded when small and medium-sized floods occur in the basin, but it is difficult to ensure that no floods occur when there are large floods and extraordinary floods

that are rarely encountered in many years. In addition, the junction of some mountainous areas and coastal plains along the southeastern coast also belongs to areas with high flood risk.

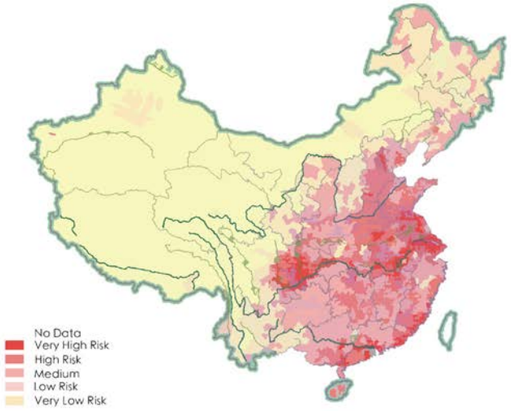
Site selection

As far as flood disaster is concerned, it includes two meanings: one is to cause floods and the other is to cause losses. The losses caused by floods depend mainly on economic factors. So we focus on site choices that are important, but small cities or counties where economic resilience is inadequate.

We choose Yangshuo County, Guilin, Guangxi Province in southwest China to carry out research and exploration. Yangshuo has abundant natural and cultural tourism resources. As one of the best secnic area in China. there are thousands of tourists every year coming for the singular landscape.



Frequency of flood events (times/year)



Flood risk assessment (Micro-scale region)

Yangshuo belongs to karst landform, with beautiful peaks and rivers. The most beautiful section of Li River(a branch of the Pearl River) is in Yangshuo.

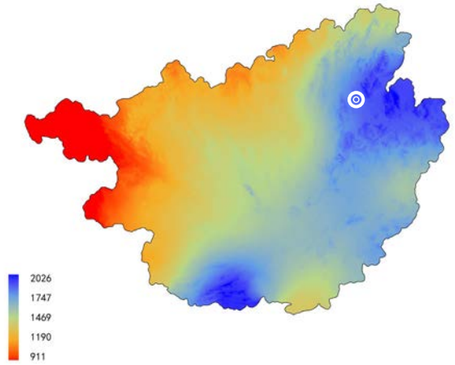
Relying on the beautiful scenery of the Li River to develop tourism, Yangshuo also suffers from the annual flooding of the Li River during June and July. Because of the geomorphological characteristics, it becomes to one of the most flooded areas in Guangxi every year.The water level ranges from 2 cm to 5 meters, in the worst condition.

By the end of 2018, Yangshuo had a total GDP of 10.822 billion yuan, received 13.449 million tourists, and realized a total tourism income of 10.02 billion yuan.

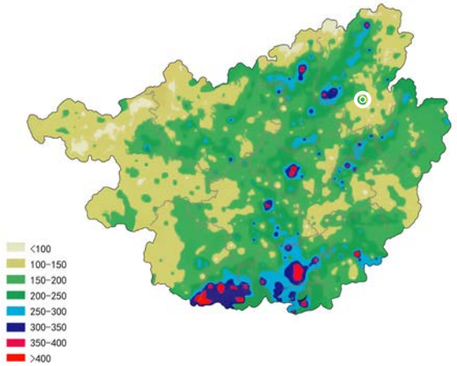
Guangxi

Guilin

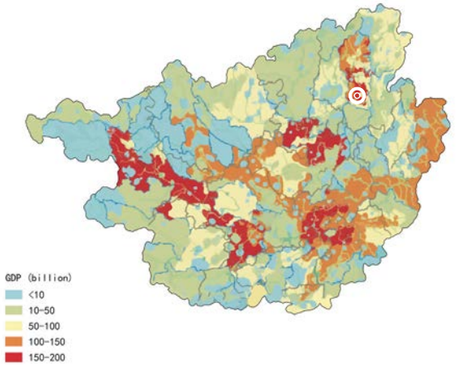
Yangshuo



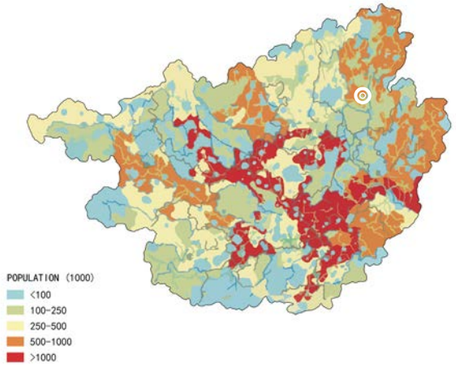
Annual Precipitation of Guangxi (mm)



Extreme Precipitation Events in Guangxi (mm)



GDP of Guangxi Spatial Distribution



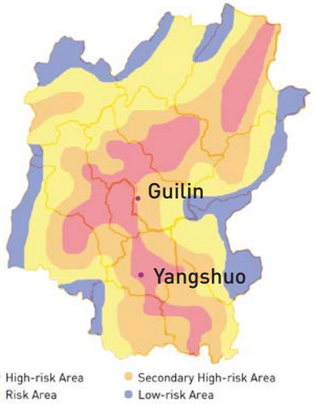
Population of Guangxi Spatial Distribution

Current situation

Yangshuo has a total area of 1428 square kilometers, 20,000 hectares of arable land and a total population of 308,300.

It is a county without dikes. When floods occur, it can only rely on non-engineering flood control measures to minimize flood losses and adverse effects caused by floods. Flood forecasting is an important aspect of such measures.

1. Watershed profile
The Li River originates from the southern side of the Laoshan boundary in Xing'an County, Guangxi. It runs through Xing'an from north to South at an altitude of about 2000 m. It joins with Lingqu and Xiaorong River and is called the Li River. The Li River flows through Guilin, Yangshuo and Pingle. In the northwest of the basin, there are Danan Mountain, Tianping Mountain, Yuechengling Mountain and Ocean Mountain in the northeast, all above 1500 m above sea level.



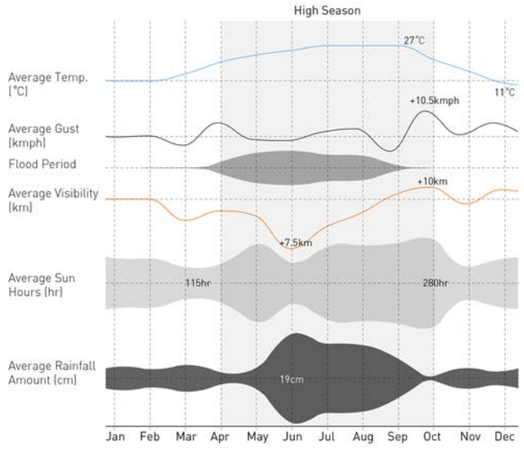
Rainstorm Risk Zoning of Gilin City

Flood Disaster Risk Zoning of Li River

Under the influence of comprehensive factors such as topographic uplift of the basin, the upstream of the basin is one of the high-value rainstorm areas.

2. Climate Characteristics

Located in the mid-subtropical monsoon area, it has abundant heat, abundant rainfall and abundant sunshine. The annual average temperature is 19.3 degrees Celsius. The spatial and temporal distribution is uneven, concentrated from April to August. Affected by the topography, the annual precipitation distribution is more in mountainous area than in flat land.



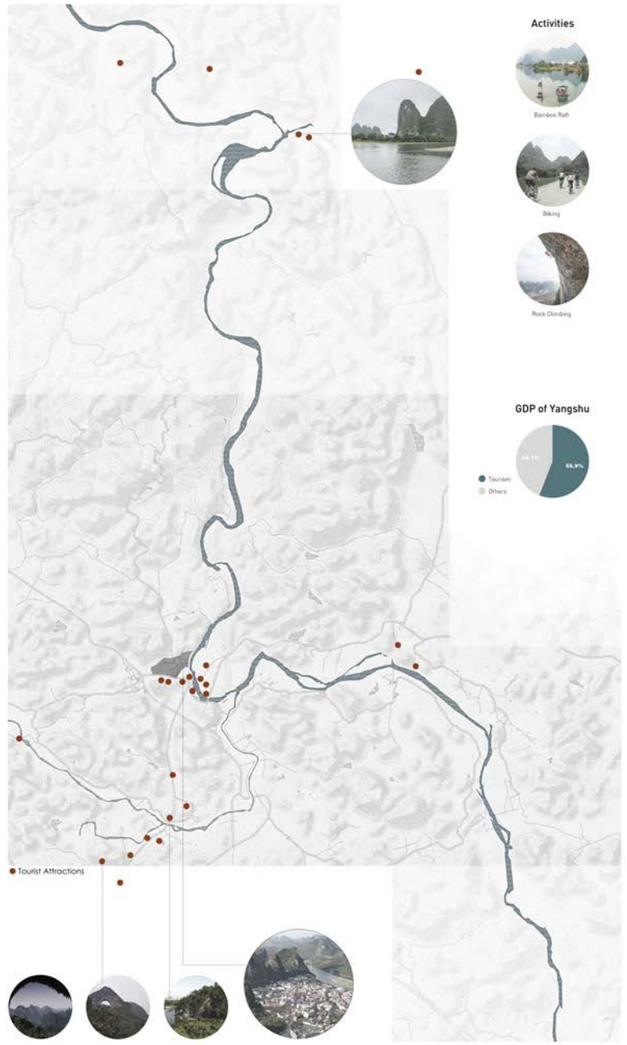
Annual climate in Yangshuo

3. Rainstorm Characteristics

The watershed is located in the center of the rainstorm area in northern Guangxi. The average annual rainfall over the watershed is about 2200 mm. Frontal rainstorms occur from April to June every year. From June to July, the front is stationary or swinging back and forth due to the barrier and uplift of Alpine veins in the watershed, resulting in rainstorm flood.

4. Flood Characteristics

The synchronicity of rainstorms in the upper and lower reaches of the basin is poor. It is not easy for a continuous rainfall to form a larger flood. It needs the superposition of two or more rainstorms to form a large flood. Therefore, the larger floods are mostly peak-watching or multi-peak-shaped, which makes the duration of high water level long and the flood rising fast, which is not conducive to flood control.



Yangshuo natural views
(image: https://you.ctrip.com)

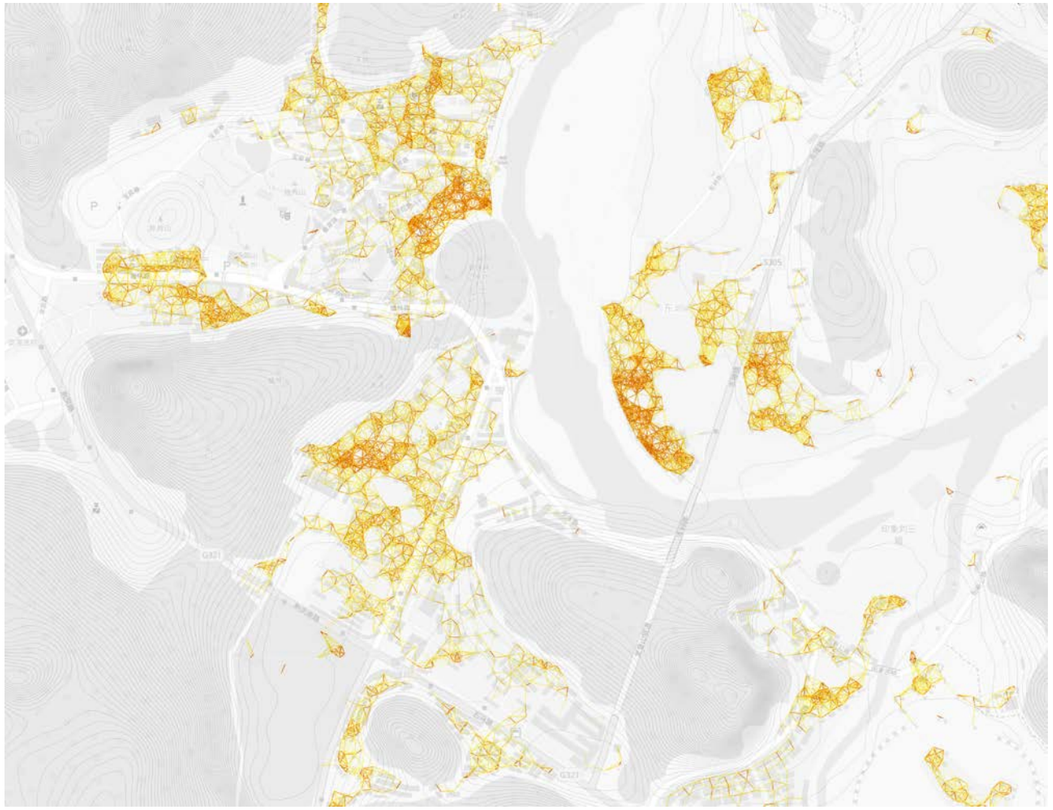
03 SITE ANALYSIS

In order to facilitate the analysis, we chose the central town of Yangshuo County as the final base.

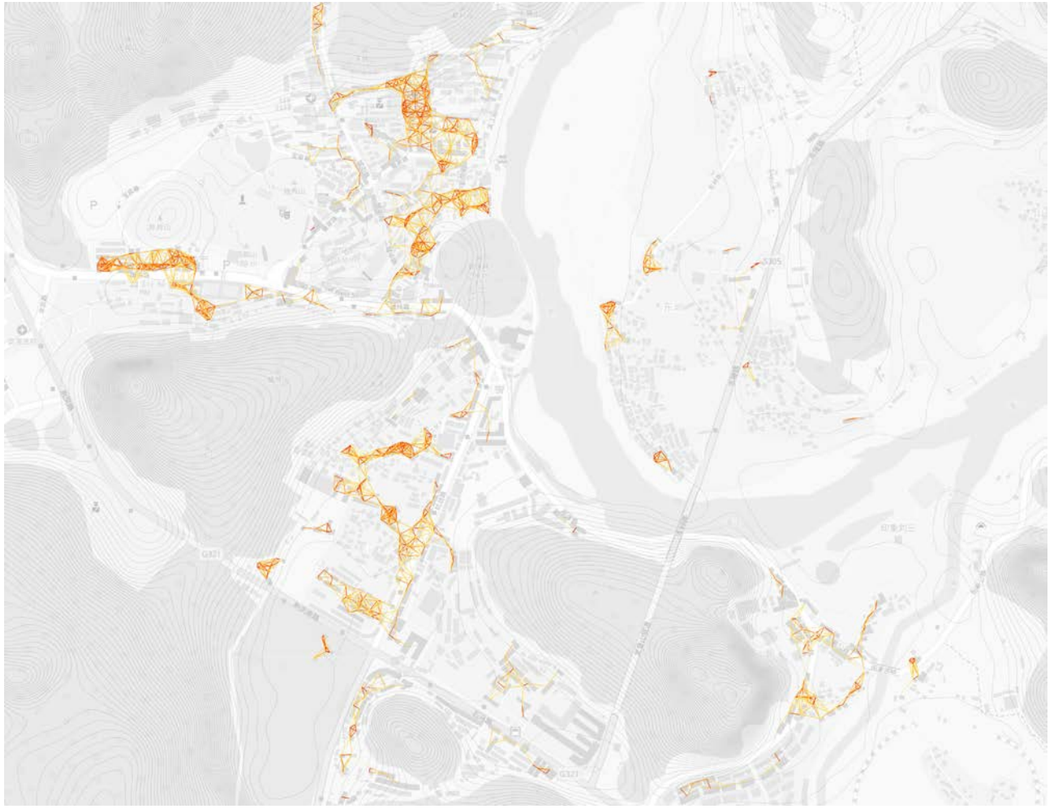
The town offers wonderful restaurants, shops and a wide variety of hotels and hostels. It has a relatively large expatriate community.

The town is situated at a corner of the Li River, with a small turning radius. The watershed reaches the plain through mountains and mountains, which is very easy to cause large flooding disasters.

