Kunming X Dianchi
Forming Ecological Infrastructure Through Urban Water Management

By

Wei Zou

A Practicum submitted to the Faculty of Graduate Studies of
The University of Manitoba
in partial fulfillment of the requirements of the degree of

MASTER OF LANDSCAPE ARCHITECTURE

Department of Landscape Architecture
University of Manitoba
Winnipeg

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Figure 1

FORMING ECOLOGICAL INFRASTRUCTURE THROUGH URBAN WATER MANAGEMENT

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FACULTY OF ARCHITECTURE
UNIVERSITY OF MANITOBA
WEI ZOU

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by Wei Zou
Academic Advisor: P. Richard Perron
Internal Advisor: Alan Tate
External Examiner: Emeka Nnadi

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Contents

Abstract

Since the establishment of the People's Republic of China, especially after the economic reforms in 1978, China has achieved unprecedented social and economic development. Rapid urbanization is one of the most outstanding outcomes of the social and economic success. Like many other cities in China, during the last 40 years the city of Kunming experienced enormous growth of population and economy. During the rapid urbanization process the Dianchi Lake, the sixth largest fresh water lake in China, has suffered serious pollution from industrial wastewater, agricultural runoff, and domestic sewage. Moreover, combined with the water scarcity and urban flooding caused by rapid urban expansion, the environmental crises have raised the tension between the city and water, and had a negative impact on the development of the city.

This practicum exams the evolving relationship between Dianchi Lake and Kunming through time; it explores a variety of precedents on urban water management strategies; and it experiments with emergent technology to formulate a water management based *ecological infrastructure* from a landscape architecture approach. In particular, proposals for the redesign of the abandoned airport will demonstrate a potential approach to alleviating the tension between human and water within the Dianchi Lake drainage basin.

Acknowledgment

To Richard Perron.

Thank you Richard for your incredible guidance. It is a pleasure to have you as my committee chair. Thank you for always providing enlightening advice, heartwarming encouragement, and most notably, your patience and trust through this long journey. There is no words can express my gratitude for your involvement in this practicum.

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To Emeka Nnadi.

Thank you Emeka for your unique comments on my work from a practical point of view. You could instantly point out the challenge this practicum can have, and push me further to explore better solution.

To My Family and Friends.

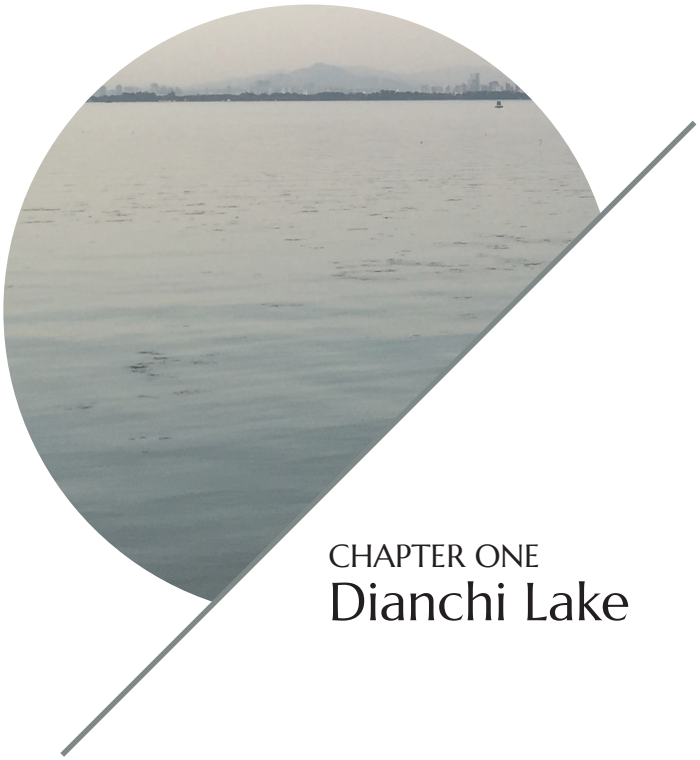
Thank you to all the amazing friends I have met during my study in Canada. For all the memories and moments, the good the bad.

Thank you to all the rest of the faculty members and classmates in the Faculty. It has been amazing to studying with you all.

Thank you Mom and Dad for sending me out on this unforgettable journey. For doing everything to support me and educate me to be a better version of myself. Thank you Yadan for being here with me.

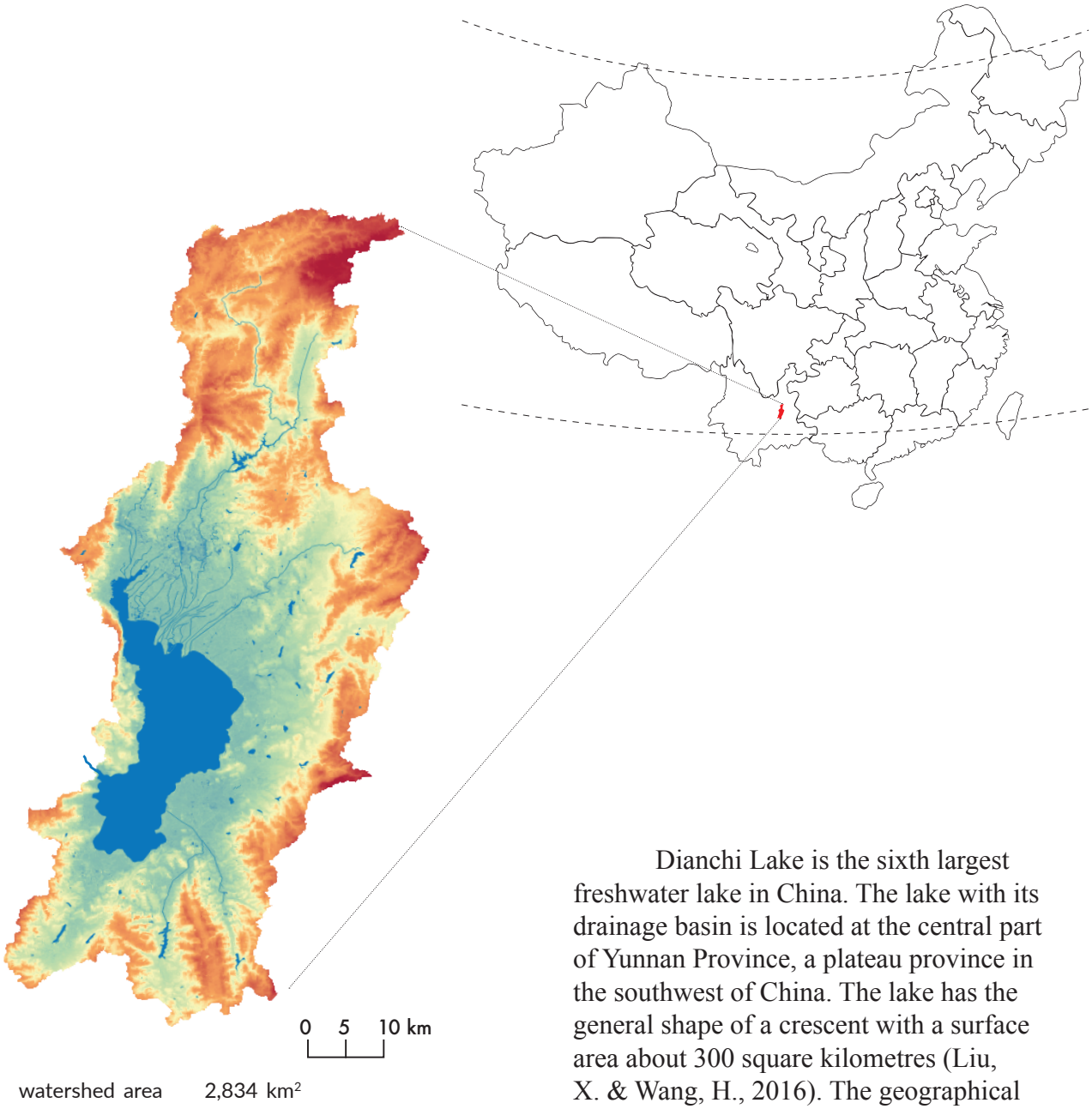
感谢一路走来有你们的陪伴

List of figures



CHAPTER ONE

Dianchi Lake



Dianchi Lake is the sixth largest freshwater lake in China. The lake with its drainage basin is located at the central part of Yunnan Province, a plateau province in the southwest of China. The lake has the general shape of a crescent with a surface area about 300 square kilometres (Liu, X. & Wang, H., 2016). The geographical formation, location of the lake, and the human activities in this drainage basin create a unique landscape and ecosystem.