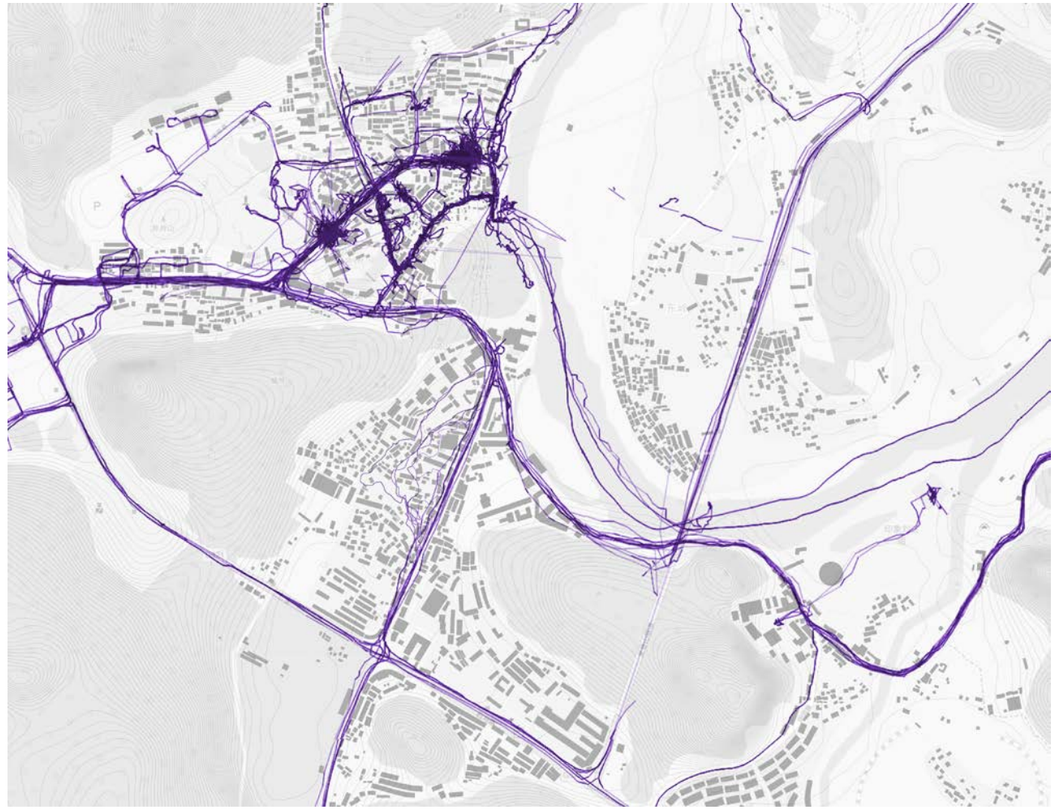
Density of the existing buildings



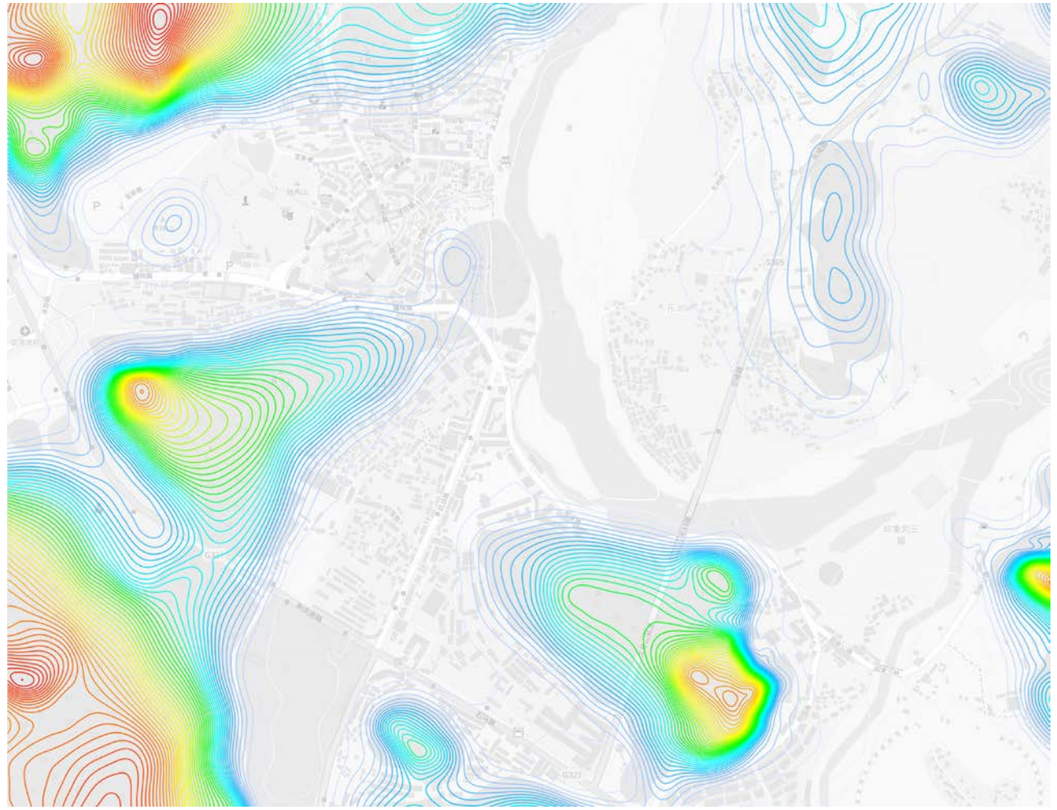
Density of the commercial buildings



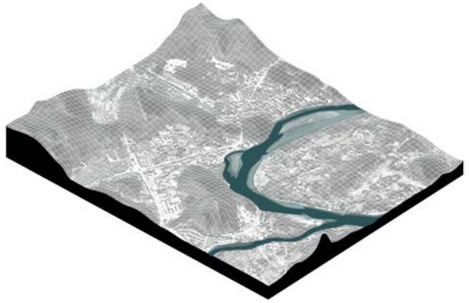
GPS trails



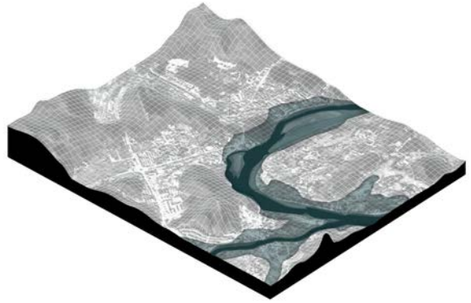
Altitude



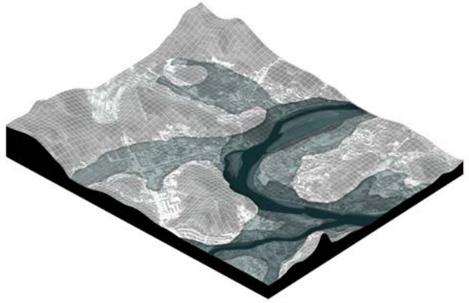
Simulation of water level



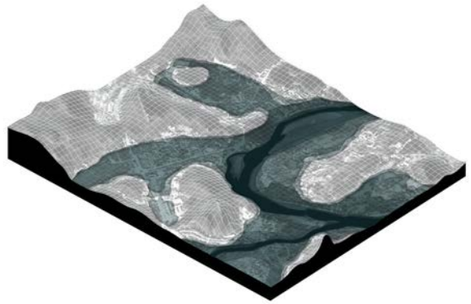
[Water Level: Normal]



[Water Level: 1m]

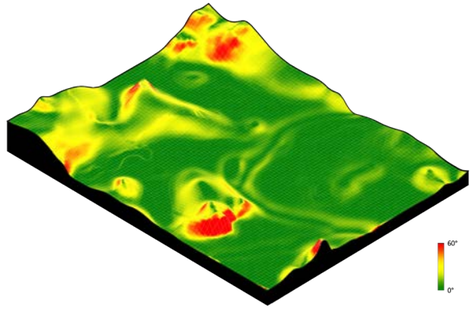


[Water Level: 3m]

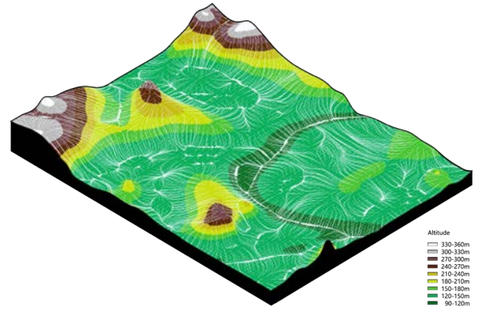


[Water Level: 6m]

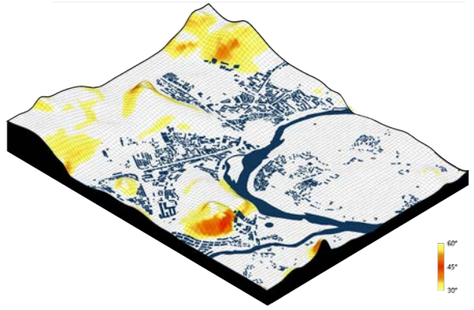
Topographic features



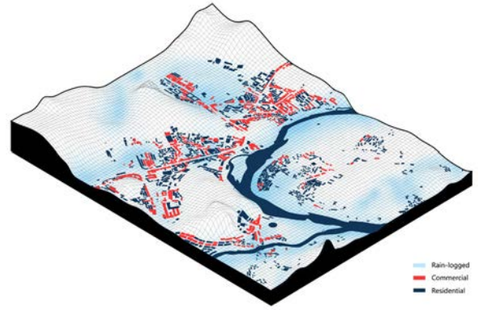
[Slope / 0-90°]



[Rainflow]



[Slope / 30-60°]
in danger



[Gathering Area]

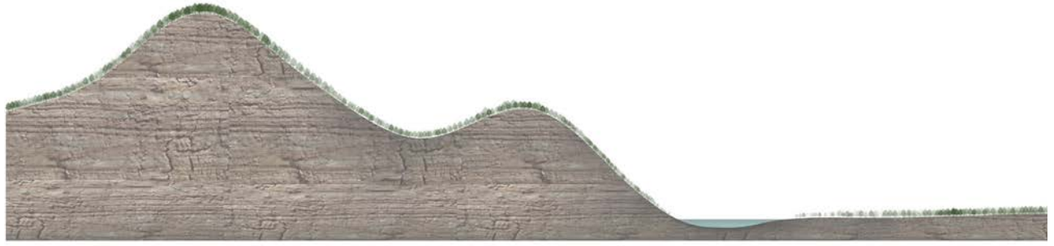
Section positions

Sections

A-A SECTION

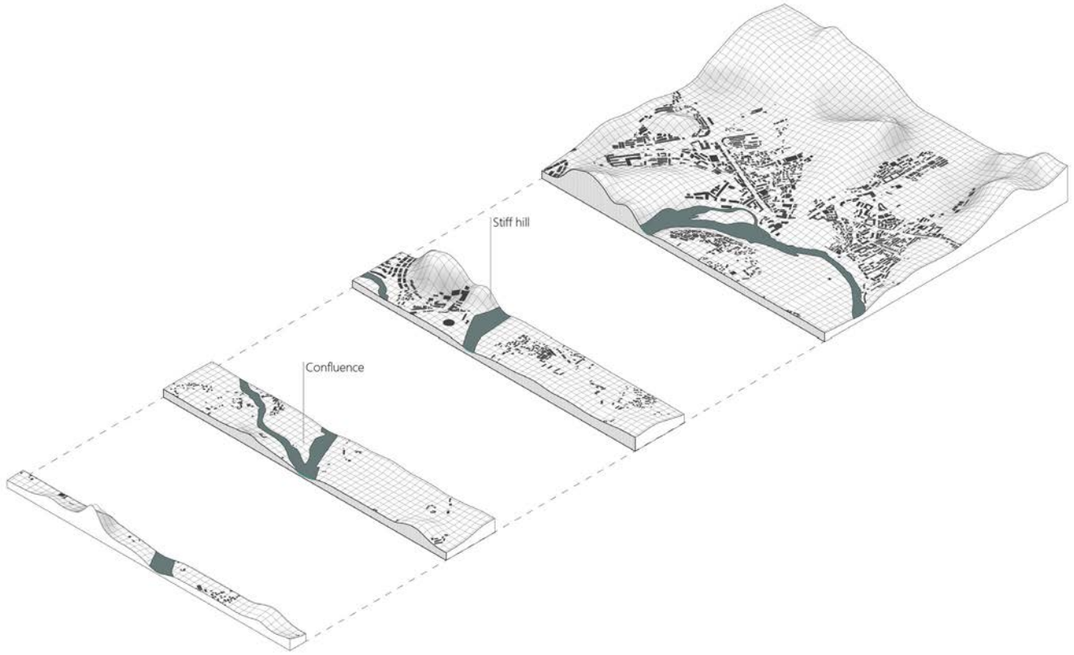
B-B SECTION

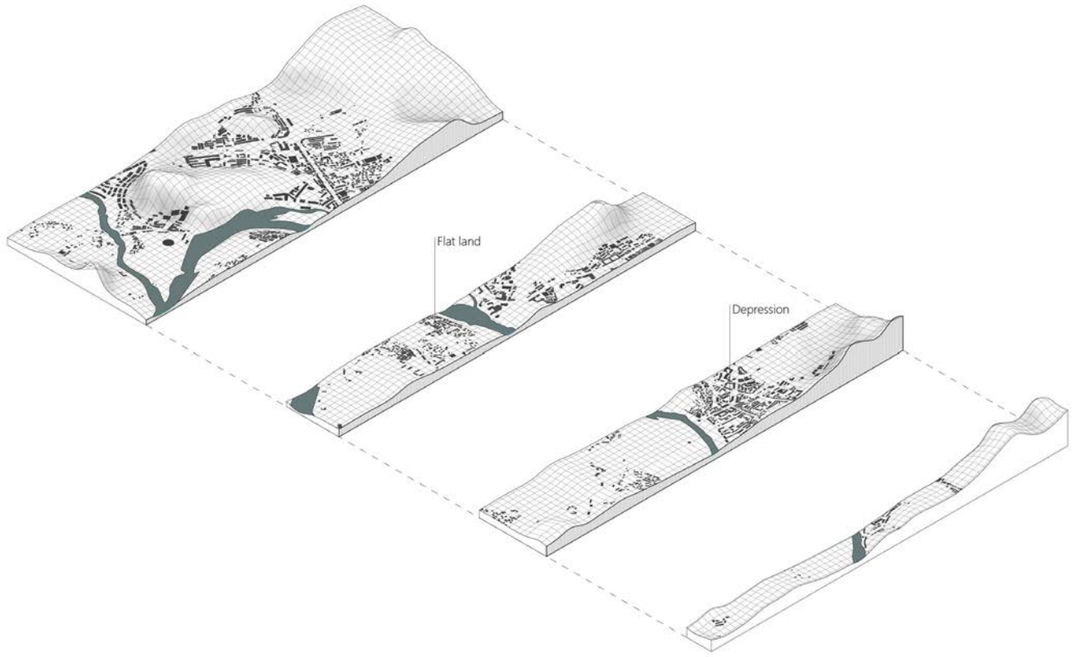
C-C SECTION



D-D SECTION

E-E SECTION


Stiff hill
Confluence


Flat land
Depression

04 STRATEGIES

In the process of social development, with the deepening of human understanding of flood, the ability of flood control is also growing. However, the number of disasters caused by floods has increased.

At present, flood control measures include flood control engineering measures and non-engineering measures. Flood control engineering measures mainly include dikes, river regulation projects, flood diversion projects and reservoir flood control projects. Through the construction and application of these projects, the river discharge, diversion and diversion, and flood storage can be expanded to achieve the purpose of flood control. Non-engineering measures include flood forecasting, flood warning, flood area management, flood insurance, River barrier clearance, River management, ultra-standard flood prevention measures.

In this design, we mainly adopted three kinds of Engineering flood control measures.