Figure 2
Location of Dianchi Lake

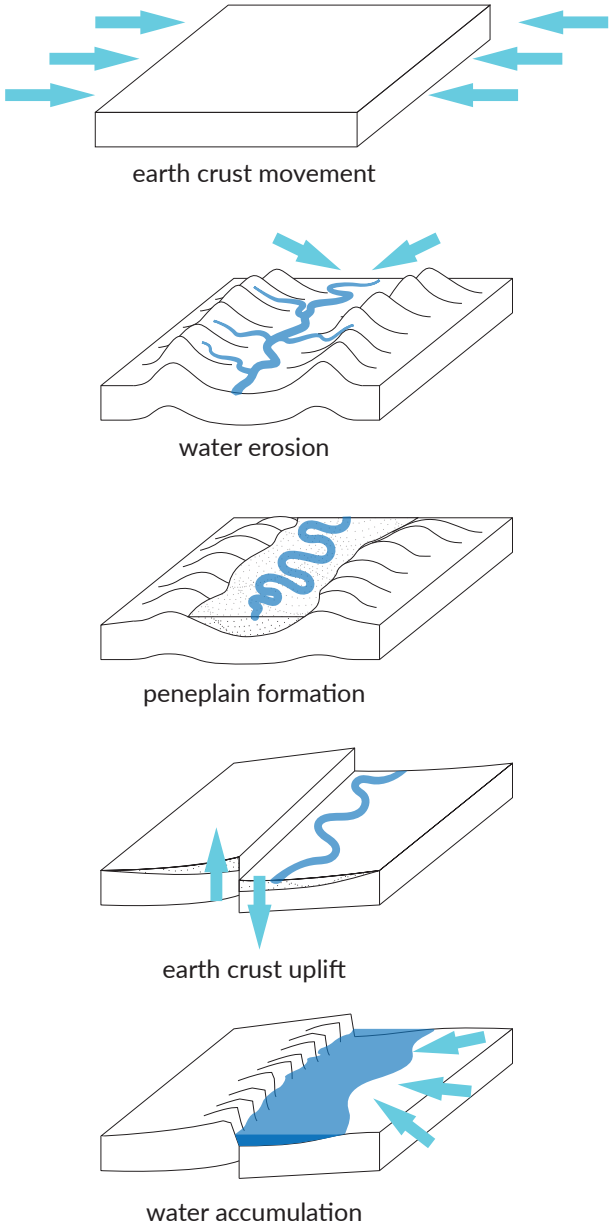
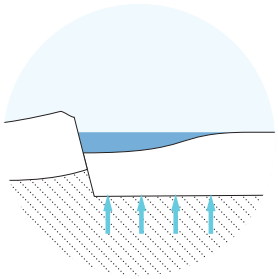


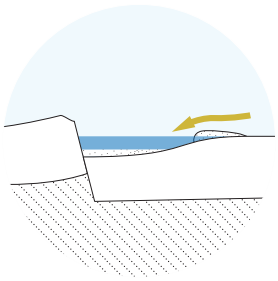
Figure 3
Formation of Dianchi Lake

1.1 Geological Formation of Dianchi Lake

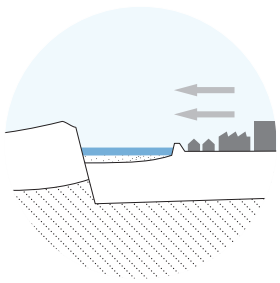
Dianchi Lake is an ancient tectonic lake which formed through a long process of crustal movement. Around 100 to 70 million years ago, the Yunnan-Guizhou Plateau experienced strong crustal movement. The earth crust was strongly squeezed and folded, forming mountains and basins. Combined with the effects of erosion, it became a peneplain (Liu, X. & Wang, H., 2016). Subsequently, the crustal movement has continued to sculpt the landscape of Yunnan-Guizhou Plateau. Around 12 million years ago, after several uplifts and drops, an intense tectonic movement of the earth's crust occurred. A major north to south fracture was formed, creating a tens-of-kilometres-long cliff, currently known as Xishan Mountain, forming the west boundary of the Dianchi drainage basin. On the east side of the cliff the dramatic drop allows water to accumulate below the cliff. This basin-controlling fracture had a decisive influence on the formation of Dianchi Lake and the drainage basin (Yu, 1999). The geological structure of the basin determines the north to south lake topography, as well as the north to south, and east to west flow direction of the main rivers running into and out of it.



crust movement
land raise



sediment accumulation



human activities

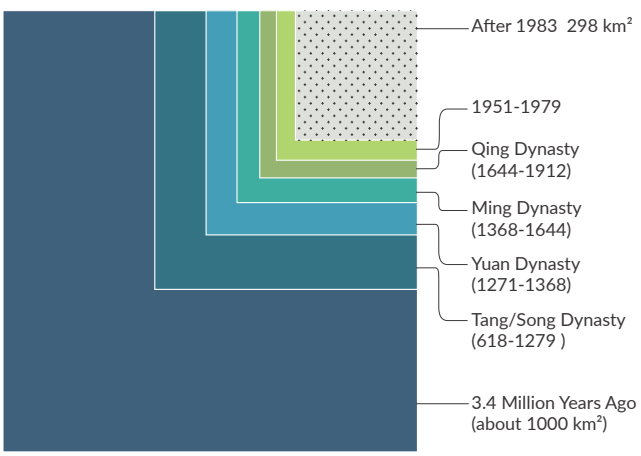


Figure 4
Shrinkage of Dianchi Lake

1.2 Evolution of Dianchi Lake

When the lake was formed it was more than 100 metres deep and its surface area exceeded the current lake area several times. In Xixian Yu's article *Preliminary Study on the Historical Geography of Dainchi Lake* archaeological and geological evidence shows that even the city of Kunming was part of the lake (Yu, 1999). With the passing of time, the lake area and volume kept shrinking. The three main factors that make the lake shoreline retreat are geological activities, accumulation of lake sediment, and human activities. At first, with the crustal movement continuing to work on the plateau, the land became raised and water was drained out of the basin. In addition, the rivers within the Dianchi drainage basin carry sand and soil into the lake; at the same time organic matter such as plants and animals remains accumulated at the bottom of the lake to form layers of sediment. The lake bottom has therefore risen through time. Lastly, after the Neolithic Age, human activities thrived along the shoreline, accelerating the shrinkage of the lake (Yu, 1999). Especially after 1270s with the demand of a stable water level and agricultural land a series of hydraulic works took place to drain out water and provide control of the water level in this basin. From then on, human activities have become the primary cause of the lake's shrinkage. In 700 years the lake size reduced to less than 300 square kilometres (Liu, X. & Wang, H., 2016).

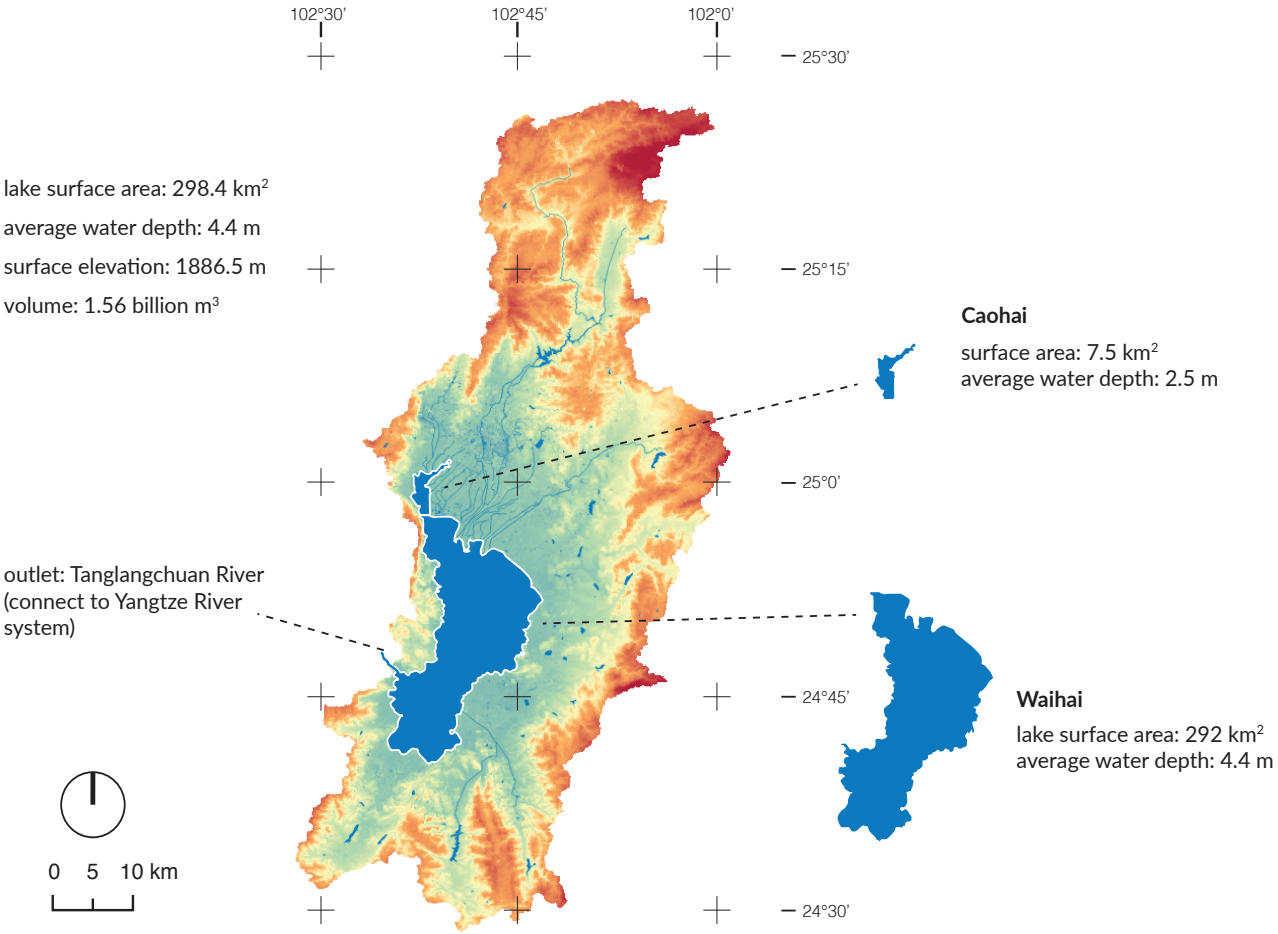


Figure 5. Geo-location of Dianchi Lake

1.3 The Lake and the Basin in Modern Times

Dianchi Lake is located at the subtropical region between 24°40'and 25°2'North and 102°35" and 102°48'East, downstream of Kunming, capital city of Yunnan Province. The lake is set at 1887.5 metres above sea level at the normal water level, with a surface area of 298.4 square kilometres. The total volume of the lake at its normal water level is about 1.6 billion cubic metres and the water residence time (WRT=lake volume/outflow) is about 2.94 years (Liu, X. & Wang, H., 2016). The lake is divided into two parts by an artificial causeway. The northern, inner part is called Caohai and has a surface area of 7.5 square kilometres and an average depth of 2.5 metres; the southern, outer part is called Waihai and has a surface area of 292 square kilometres and average depth of 4.4 metres. Currently there are over 36 rivers, and creeks flowing into the lake. Panlongjiang is the main incoming river, developed from the north of Dianchi drainage basin and running through the city center. On the southwest side of Dianchi Lake, the water drains out from Tanglangchuan River and flows towards the north. At the outlet of Dianchi Lake an artificial weir is constructed to maintain the water level of the lake. After the water flows out from the weir, it connects to the Jinshajiang River system, which is an upper stream of the Yangtze River Basin (Liu, X. & Wang, H., 2016).

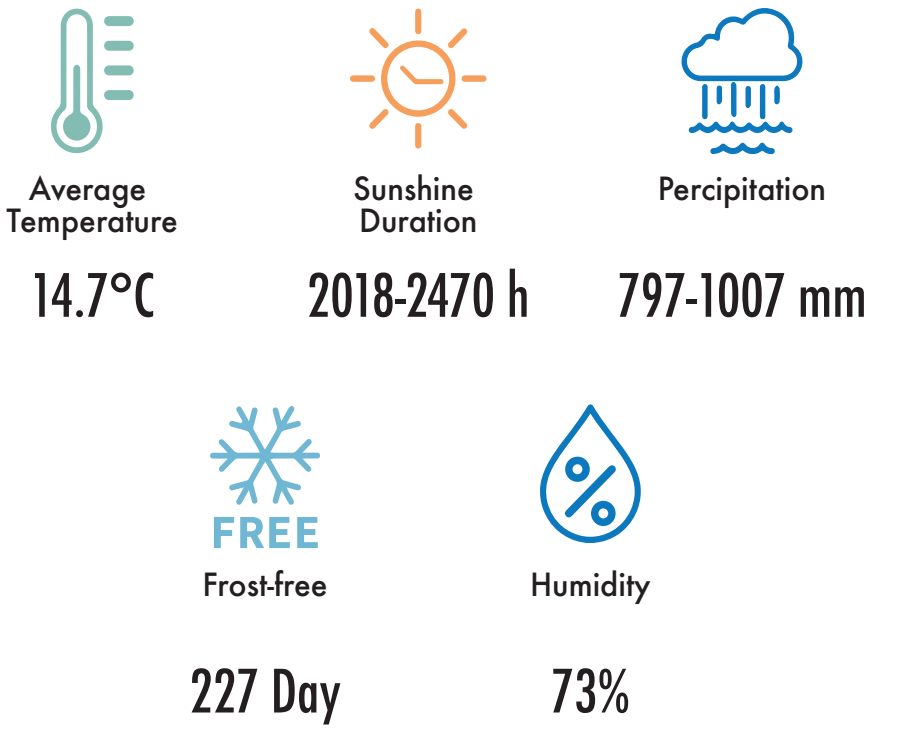


Figure 6. Climatic status of Dianchi Lake

According to the Köppen climatic classification, Dianchi Lake and its drainage basin are influenced by a subtropical highland climate (Cwb) (Chen, D. & Chen, H.W. 2013). In general, this climate is characterized as having dry and noticeably cool winters, and moist warm summers (GeoDiode, 2018). The subtropical location of the Dianchi drainage basin excludes the harsh cold winter, and the high altitude of Yunnan-Guizhou Plateau filters out extra summer heat. In terms of precipitation, the tropical air masses from the south bring in generous rainfall during the rainy season, but the subtropical high pressure creates dry winters in this region. In addition, Dianchi Lake makes the climate of the drainage basin unique. It provides natural air conditioning and adjusts the temperature all year round. During the day in the warm summers, the lake water body absorbs excessive heat and lowers the temperature of nearby areas; during the night and in the cool winters, the water body releases the heat to warm up the air and raise the humidity (Zhang, Zhang, & Liu, 1986).

The annual air temperature of the region is around 14.7 ºC and the average annual rainfall is between 797 to 1007 mm. The annual sunshine duration is 2018-2470 hours; relative humidity is around 73%. There are 227 frost-free days in an average year (Jin, Wang, & He, 2005). With the benefit of the lake, the surrounding area, especially the city of Kunming located at the northeast shore, has one of the mildest climates in China. The city of Kunming has even been named “the city of spring”. Within the drainage basin the geo-location, altitude, precipitation, and the water body mass of Dianchi Lake provide a favourable micro-climate. This mild and pleasant all-year-round climate has made this region attractive to human settlement throughout history.

1.4 Legacy of the Lake

Through the long history of the lake incoming water brought abundant nutrition into it. After the retreat of the water, the rich sediment from the former lake bottom became fertile land for human settlement. The fertile soil and beneficial climate in the drainage basin allow agriculture to thrive. This legacy from Dianchi Lake became the foundation for the development of the drainage basin and the establishment of Kunming.