1. Embankment
Embankment is the earliest widely used flood control engineering measure in the world to build dikes to resist floods, tide and wave, and to protect the safety of residents and industrial and agricultural production in dikes.

2. Ecological Flood Control
In order to prevent soil erosion and flood disasters, grasses are planted on slopes along both sides of the river to conserve water and soil, stabilize embankments and prevent the erosion of flood waves on flood embankments.

3. Water reservoir
Reservoirs have the functions of flood control, water storage and irrigation, water supply, power generation and fish culture. There are two different ways for reservoir to regulate flood, one is to detain flood, the other is to store flood.

04/01 EMBANKMENT

Tpyes of embankment

1. Submersible embankment
It is mainly designed to protect preparation from pre-monsoon floods. During the rainy season, this embankment is still submerged.

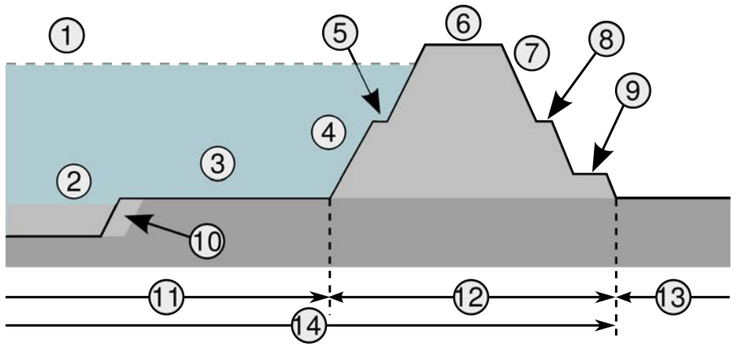
2. High embankments
Its main purpose is to protect towns from or reduce flooding by eliminating pre-monsoon floods and high monsoon floods.

Requirement

1. Rationally Setting up Level of Embankment
Plan different sections according to the level of the river reach.

2. Selection of embankment position
Decide whether to set up embankment and the height of embankment according to need.

3. Combining with Ecological Protection
Design and construction concept of harmony between man and nature.

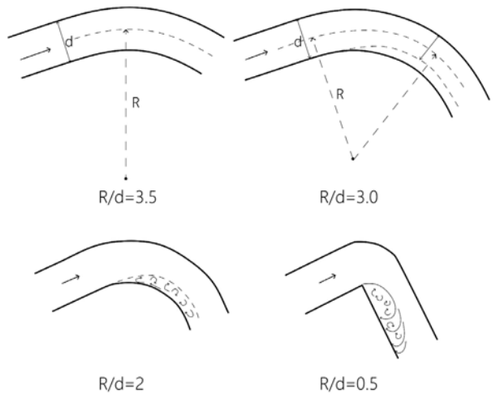


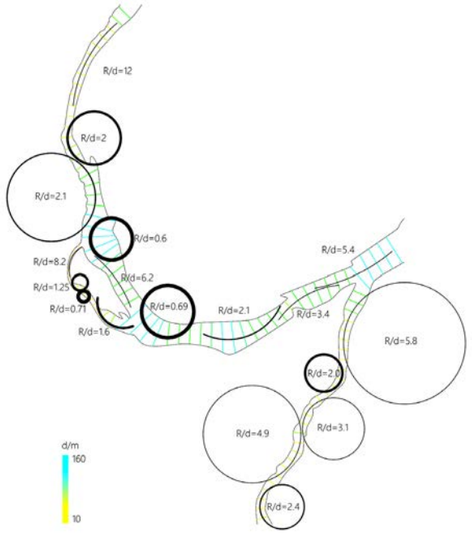
1. Design high water level
2. Low water channel
3. Flood channel
4. Riverside slope
5. Riverside banquette
6. Levee crown
7. Landside slope
8. Landside banquette
9. Berm
10. Low water revetment
11. Riverside land
12. Embankment
13. Protected lowland
14. River zone

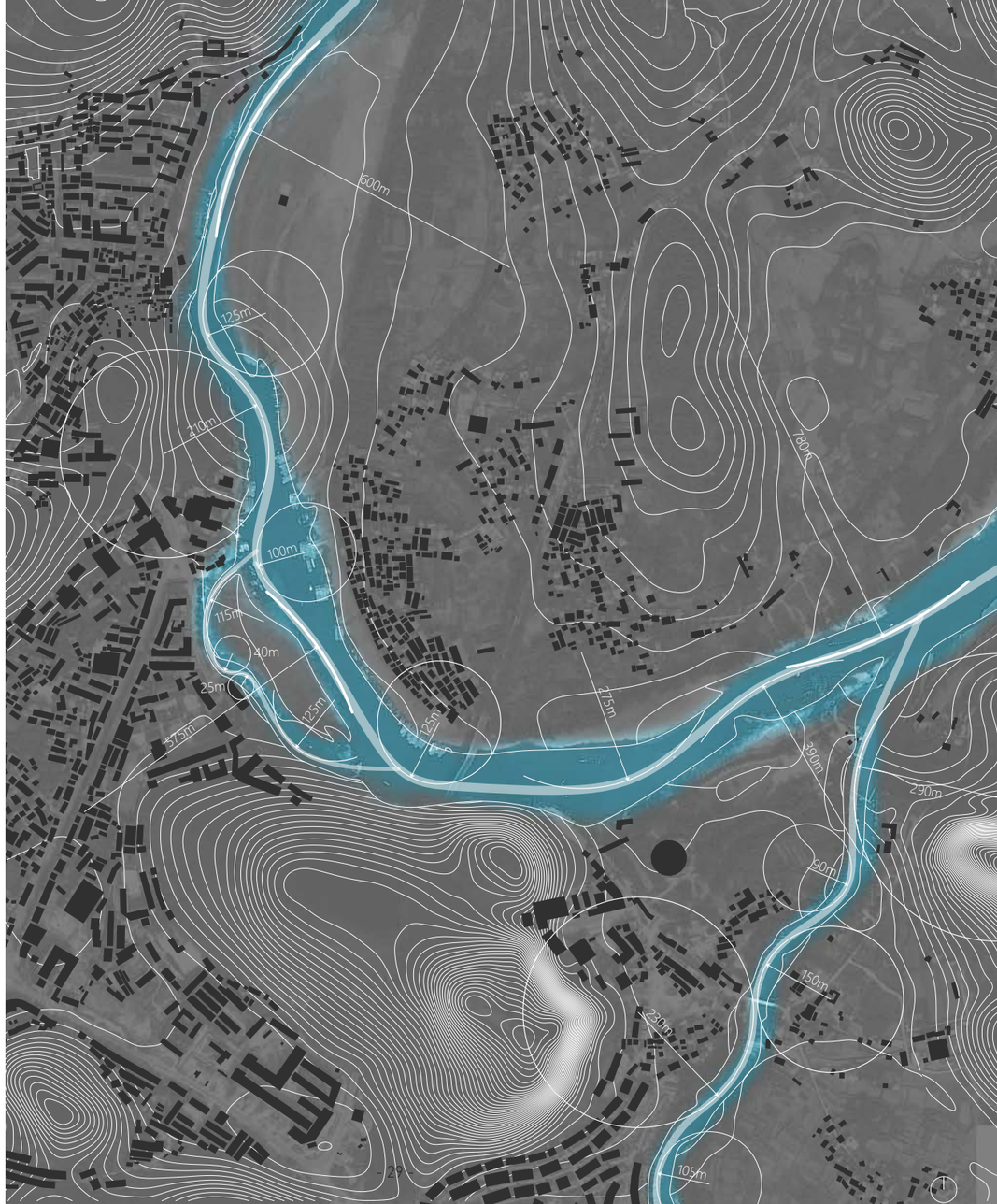
Position

The flooding area is related to the curvature and aspect ratio of the river.

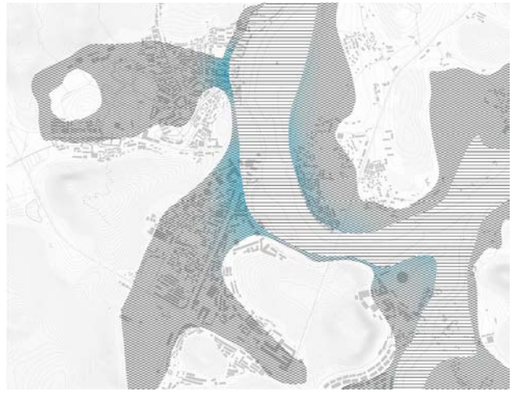
Therefore, we determine the location of the embankment by analyzing the curvature and velocity simulation of the river course.







Flood area



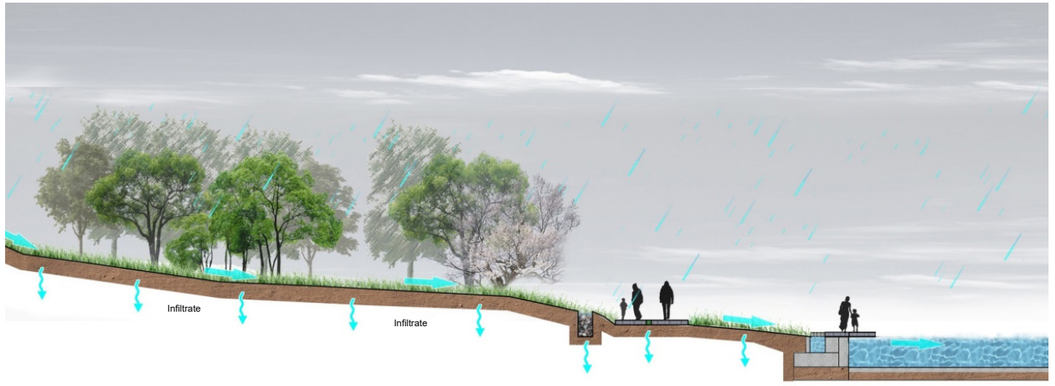
River flow Exceeding area

04/02 ECOLOGICAL FLOOD CONTROL

Water and soil erosion will lead to rain water can not be absorbed in situ, downstream, erosion of soil, resulting in simultaneous loss of water and soil, and raise the river bed.

Because of the serious soil erosion in the upstream, the sand content in the rivers will be very high in flood season, and the riverbed will be gradually raised. In addition, the climate is drought and the rainfall is less, which leads to the continuous decrease of the runoff of the rivers, and a large number of riverbanks and riverbeds are exposed.

While preventing water and soil erosion, ecological flood control provides water and air exchange channel and good ecosystem function.



04/03 WATER RESERVOIR

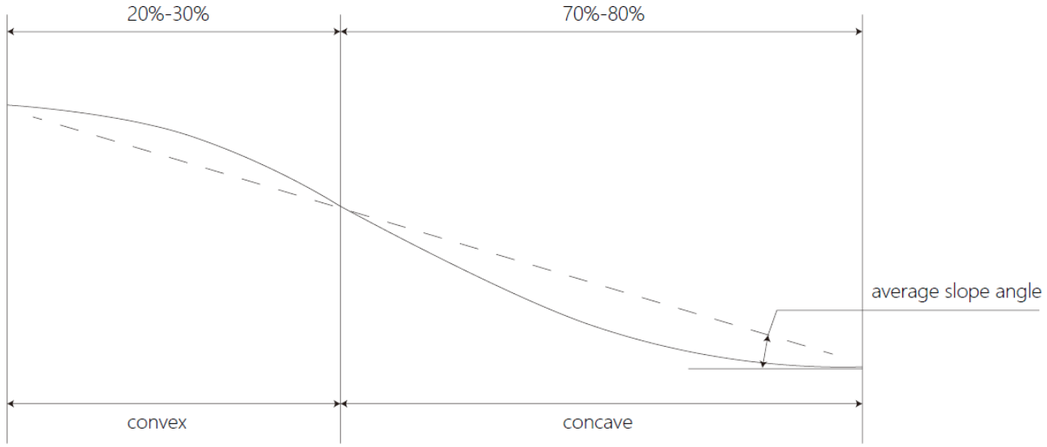
Advances in the field of urban hydrology and flood control have highlighted the use of compensatory measures in urban drainage projects as a necessity for achieving a sustainable development of cities, always looking for a way to mitigate and reduce the urbanization impacts on hydrologic cycle. Several alternatives for urban projects have been studied to reduce urbanization impacts on hydrological cycle, such as compensatory techniques in urban drainage and unconventional measures in urban drainage, but these alternatives are more effective when provided within a Sustainable Stormwater Management System.

Detention or retention ponds are widely used devices in such systems, in order to control the volumes and peak flood runoff, considering in some cases both aspects of quantity and quality. Development of such interventions in urban environment becomes important when associated with other uses like landscaping and recreational area, being inserted in the city as multifunctional landscapes and thereby further enhancing urban space and its surrounding area, through a harmonious design of built and natural environment. 2 Multifunctional landscapes for flood control.

Miguez et al (2007) state that the basic idea of the use of multifunctional landscapes is that an urban area can meet different objectives and functions with ecological, economic, cultural, historical, social and aesthetic concerns. This technique has a good feasibility of application in peripheral countries, but it is important to emphasize that particular aspect of communities and stakeholders should be considered, in order to increase the acceptability of these interventions.

Technology

The natural drainage patterns and slope profi les at a site are formed by natural erosion, sedimentation and geological processes over a geological timeframe. The number of drainage channels, their gradient and cross-sectional area are in equilibrium with the catchment area, soil type, slope, rainfall characteristics and vegetation. An alteration to any one of these parameters disturbs the equilibrium and can result in accelerated erosion and/ or sedimentation of the drainage channels and downstream waterways.



Position

This map shows the YANGSHUO town is in a really bad condition to get the water out of the town when the flood or rainstorm happens. the town is divided two parts, each of of which is surrounded by local mountains. Only lefting one side to the LI river, which means flood is unable to avoide.

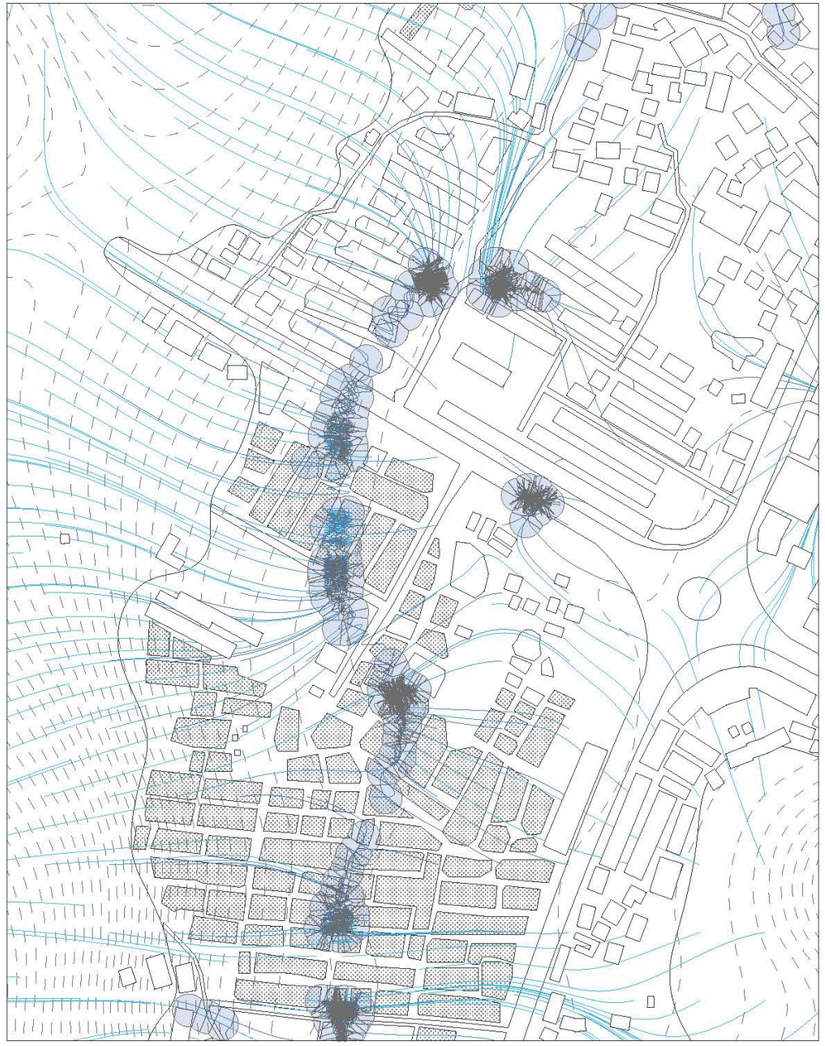
Genarally, there are three principles to help the water flood in the town. redevelop the existing pool, block the flow path and organize the water gathering point. Using the grasshopper in rhino, i managed to simulate the rainfall among this area. And through adjustment the flow of the rainfall, we got two maps below, which shows the water path and the gathering point. And because the mountain in this area are extremely steep, it is very hard to block the water path. For the existing pool, most of them are located in the town, surroundes by the existing buildings. As a result, i choose to manage the gathering point, which means to build a water reservoir.

NOMAL PRECIPITATION - BLOCK WATER FLOW

PRECIPITATION DOUBLED - WATER GATHERING POINT

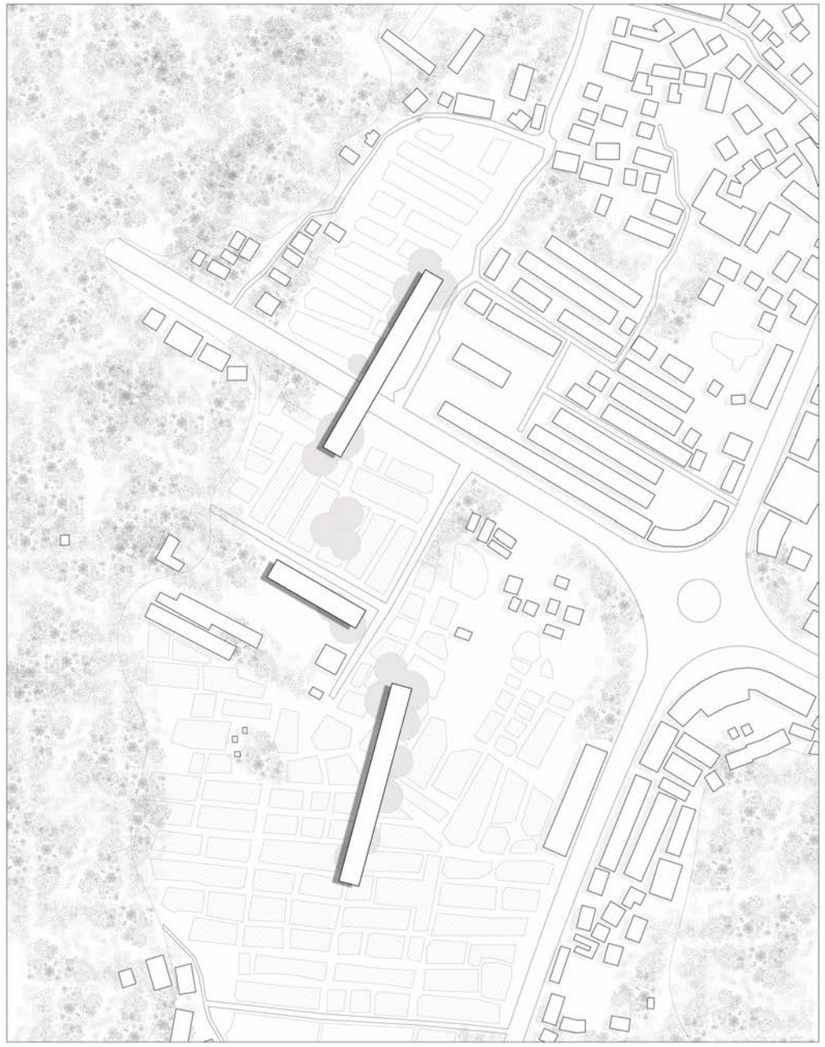
WATER FLOW

GATHERING POINT



DEPTH

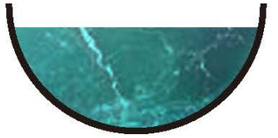
POTENTAIL LOCATION



05 PROJECT

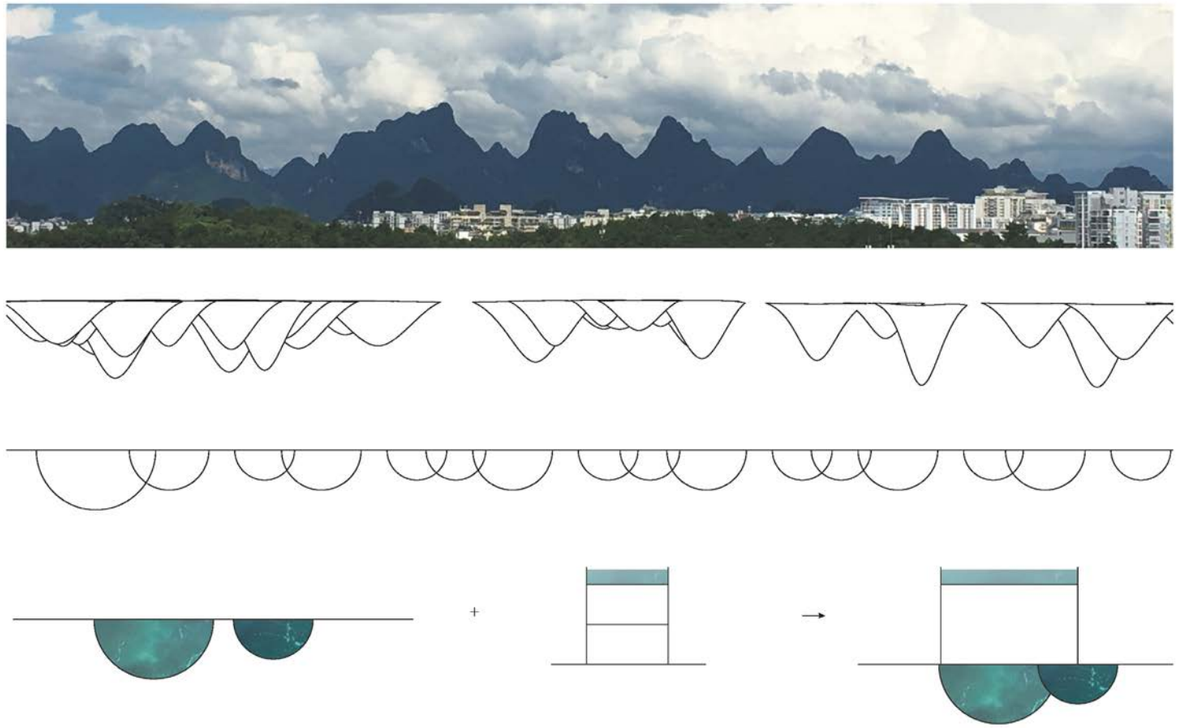
05/01

WATER RESERVOIR WITH MUSEUM

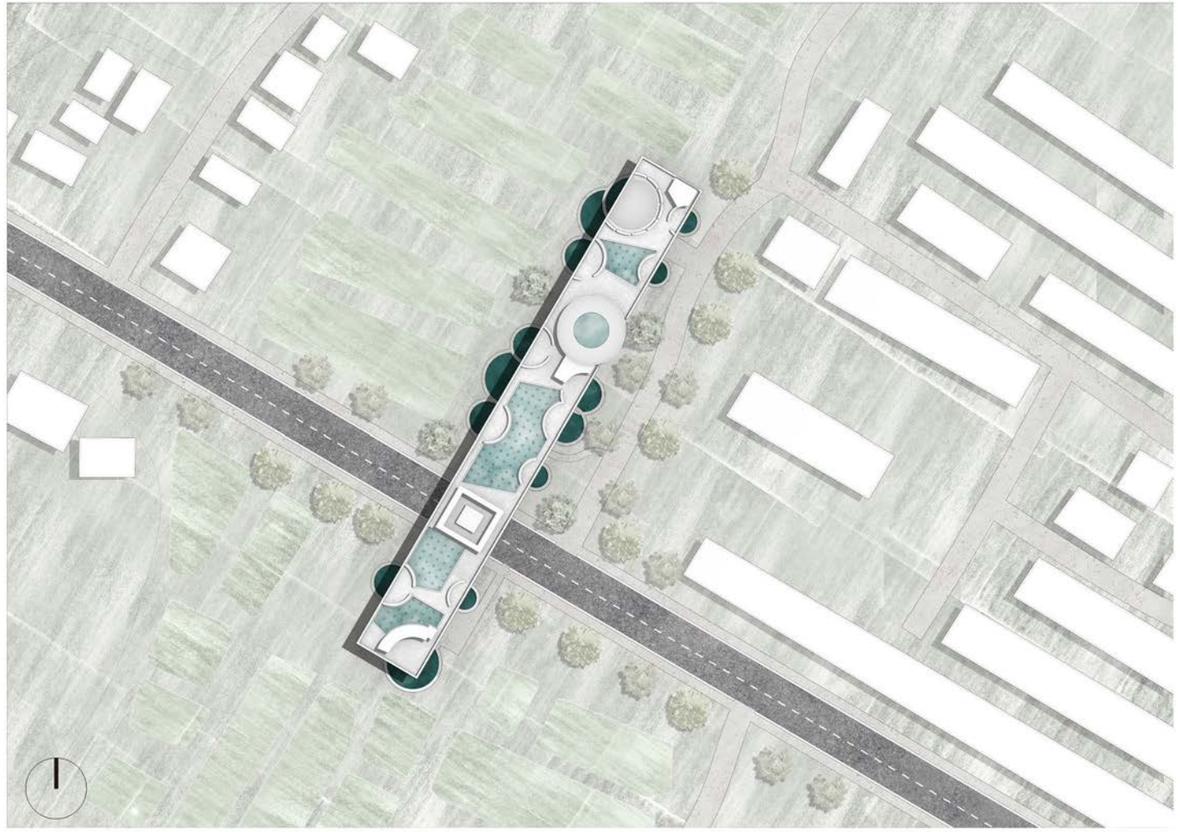


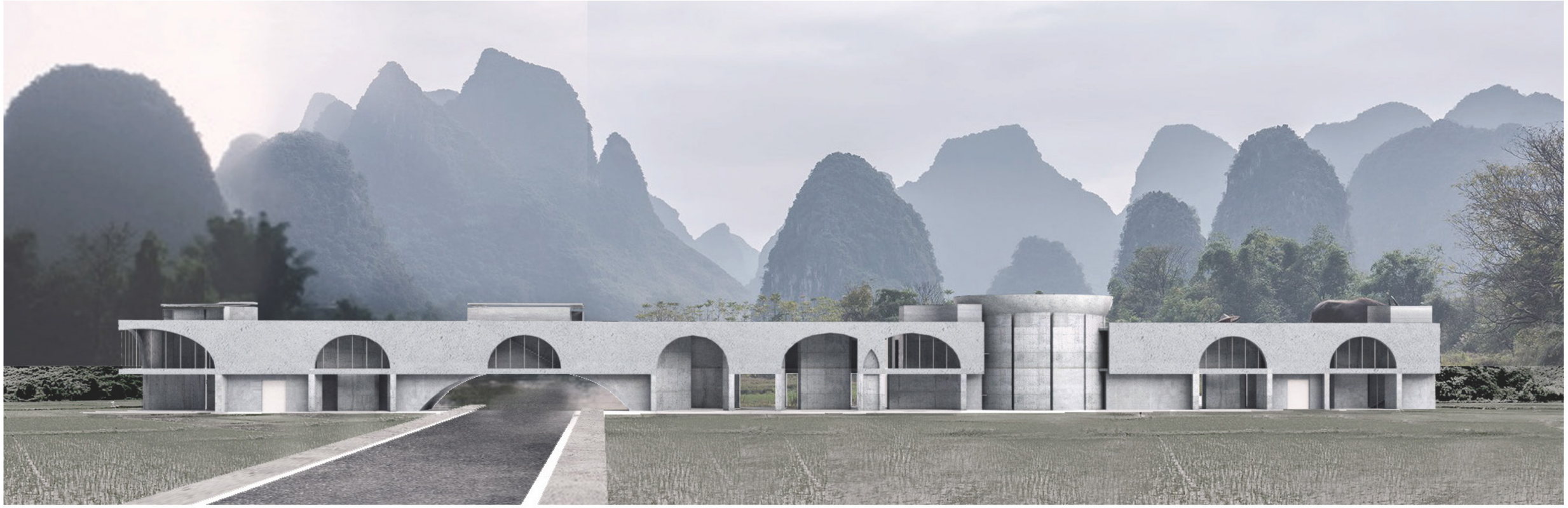
CONCEPT

The rhythm of the reservior is coresspondance with the mountain , which is a respond to the site. And the town is full of hotels and lack of public space. there is an intense to making the tourist explore deeper into the town, another idea is to place a museum in Yangshuo.