Figure 7. Panoramic view of Dianchi Lake

CHAPTER TWO

City of Kunming

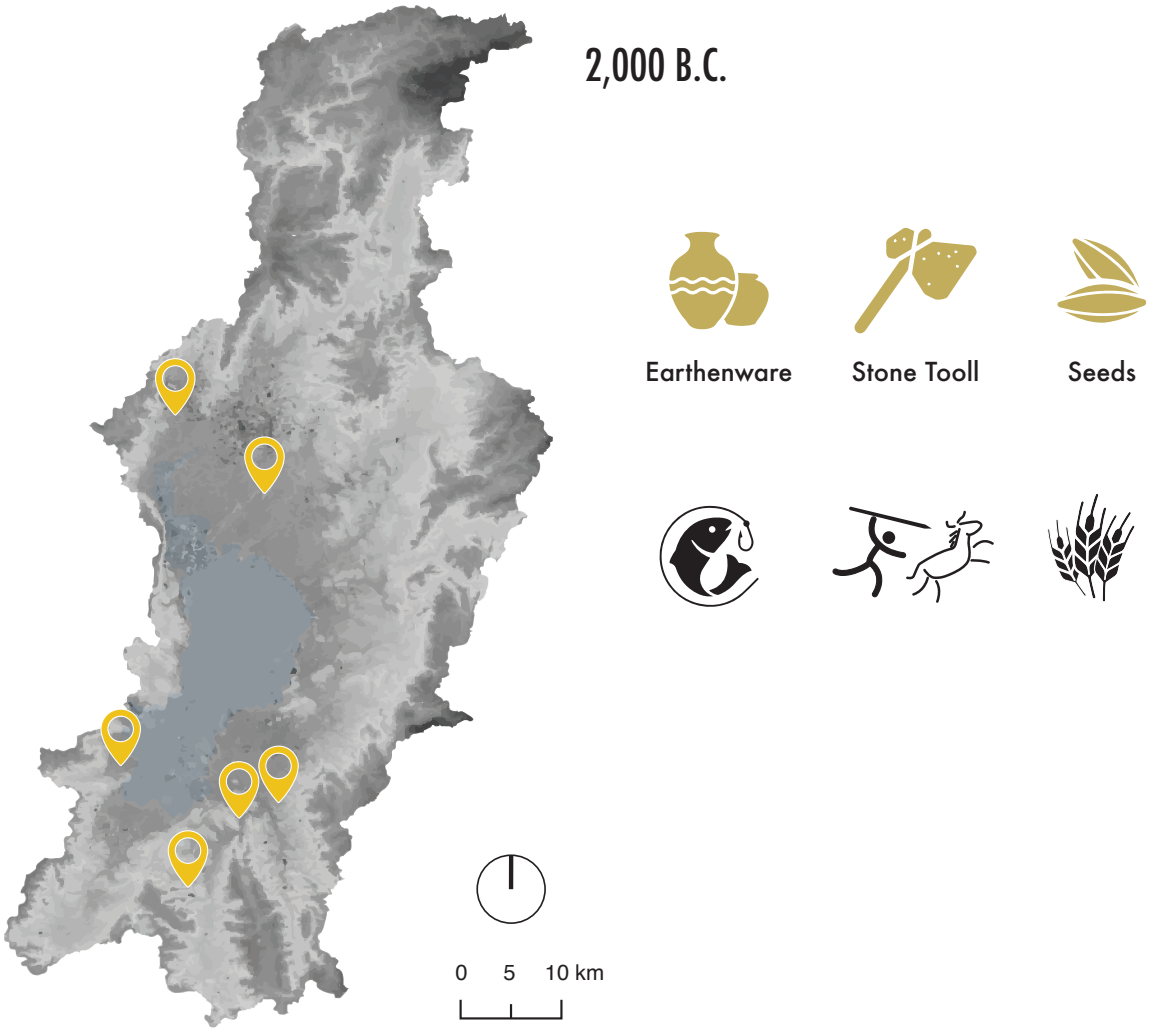


Figure 8. Early settlement in Dianchi Basin

2.1 Human Settlement and Early History of Kunming

The relationship between Dianchi Lake and humans dates back thousands of years. As mentioned, archeological evidence shows that human activities occurred along the shoreline of Dianchi Lake since late Neolithic time (Yu, 1999). Artifacts such as stone tools and earthenware were found over 15 archeological sites around the Lake. The tools and seeds found inside the earthenware indicate that people at that time were not only able to hunt and fish, but also had agricultural skills (Yu, 1999).

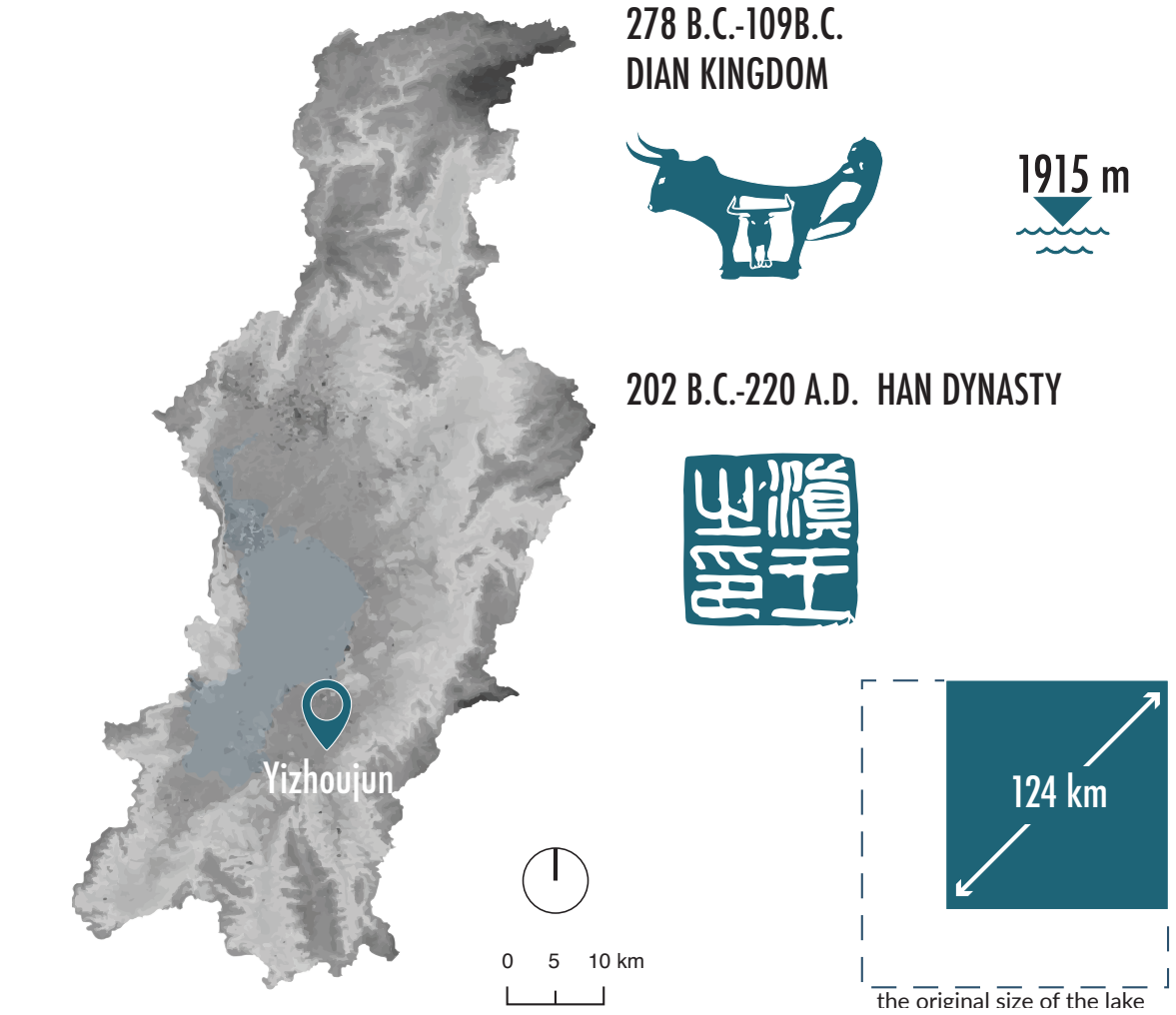


Figure 9. Establishment of political power in Dianchi Basin

The first written record of political power being established around Dianchi Lake was at the end of Warring States Period (475 BCE - 221 BCE). According to the *Treatise on the Southwestern Yi people* from the *Records of the Grand Historian* (Chinese: 史记.西南夷列传) by Qian Sima (Chinese:司马迁) (91 BCE), General Qiao Zhuang (Chinese:庄蹻) from Chu State led an army that marched to the southeast shore of Dianchi Lake and claimed the land as part of Chu's territory. After Qin unified the other six states Qiao Zhuang claimed his own political right in the Dianchi area and established the Dian Kingdom. In Qian's description, Dianchi Lake was 300 li (approximately 124 km) wide and the shoreline was broad and fertile (109 BCE - 91 BCE). After the establishment of the Dian Kingdom, the connection and cultural exchange between the Dianchi area and central China became more and more frequent. In 109 BC the Han Empire conquered the Dian Kingdom but kept the Dian's entitlement to the land. The Han empire set up Yizhou Jun, an administrative division on the east shore of Dianchi Lake, to rule southwest China.