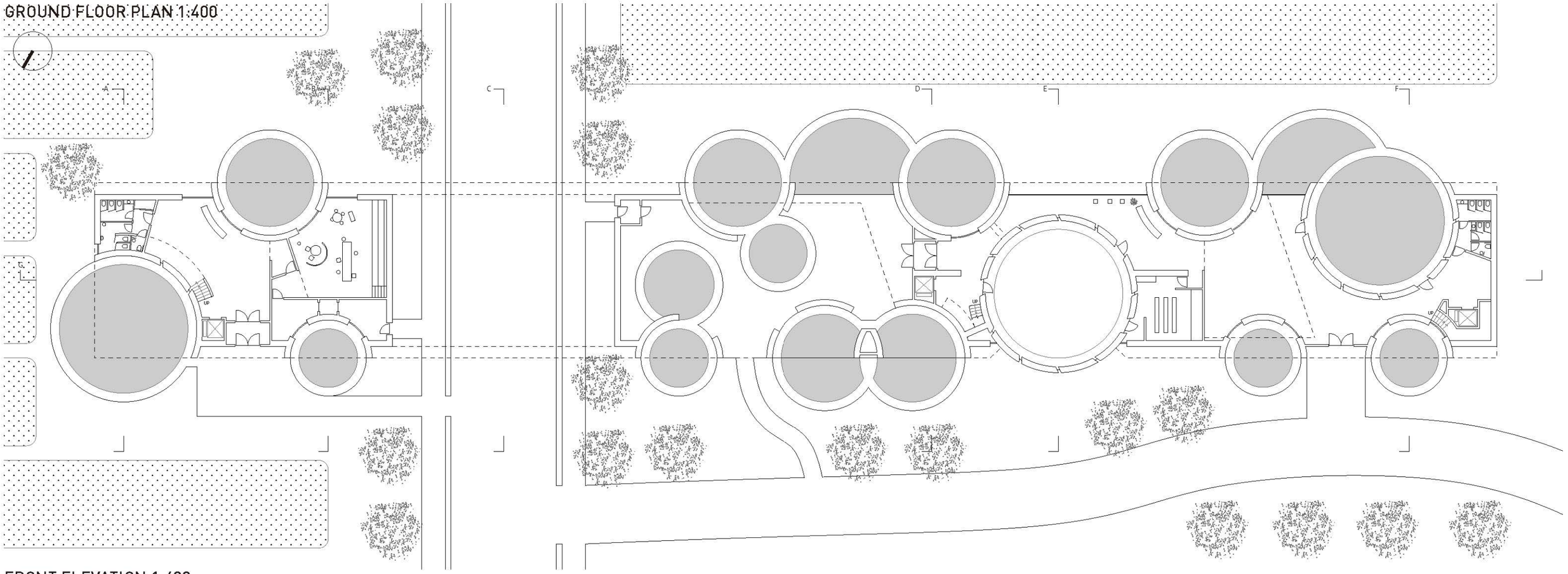


SITE 1:1500

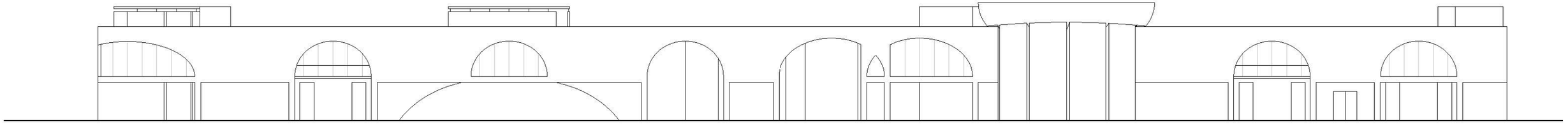




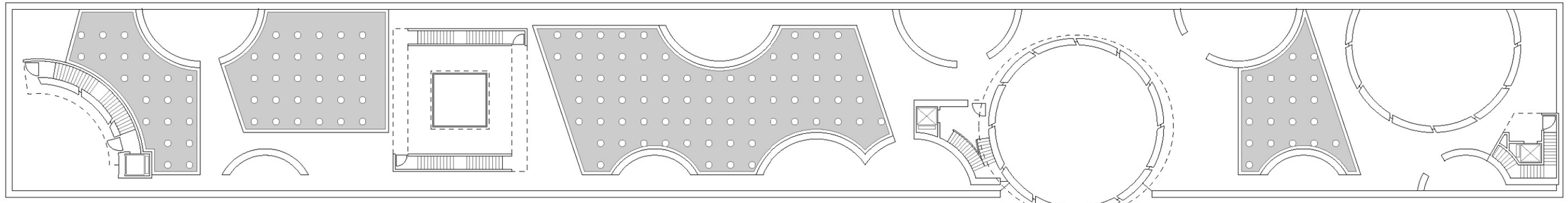
GROUND FLOOR PLAN 1:400



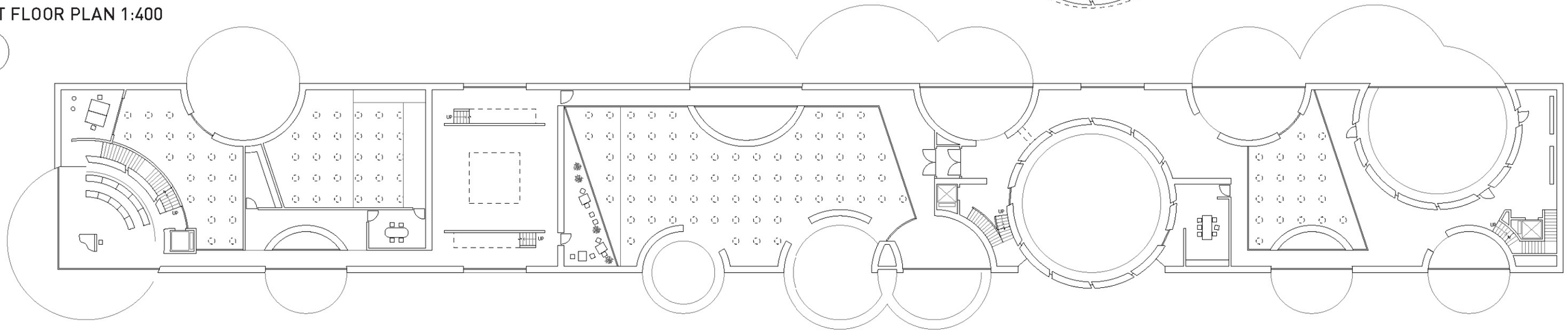
FRONT ELEVATION 1:400



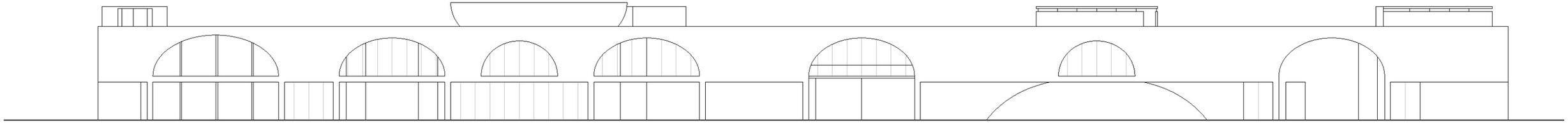
ROOF FLOOR PLAN 1:400



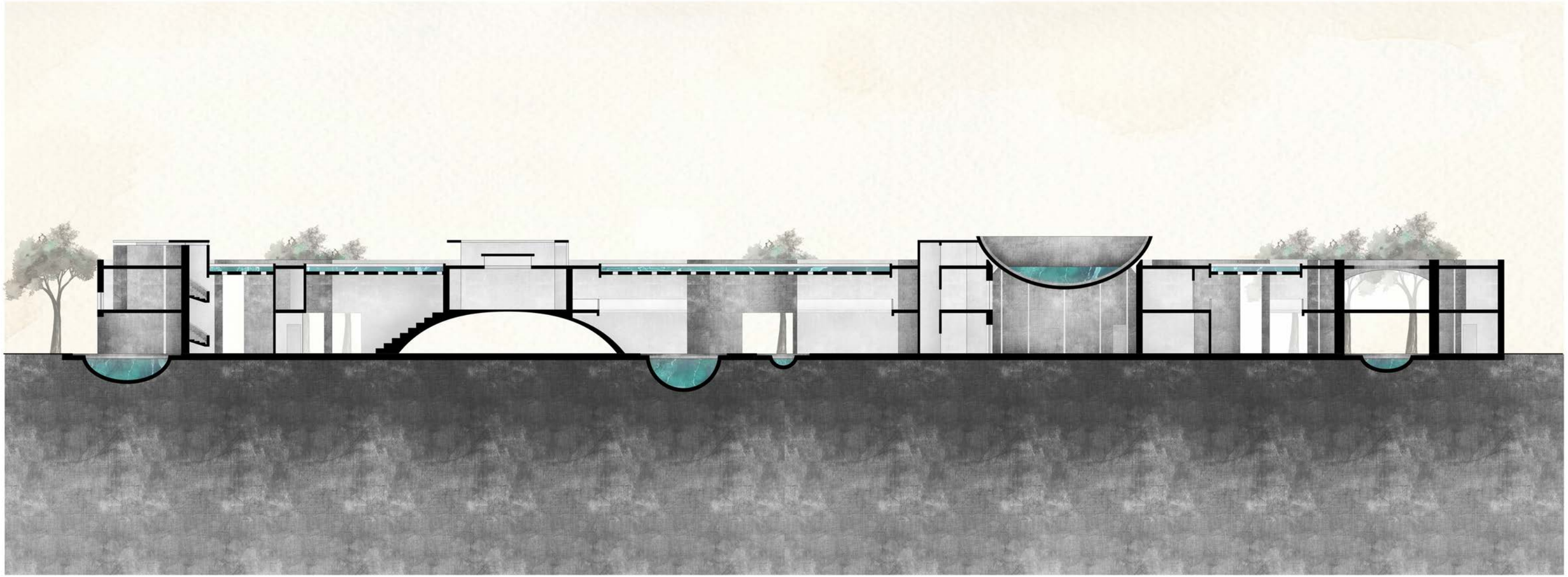
FIRST FLOOR PLAN 1:400



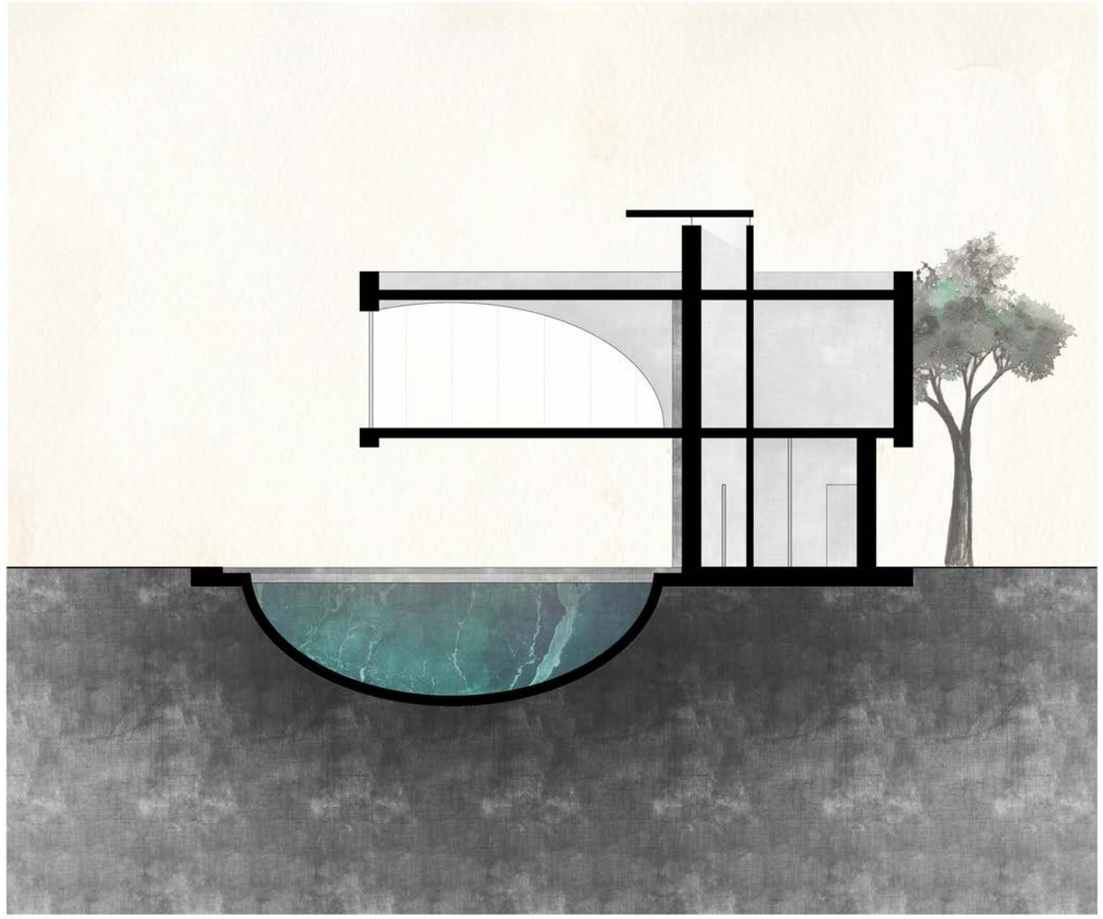
FRONT ELEVATION 1:400



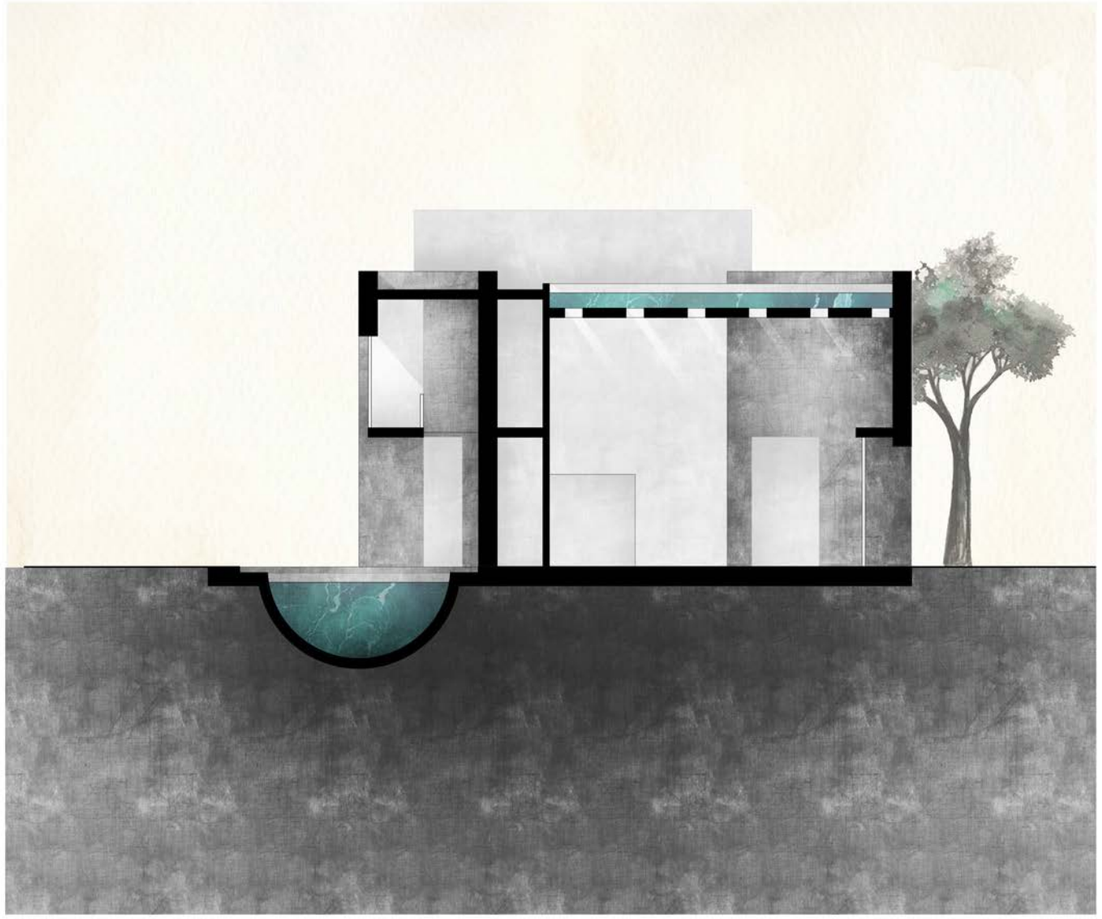
SECTION G 1:400



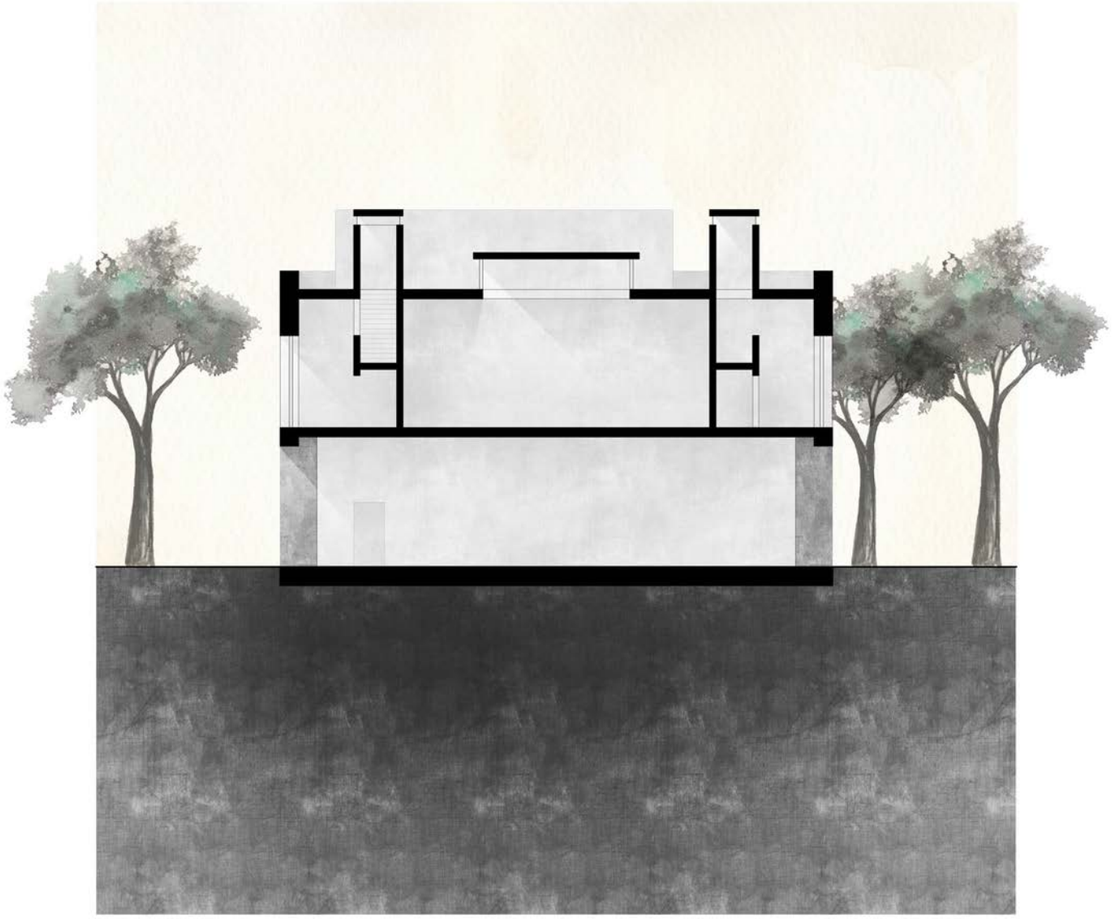
SECTION A 1:200



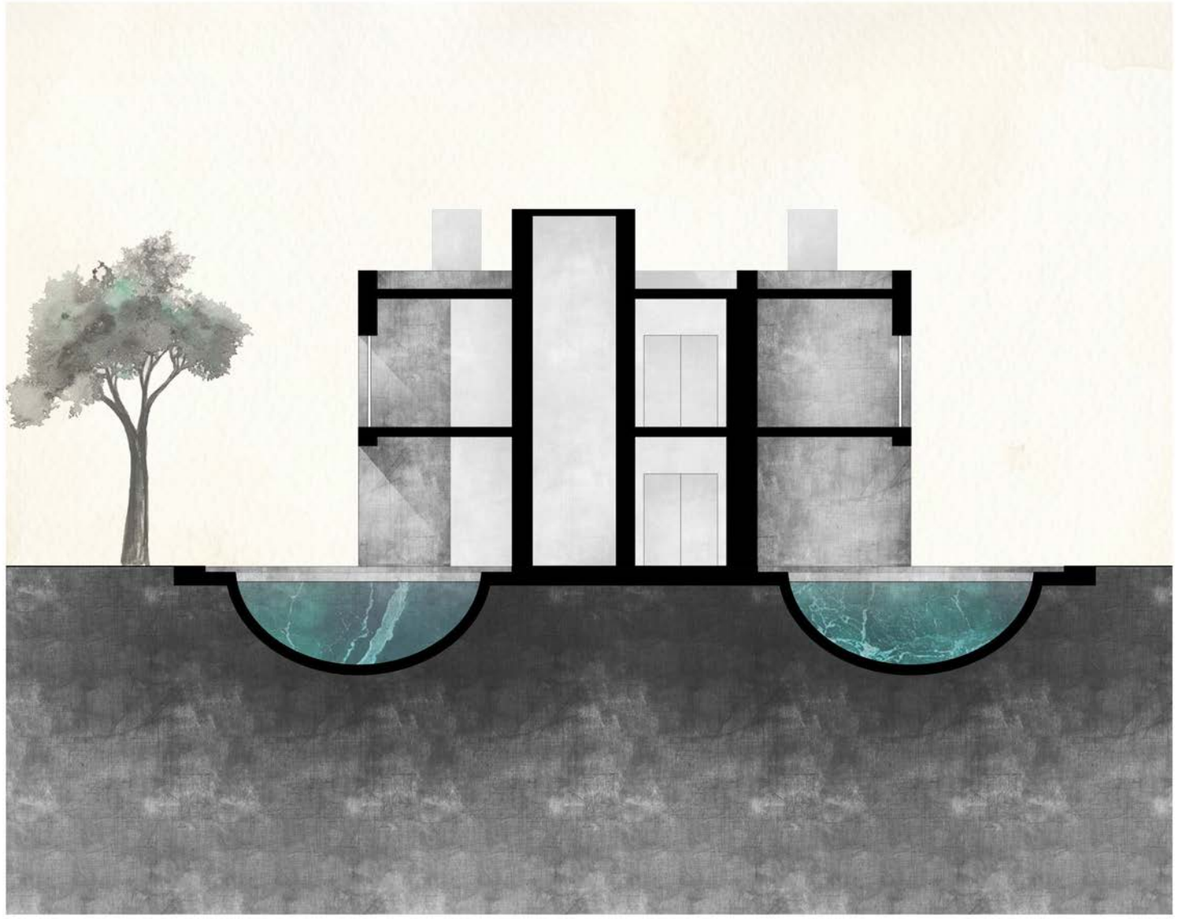
SECTION B 1:200



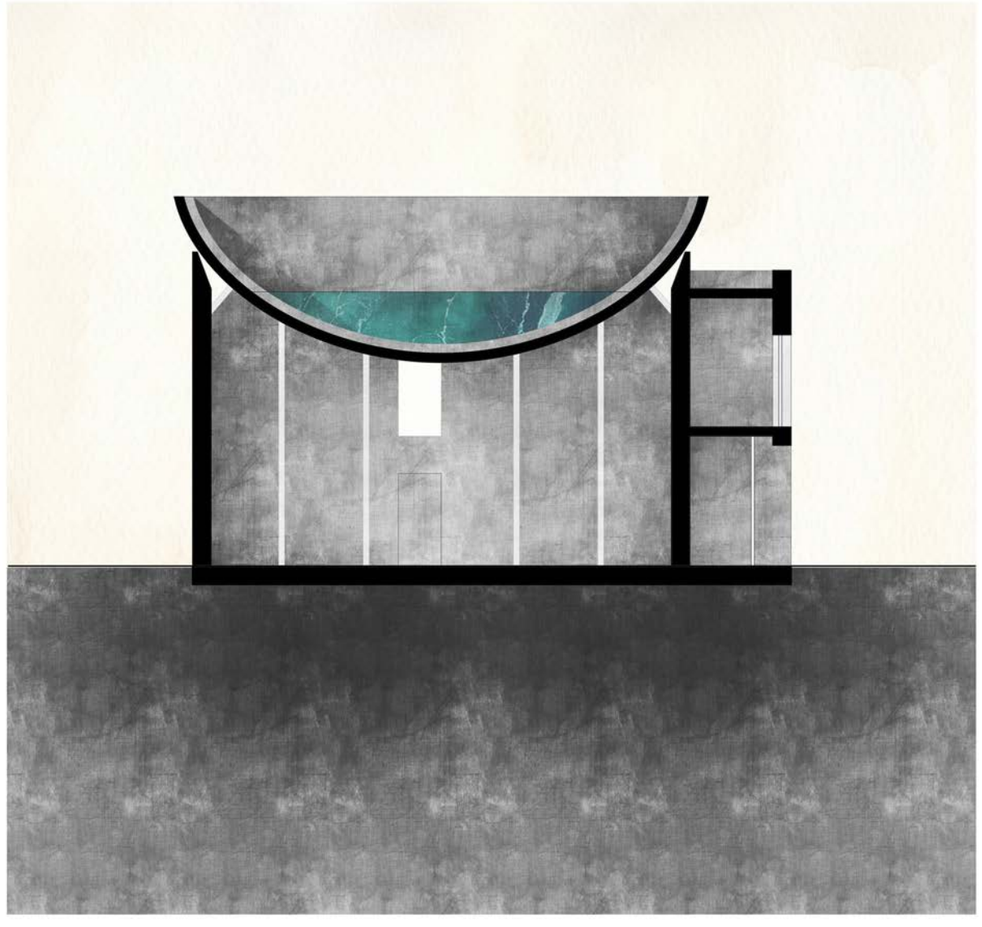
SECTION C 1:200



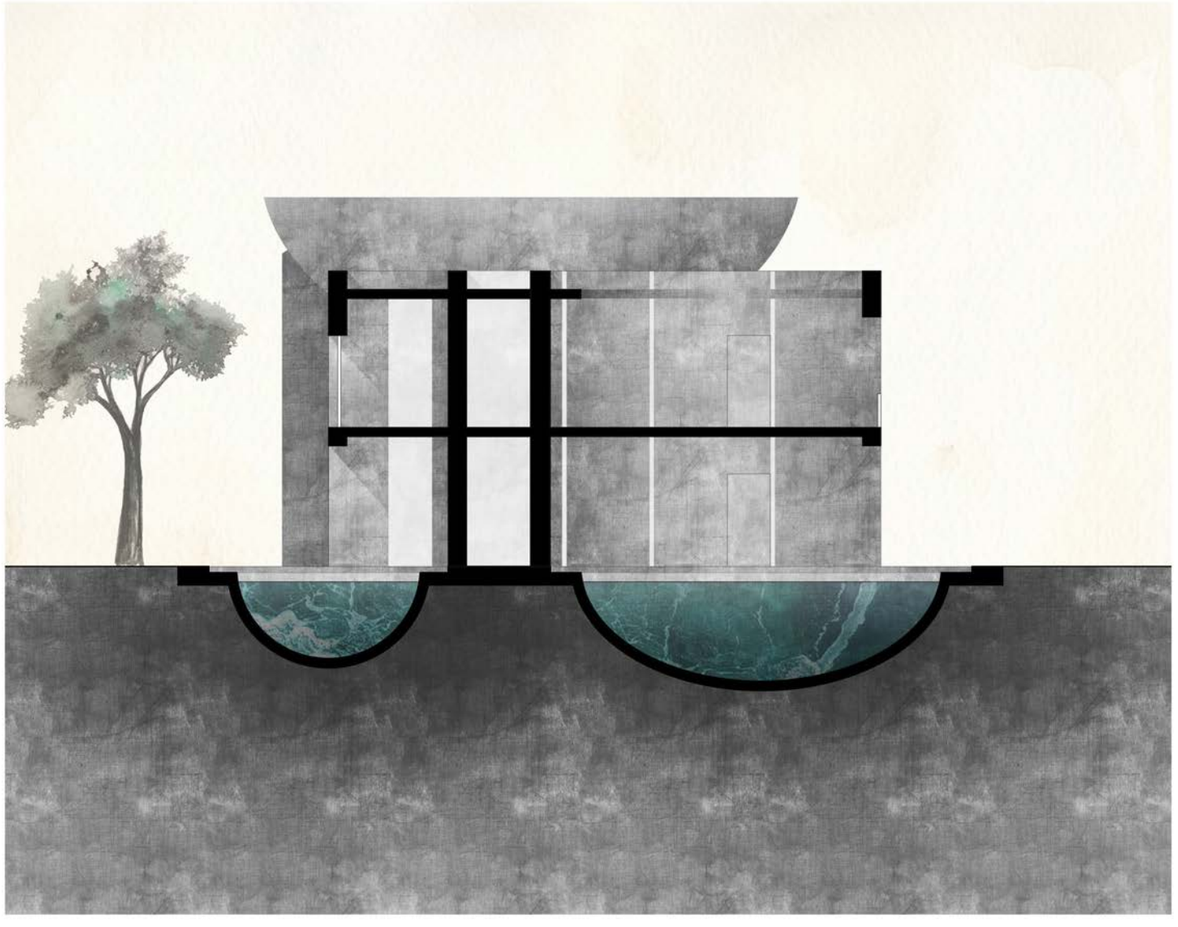
SECTION D 1:200



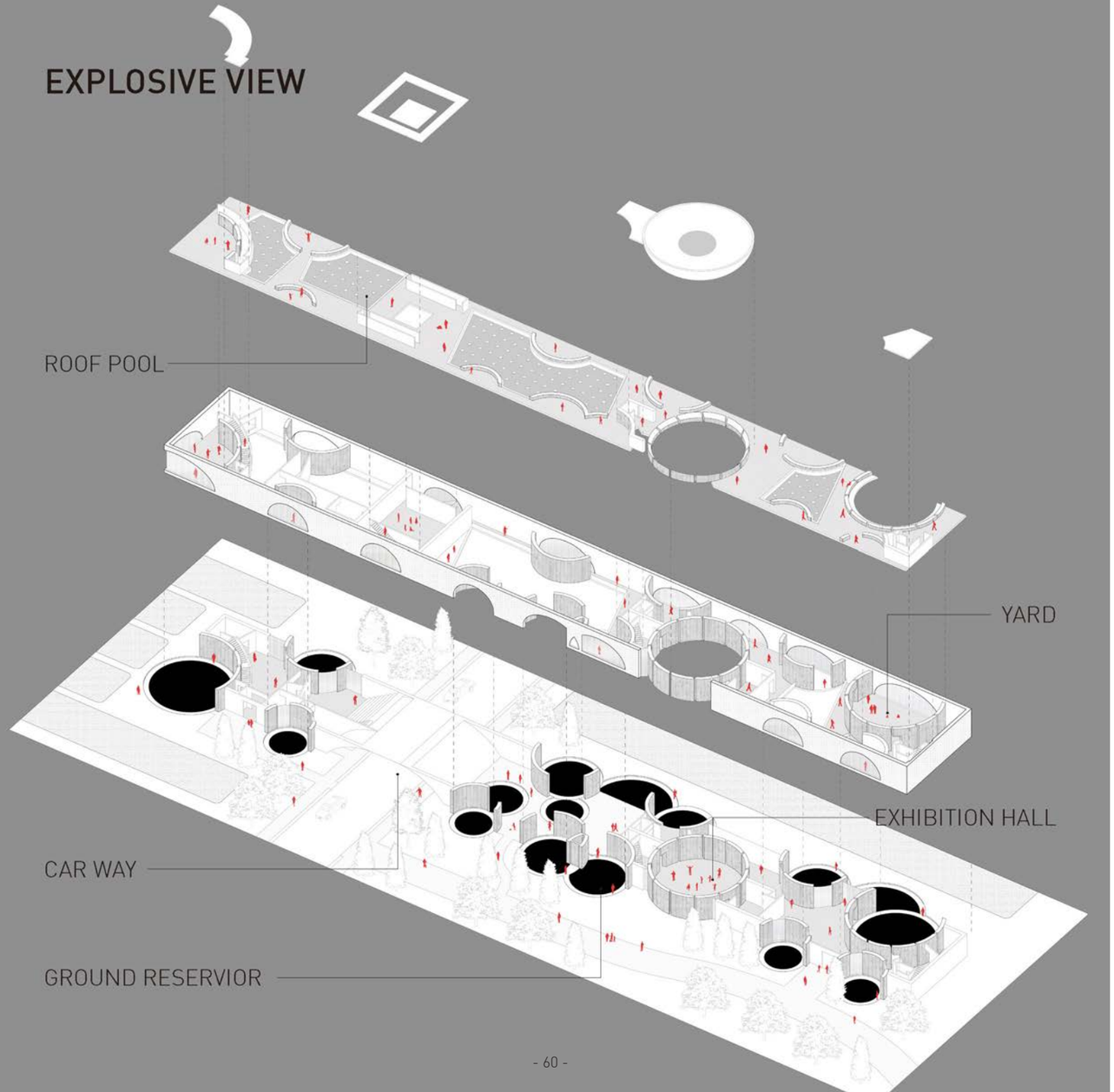
SECTION E 1:200



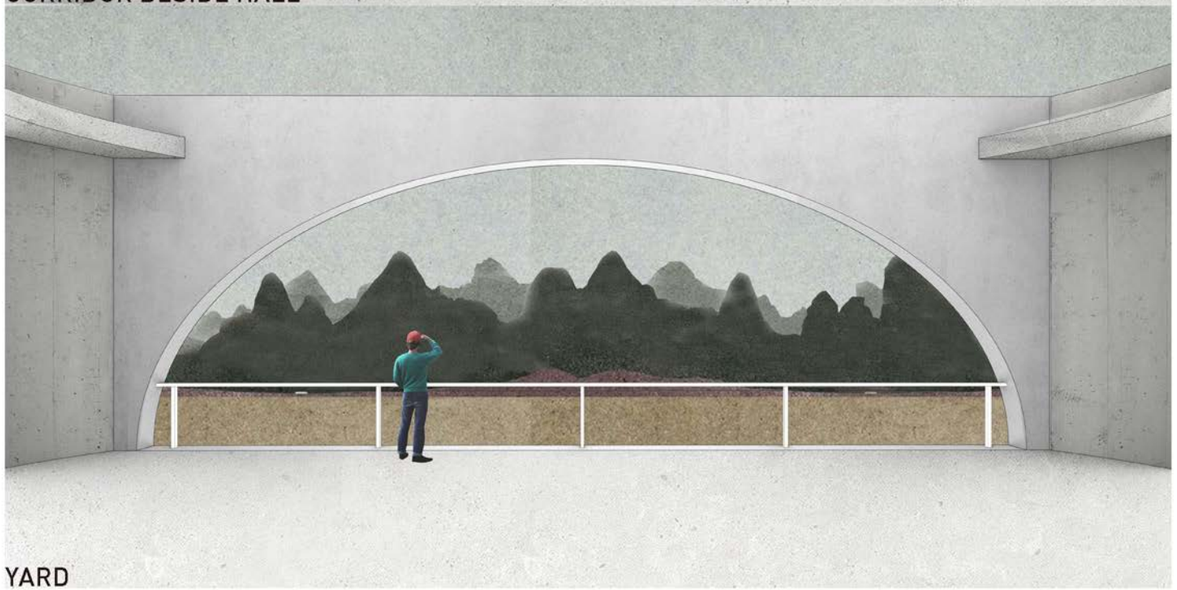
SECTION F 1:200



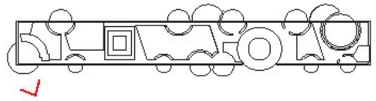
EXPLOSIVE VIEW



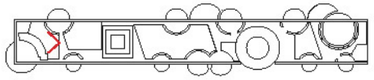
CORRIDOR BESIDE HALL



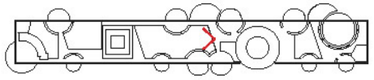
YARD



ENTRANCE HALL
GROUND FLOOR



ENTRANCE HALL
GROUND FLOOR



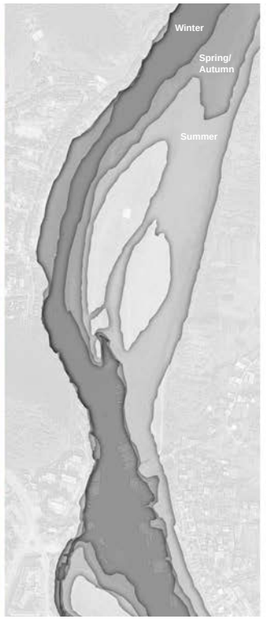
WATER RESERVOIR
GROUND FLOOR