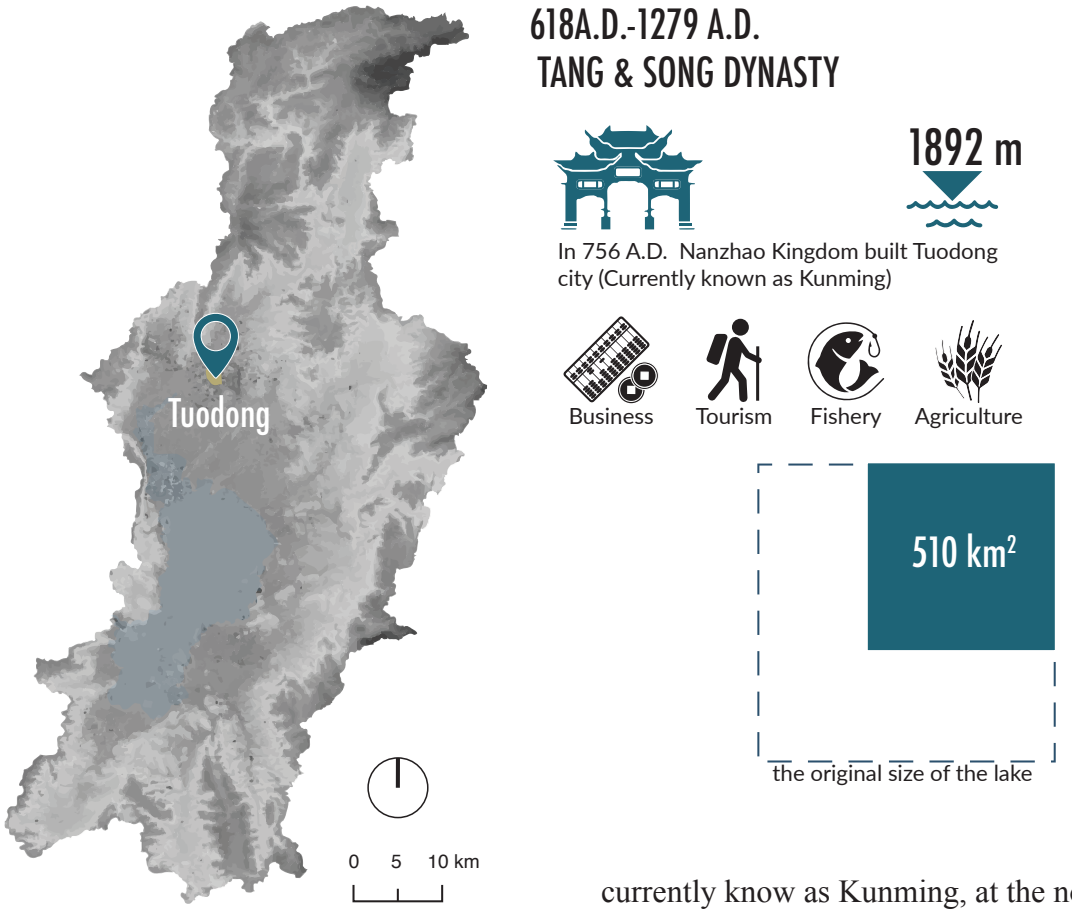


Figure 10. Dianchi Basin during Tong and Song Dynasty

As the Chinese dynasties altered, the landscape of the lake itself kept changing. The water level of the lake continued to drop. During the Dian Kingdom (278 BCE - 109 BCE) the water level of Dianchi Lake was at 1,915 metres above sea level. During the Tang and Song Dynasties (618 CE - 1279 CE) the water level dropped to 1,892 metres above sea level, and the surface area of the lake was about 510 square kilometres (Kunming Dianchi Management Bureau, 2015). As the water retreated, flat and fertile land appeared at the north side of the lake. Human activities moved towards the north as well. In 756 CE the Kingdom of Nanzhao built Tuodong city, currently know as Kunming, at the northeast side of Dianchi Lake. With the benefit of comforting weather and fertile soil, Tuodong city quickly became a flourishing settlement. Government officials, intellectuals, businessmen, craftsmen, and farmers gathered in the city and helped to formed a vibrant settlement. Markets, ferry docks and fishery ports were established along the shoreline. Sailing of boats on Dianchi Lake and enjoying the landscape became a popular entertainment during the Tang and Song Dynasties. The relationship between the lake and the people was close. Many place names were associated with water or fishing. Place likes Dongjiawan Bay (Chinese: 董家湾), and Fishery Department Street (Chinese: 鱼课司街) are named with characters associated with water and fishery even though the water retreated far away from these location (Kunming Dianchi Management Bureau, 2015).

2.2 History of Water Management

The lake is not always pleasant and joyful. Due to the drainage basin's unique climate pattern during the wet season intense heavy rainfall causes frequent flooding in the city and has continuously changed the shoreline. At the beginning of the Yuan Dynasty (1271 CE - 1368 CE) the average water level was at 1,892 metres above sea level. As more and more people gathered in the city, Kunming kept expanding. The conflict between humans and nature became more and more intense. People claimed land from the retreating water and converted it into housing and farmland, while annual flooding kept destroying people's houses and livelihood. The governor Sayyid Ajjall Shams al-Din Omar al-Bukhari (1211 CE - 1279 CE) (Chinese: 赛典赤•瞻思丁), organized a series of investigations and hydraulic projects to manage the water issues in Kunming. By observation and study of the landscape of the drainage basin and the history of flooding, Sayyid Ajall figured out that the intense rainfall quickly