05 PROJECT
05/02

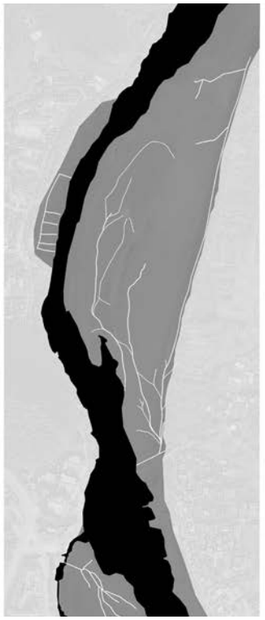
THE BORDER

Landforms

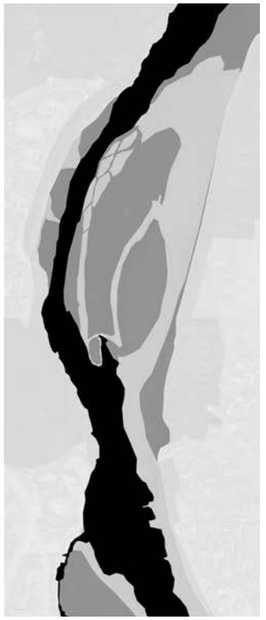
Satellite Imagery



Water level



Path Trace



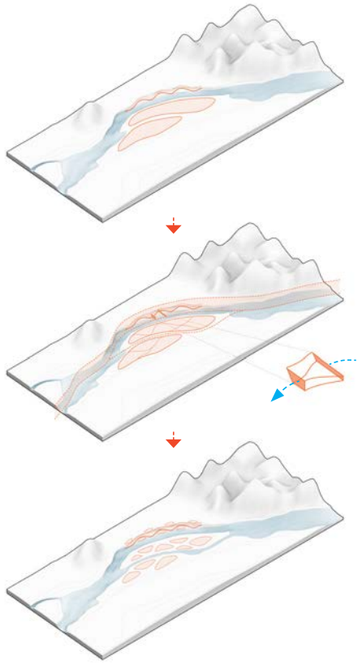
Texture

Current river bank

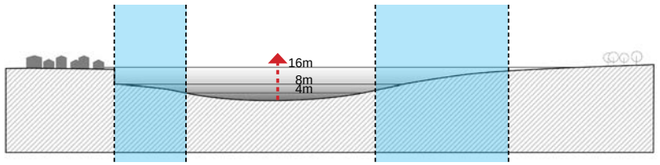
Spring

Winter

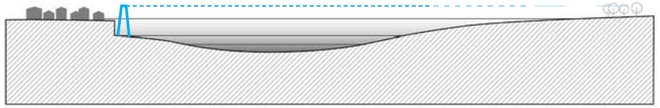
Generation



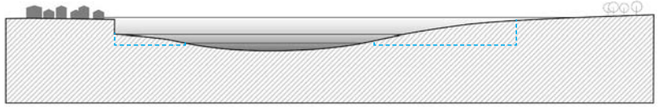
Concept



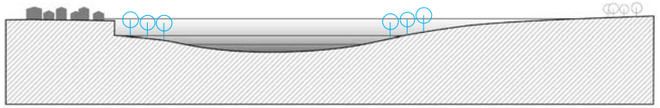
Rise the embankment for Water retaining



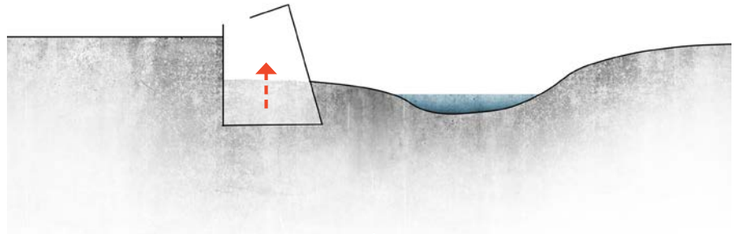
Deepen the riverbed to increase water capacity