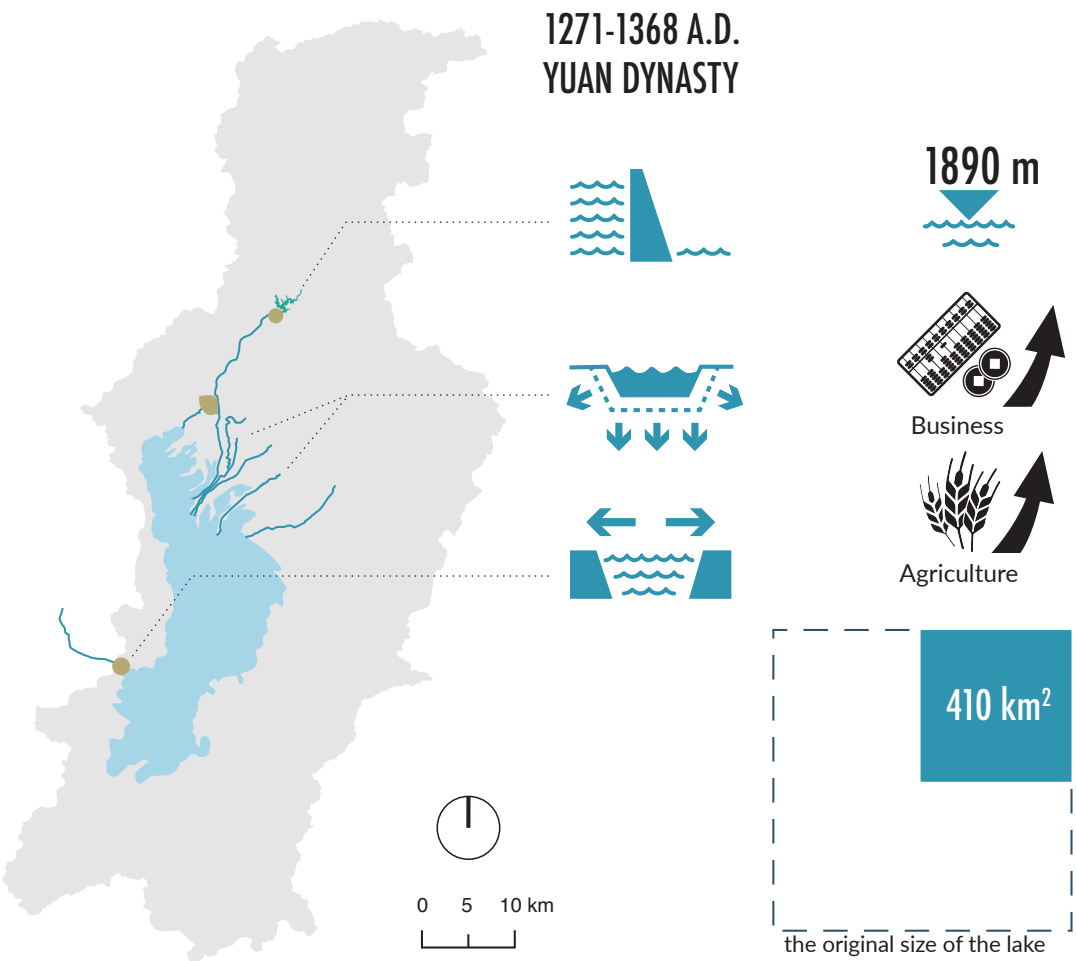


Figure 11. Dianchi Basin during Yuan Dynasty

raises the water level. Moreover, inefficient water courses and narrow water outlets caused the water to be held up within the basin. From 1274 – 1278, Sayyid Ajall organized manpower and other resources to widen and dredge six major rivers and streams to create a network of waterways through the city. He also expanded the water outlet at Haikou town for Dianchi Lake to let water drain faster. Last but not least Songhua dam was built in the upper reaches of the Panlong River (the major river in the drainage basin) to control the inflow and water supply for the city (Kunming Dianchi Management Bureau, 2015). As a result, the water management system created by Sayyid Ajall provided a stable water level in Dianchi Lake, and improved the irrigation system for the farmland. Since the completion of the hydraulic projects in 1278 CE, Kunming entered a long settled period of prosperity. Due to the water management system, the water level of Dianchi Lake dropped another two metres, and the surface area was reduced to 410 square kilometres. A large area of fertile land emerged from

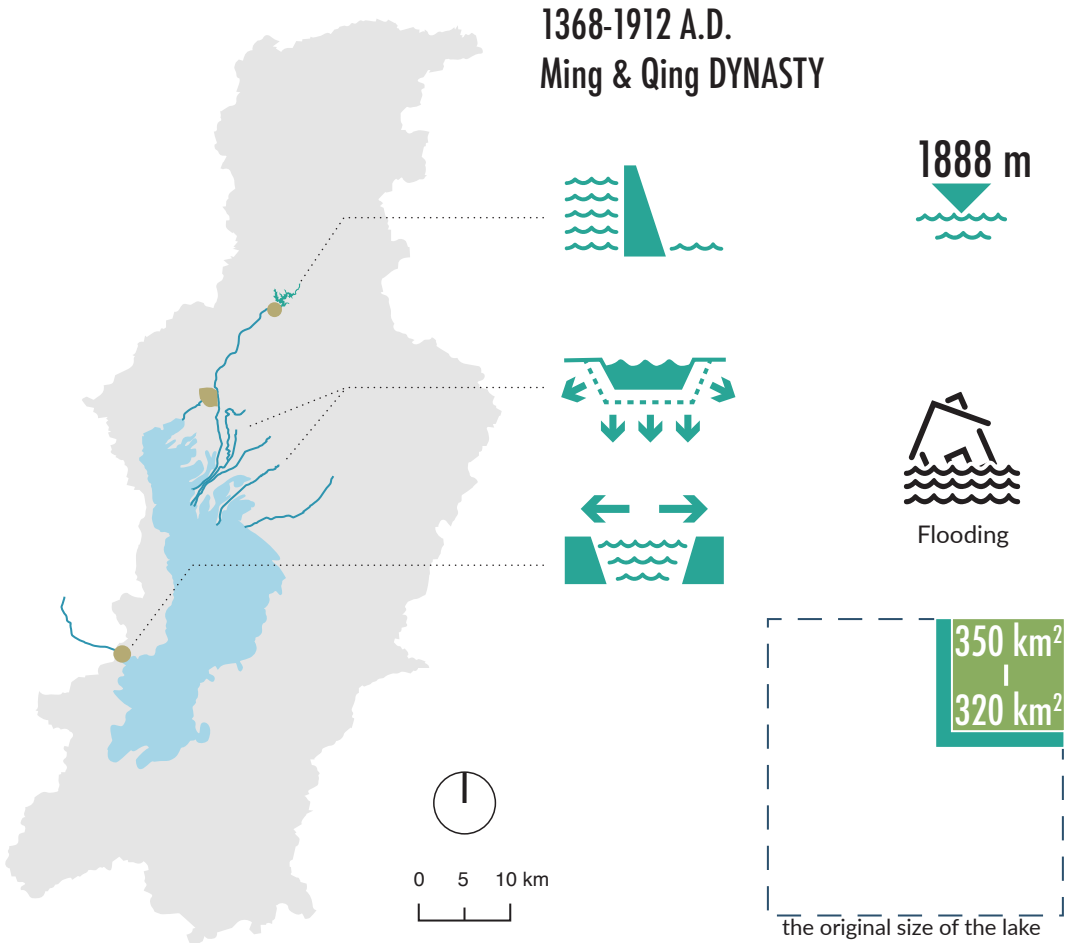


Figure 12. Dianchi Basin during Ming and Qing Dynasty

the retreating lake and agriculture was promoted to support the population growth and development of Kunming (Kunming Dianchi Management Bureau, 2015). Until the end of the Qing Dynasty (1912 CE) “dredging - expanding - draining” method was used to maintain the river system and the lake. Until the end of Yuan Dynasty (1368 CE), agriculture was thriving, and trading businesses boomed. Goods and merchants from the south reached Kunming through Dianchi Lake. On one hand, more and more land emerged from the lake and was available for development. On the other hand, the lake kept shrinking. Around 1501 CE the surface area of Dianchi Lake dropped to 350 square kilometres. By the eighteenth century the surface area had shrunk down to 320 square kilometres with a total volume of 1.6 billion cubic metres (Kunming Dianchi Management Bureau, 2015). The shrinkage of the lake did not stop the conflict between people and the water. During the Qing dynasty (1644 CE – 1912 CE), in less than three hundred years, there were over two dozen major flood events. Hundreds of houses were destroyed; thousands of acres of land were flooded and people had to use boats to move around for many days. (Yu, 1999)

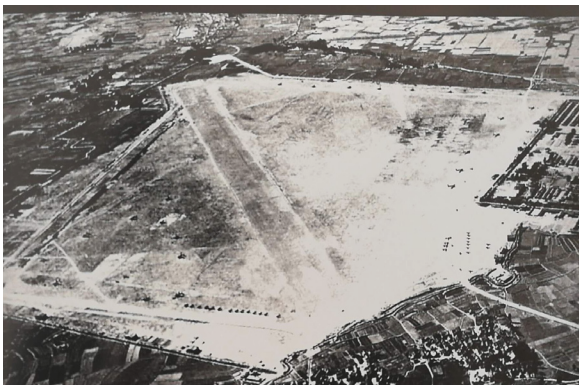


Figure 13. Wujiaba Airport during WWII

Figure 14. Map of Kunming during WWII

Figure 15. Village near the airport

2.3 Kunming in the Current Era

At the end of the Qing dynasty, the feudal system was crumbling. In 1911, the Xinhai Revolution overturned the last feudal dynasty in China, leading to an era of warlord politics. On one hand, the local political powers rose up and fought each other. On the other hand, in order to reinforce their influence and power, each faction started to develop their own region. In 1922, the governor of Yunnan Province, Jiyao Tang, established Yunnan Aviation School and built Wujianba airport in Kunming, the second airport in Chinese aviation history. In 1928, the local authority established a commercial flight path from Kunming to Hong Kong - the first commercial flight path in China. In 1935, another route from Kunming to Chongqing was created (China Yunnan TV, 2014). During World War II, Kunming became the most important location for transporting civilian and military supplies. The Burma Road was built during the Second Sino-Japanese War connecting Kunming in Yunnan and Lashio in Burma. The road was built to transport supplies to China. In 1941, the American Volunteer Group (AVG) of the Chinese Air Force was formed and arrived in Kunming. The AVG was assigned to protect the Burma Road and Kunming from Japanese attack and to transport supplies from Burma to China through Kunming. After the Burma Road was destroyed by Japan the Hump flight route, operated by AVG from British India to China, became

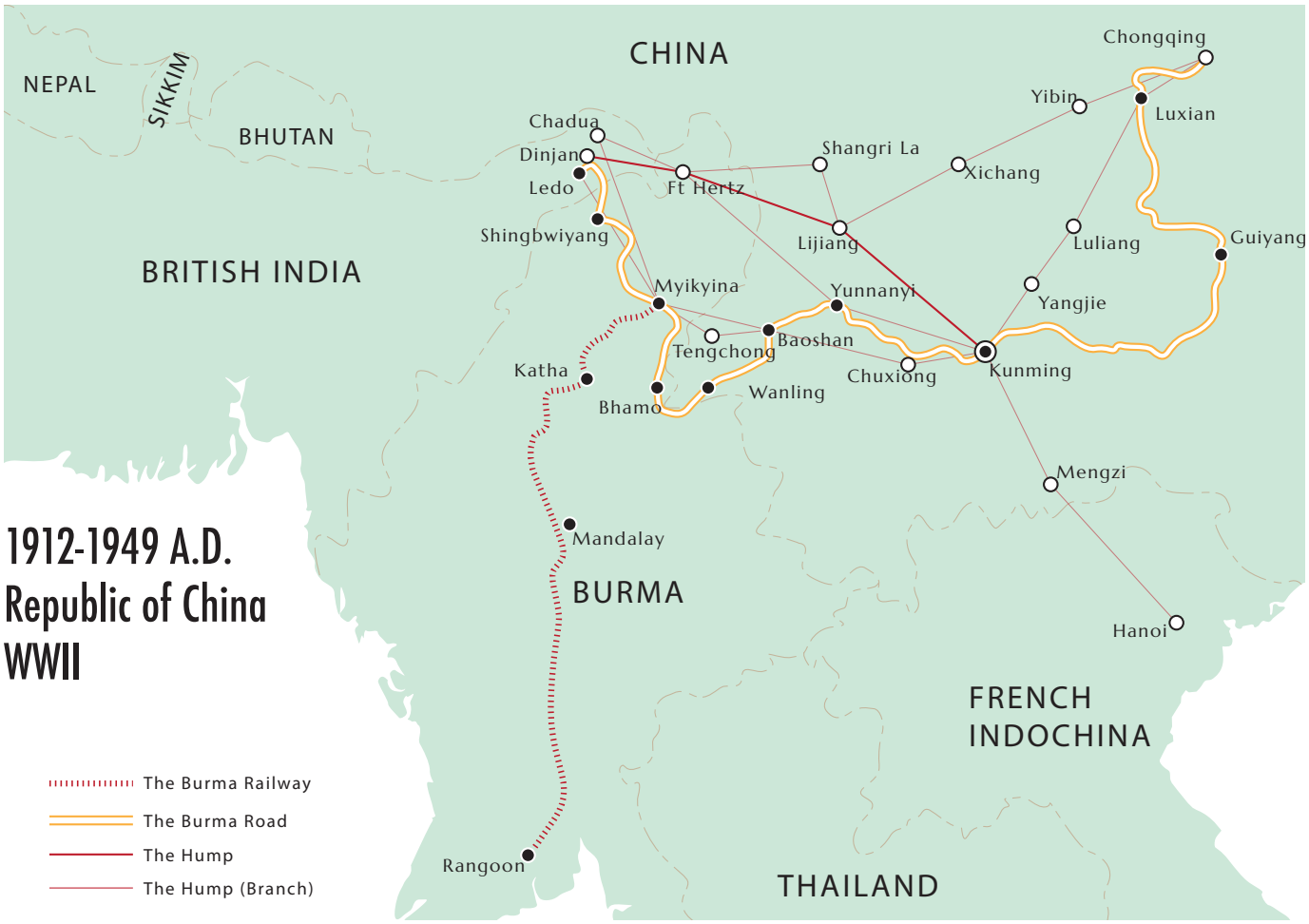
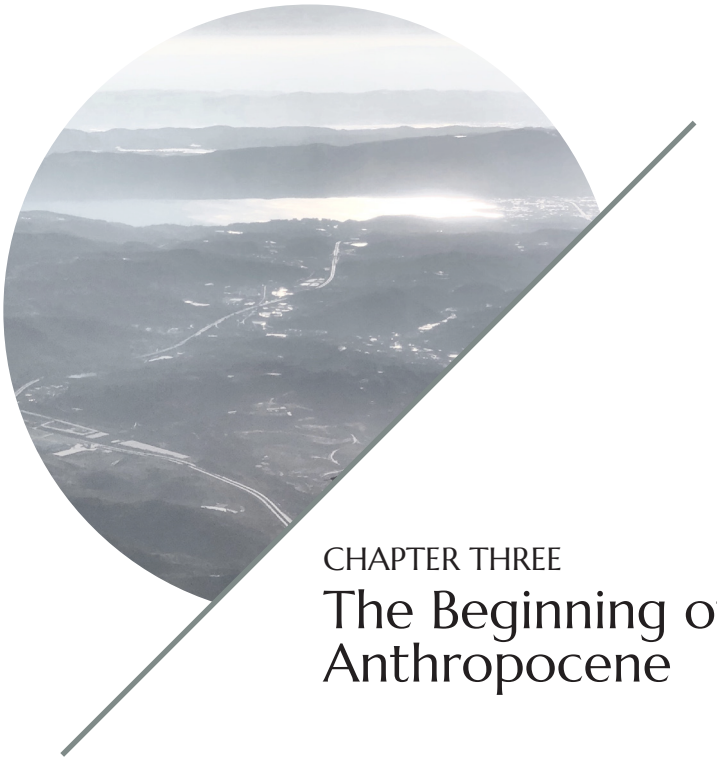


Figure 16. The Burma Road and The Hump flight route

the last route to transport supplies to China. And Kunming became the base and training ground for the AVG until 1942.

During the preserve of the AVG in Kunming, the citizens gave the name "Flying Tigers" to the U.S. air force to describe their bravery (China Yunnan TV, 2014). The establishment of an aviation school at the air field in Kunming, and the aid from the U.S. military during WWII led to the development of Kunming's aviation industry. It also influenced the economic development of Kunming.



CHAPTER THREE

The Beginning of Anthropocene

3.1 Rapid Development

Since the establishment of the People's Republic of China in 1949, especially after the China's economic reform in 1978, the economic model of China has changed from a centrally-planned economy to a market-based economy, which led to rapid economic and social development (Chow, 2004). During the past 40 years the market-based economy has stimulated tremendous urbanization across China. The general drivers of urbanization are the market-based economy, intra-country migration, increasing urban and rural income disparities, surplus agricultural laborers, and conversion of farmland to urban use (Vandamme, 2018). Kunming, as the capital city of Yunnan province, also benefited from this economic growth. In addition to the general drivers of urbanization in China, Kunming's urbanization process has been influenced by urbanization plans and socioeconomic forces, by topography and urban density (Vandamme, 2018). Taking GDP as the main indicator for Chinese economic growth, from the 1980s Kunming's GDP started to grow gradually, as did its population. After 1999, due to the successful hosting of the World Horticultural Exposition, and the new urban planning framework approved in 2003 by the central government, Kunming's economic and population growth were exceptional. By 2016, the GDP of Kunming within the Dianchi drainage basin had reached 60 billion US dollars (figure 17). And the population in the drainage basin had reached 3.5 million by 2008 (figure 18) (Pan, & Gao, 2010). With the growth of the economy and of the population, land use policies also changed rapidly. Many areas of farmland were rezoned for urban development to accommodate the rapid growth (figure 19). In addition, with the beneficial climate, diverse minority cultures, and convenient aviation and highway transportation, Kunming has become one of the most popular tourist destinations and commercial distribution hubs. But as a consequence the ecosystem of Dianchi Lake and the drainage basin has experienced severe deterioration.