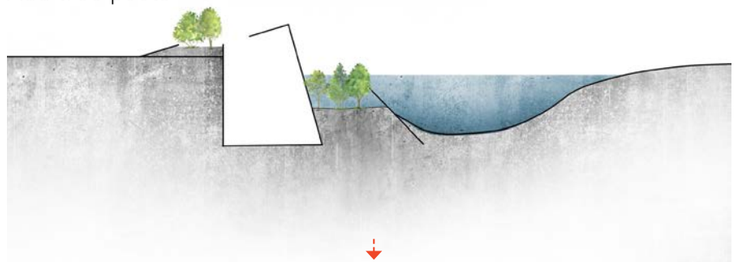
Decelerate & Ecological absorption



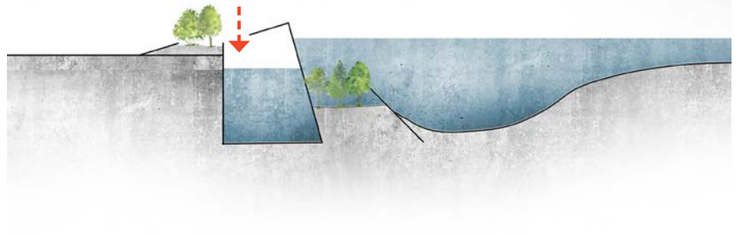
Set up the embankment



Add tree pools

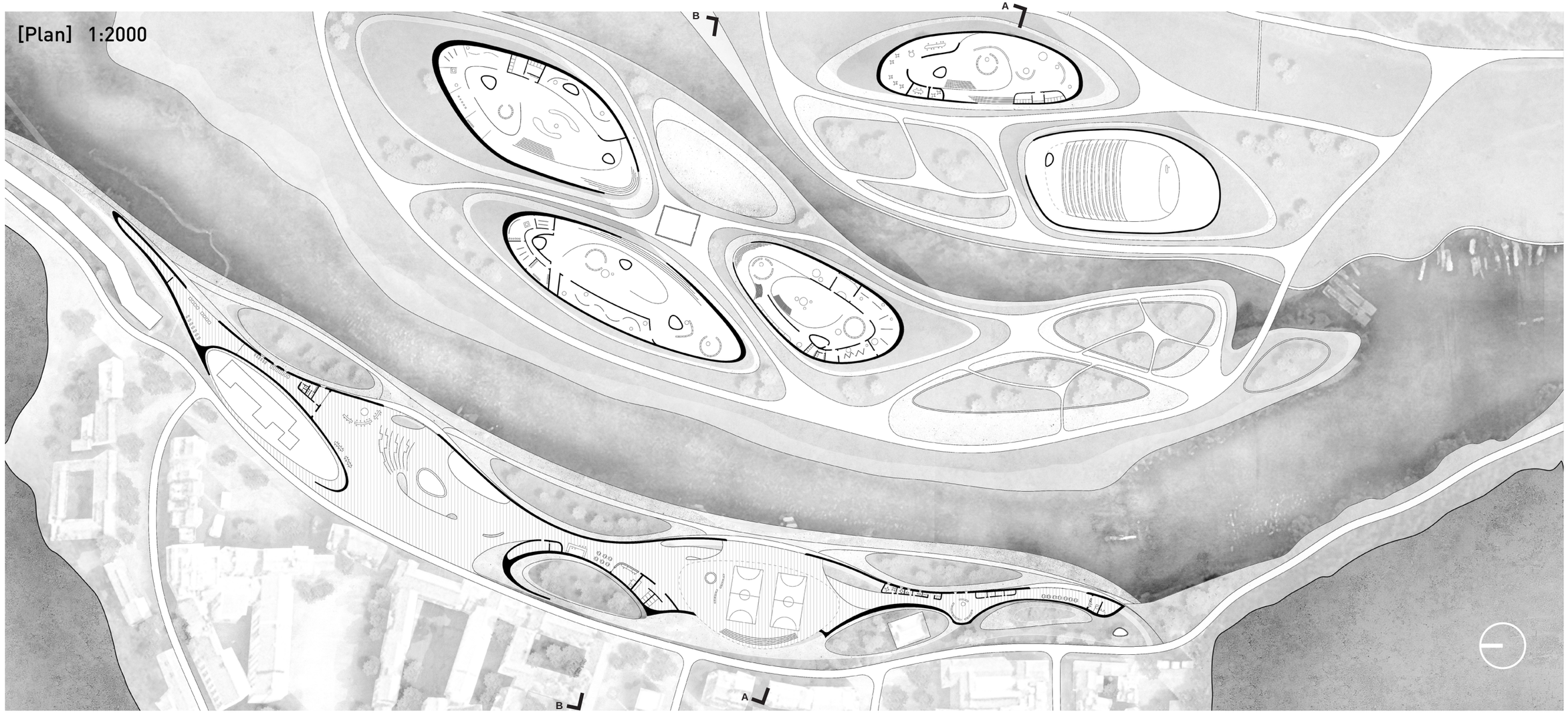


Receive spilled floods

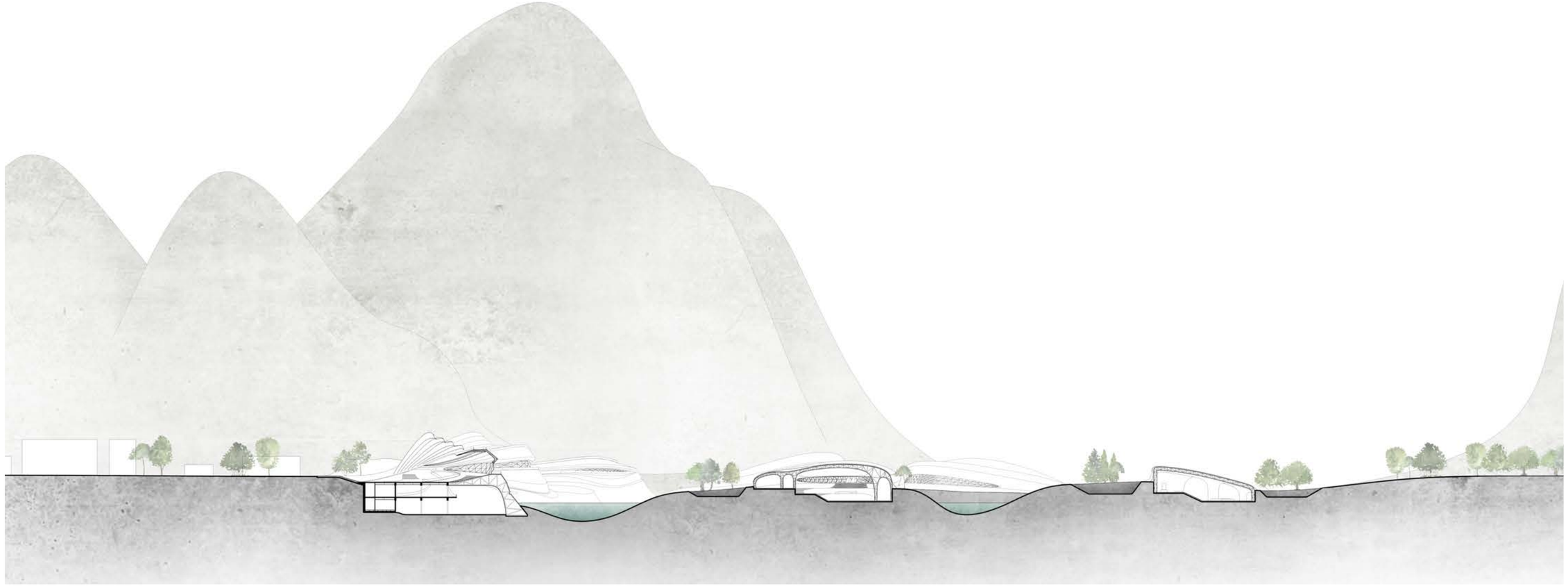



[Master Plan] 1:2000

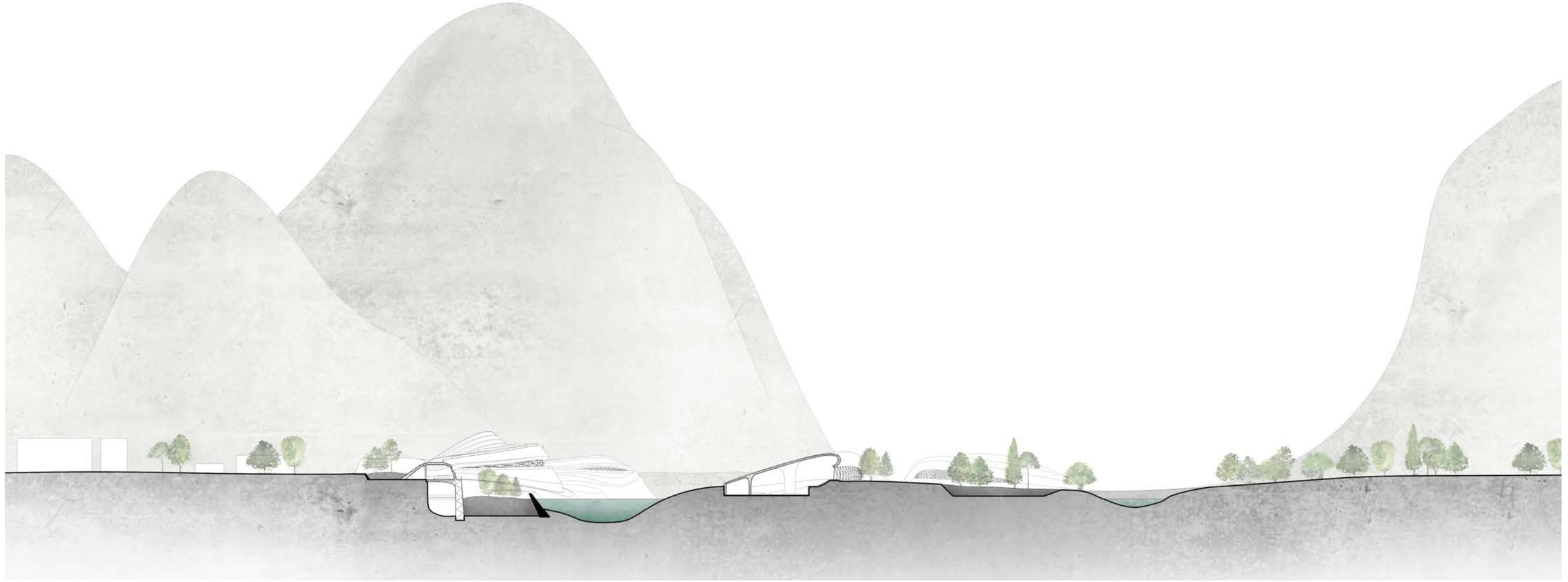
[Plan] 1:2000

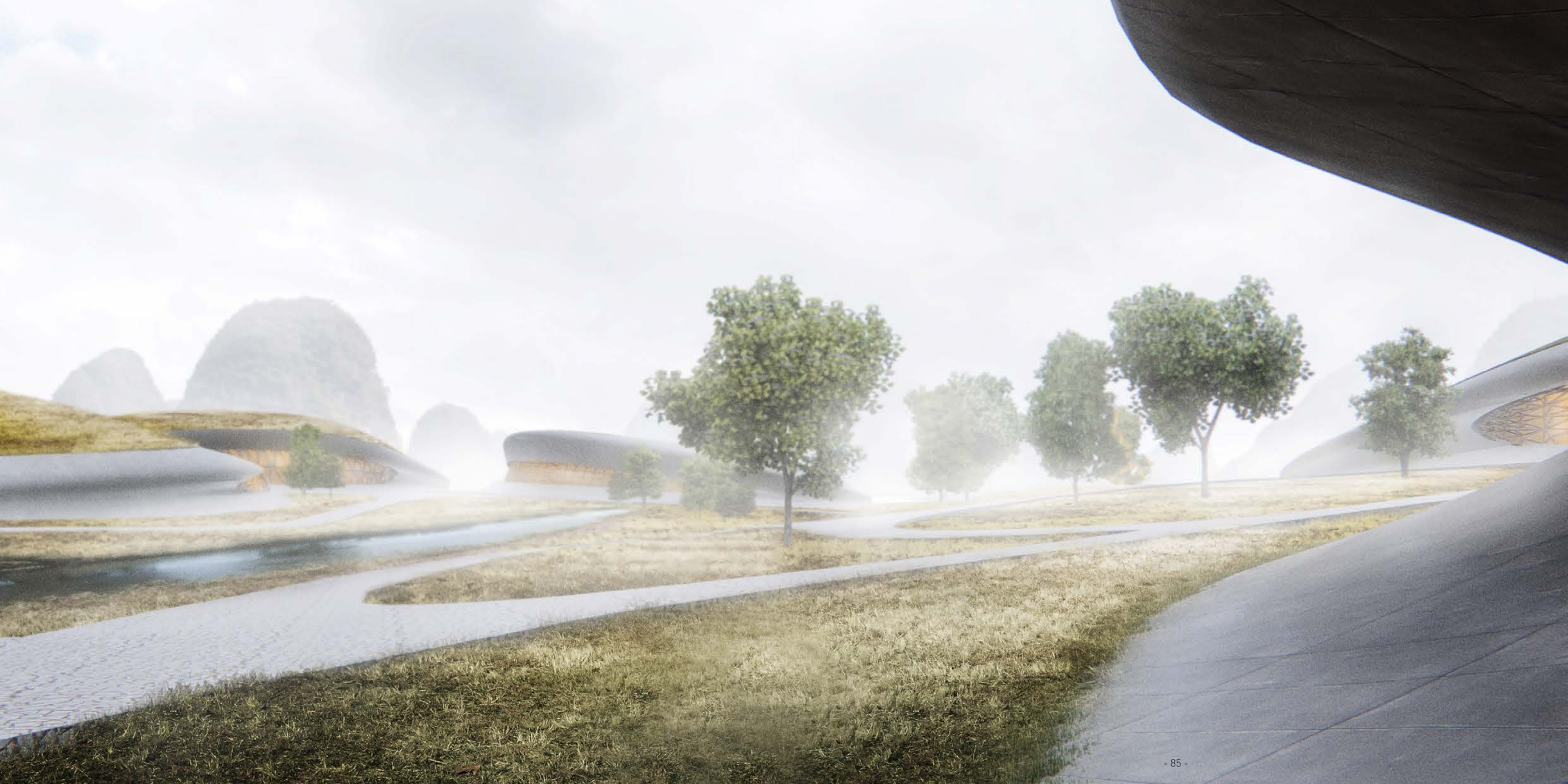


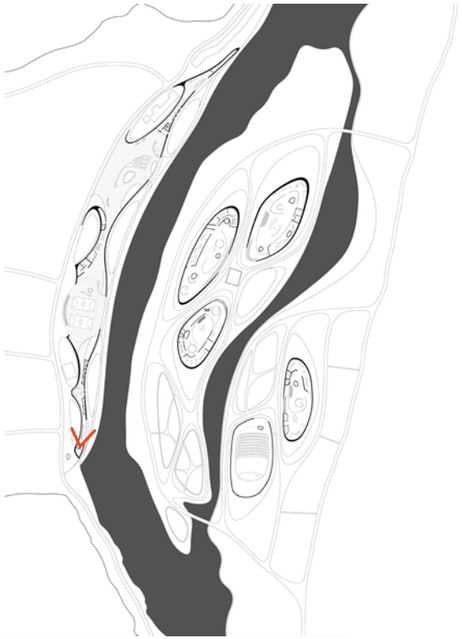
[A-A SECTION] 1:2000

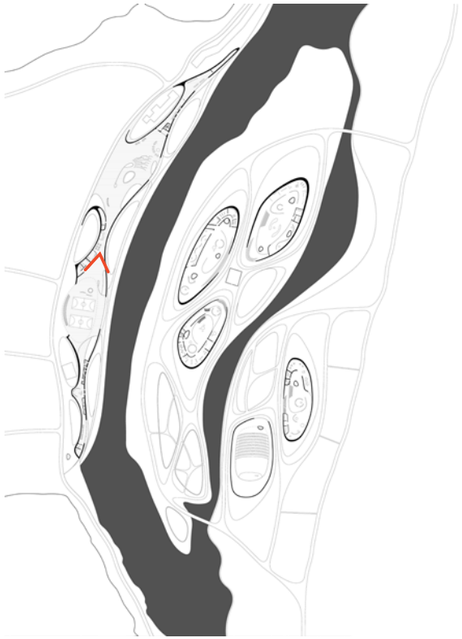


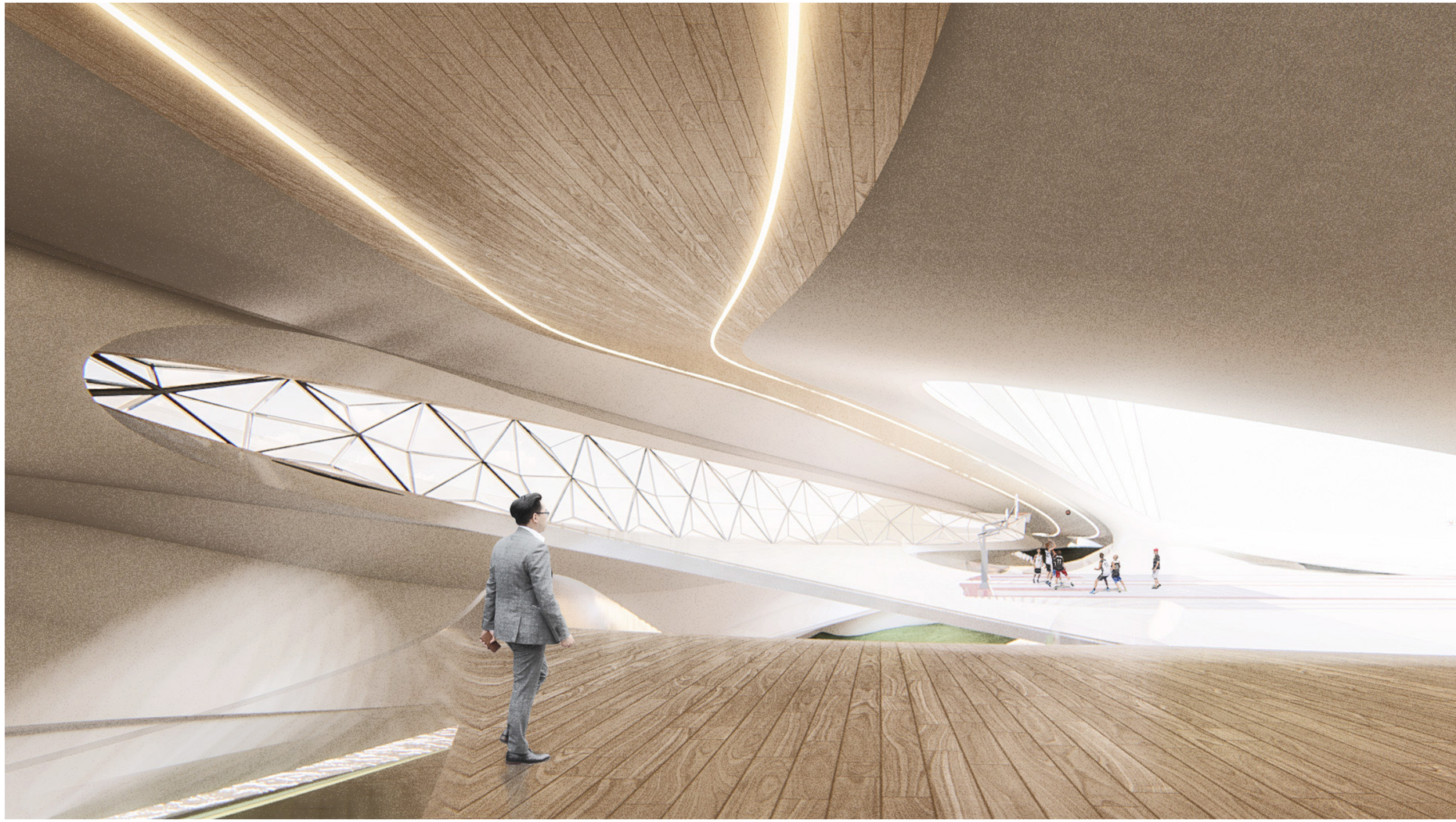
[B-B SECTION] 1:2000

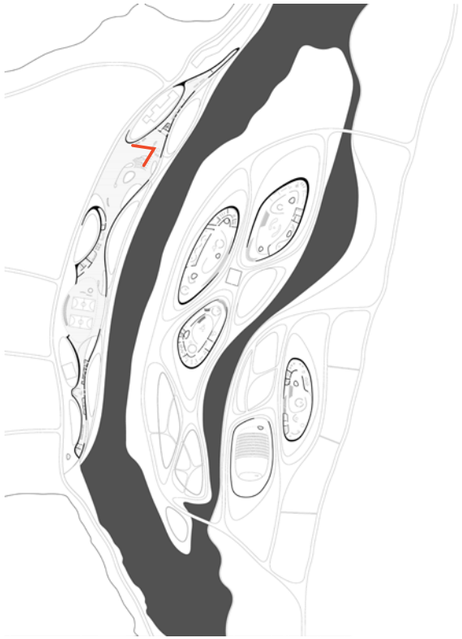


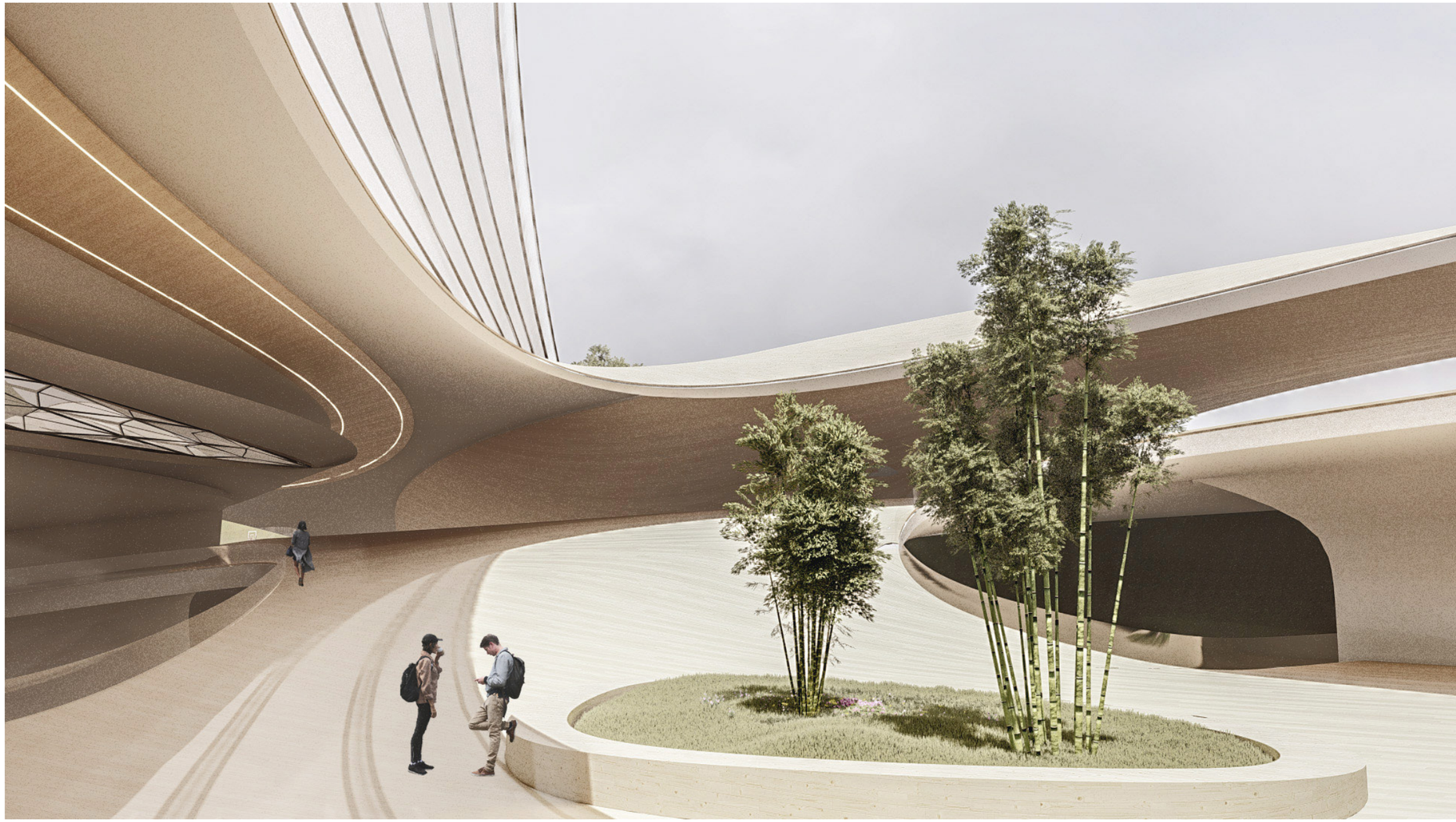












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