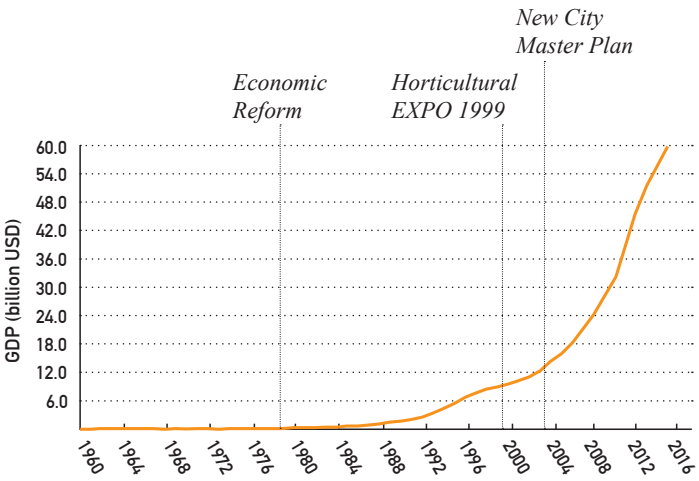


Figure 17. Dianchi Basin GDP growth from 1960-2016

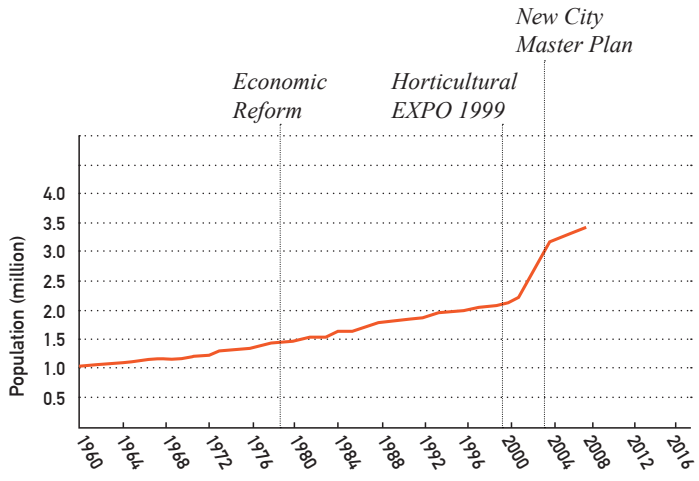


Figure 18. Dianchi Basin population growth from 1960-2008

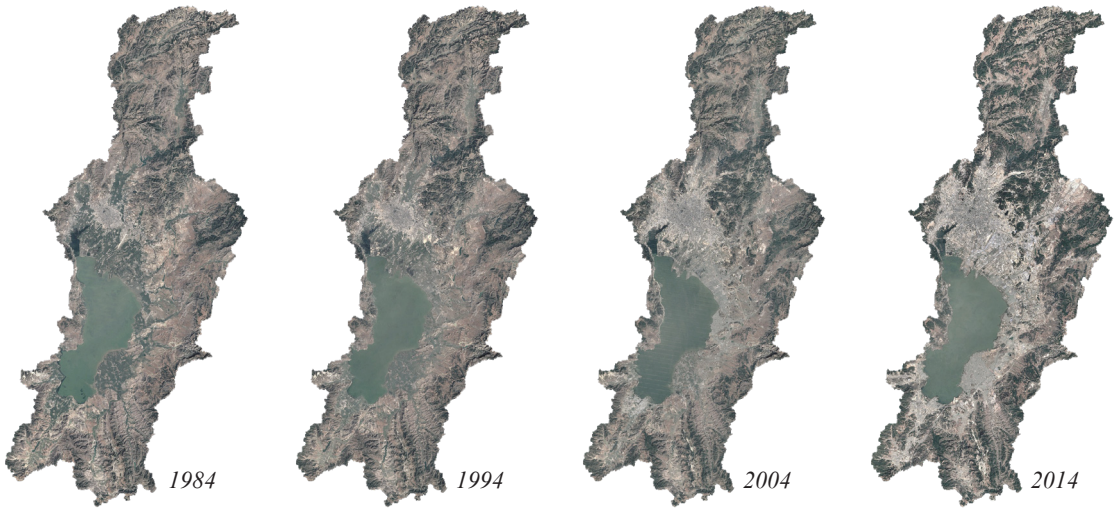


Figure 19. Dianchi Basin urban development 1984-2014

3.2 Reclamation of the Land from Lake and Deforestation

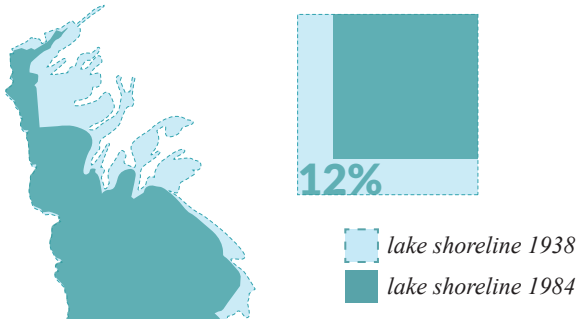


Figure 20. Dianchi shrinkage 1938-1984

Located at the northeast shore of Dianchi Lake, Kunming is surrounded by mountains. As the city expands the demand for land for agriculture and for urban development has increased. In order to obtain more land for Kunming's development, forests at the foot of the mountains have been cut down. Unregulated felling of trees has caused the forest coverage in Kunming to drop from 50% in the 1950s to 15% currently (Kunming Dianchi Management Bureau, 2015). The loss of forest has increased soil erosion during the rainy season. Each year about 400,000 tons of soil is washed into the lake, and the total amount of soil deposit in Dianchi Lake is around 561 million cubic meters (Kunming Dianchi Management Bureau, 2015). Soil erosion is not the only factor causing the volume of water in the lake to decrease. Reclamation of land from the lake has also accelerated its shrinkage. In order to obtain more land the local government had constantly appealed to people to fill the lake for decades. From 1938 to 1957 the surface area of the lake reduced by 15.5 square kilometres. Moreover, from 1957 to 1978, another 23.3 square kilometres of lake surface was removed by filling (Kunming Dianchi Management Bureau, 2015). And shrinkage of the water body has reduced Dianchi Lake's influence on the local climate.

Figure 21. Dianchi Lake land reclamation movement

3.3 Deterioration in Water Quality and Degeneration of the Lake Ecosystem

Following the economic reforms in 1978 the water quality of Dianchi Lake has deteriorated. In China, according to the national water quality standards GB3838-2002 and CJ 3020-93, based on the usage type of water, the water quality has been categorized into six classes. Class I water has the highest quality and can be drunk after simple treatment such as filtration and sanitation. The water source of Class I belongs to natural reserve areas. Class II water is suitable for centralized water supply with treatment such as, flocculation, sedimentation, filtration, and sanitation before drinking. The water source of Class II water is protected as rare and precious aquatic biological habitat, including fish and shrimp spawning grounds. The water rated as Class III is mainly suitable for centralized water supply. The water source for Class III water is protected as the area for aquatic animal wintering and migration grounds. It is suitable for fisheries and for swimming. Class IV water is mainly suitable for common industrial water use and leisure water use that contacts the human body only indirectly. Class V means water only suitable for agricultural, irrigation, and common landscape use. Any water marked as Class -V (worse than Class V) can not be used for any pupose (Department of Pollution Control, 1993). In the 1960s the water quality of Dianchi Lake was at Class II. During the 1970s the water quality dropped to Class III. During the 1980s the water quality in Caohai became Class V,

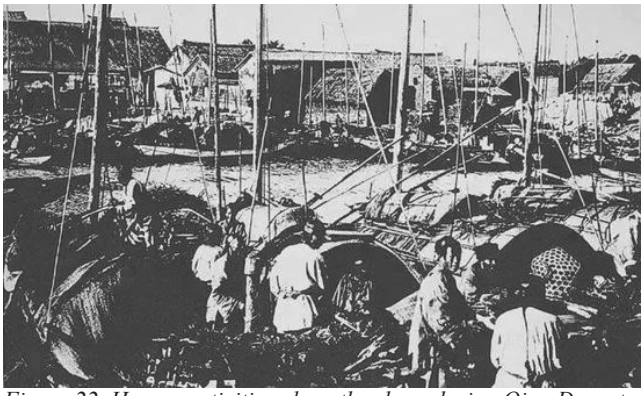


Figure 22. Human activities alone the shore during Qing Dynasty

Figure 23. Human activities alone the shore during 1970s

Figure 24. Houses long the shore of Dianchi Lake.

Figure 25. Water pollution along the canal

and Class IV in the Waihai area. After 1990, Caohai's water quality reached Class -V, and Waihai area water quality dropped to class V (Kunming Dianchi Management Bureau, 2015). Dianchi Lake is heavily eutrophicated and has become one of the most polluted lakes in China.

Not only has the water quality plunged over the past 30 years, so has the lake ecosystem. According to Jun Zhang (2015), during the 1950s the lake bottom was full of aquatic plants. There were about 44 types of aquatic plant species, and over 90% of the lake bed was covered by aquatic plants. For example, *Ottelia acuminata*, locally know as sea cabbage flower (Chinese: 海菜花), was one of the major aquatic plants growing in the lake. The plant grows in shallow water and has an edible long petiole, and showy three-petaled white flowers. Local people use sea cabbage flower as one of their food sources. Before the 1960s the Caohai area was full of sea cabbage flower. During the flowering season countless small white flowers could be seen floating on the water, and people used to call Caohai "flower lake". By the 1970s only 20% of the lake bottom was covered by aquatic plants, and the sea cabbage flower became very rare in Dianchi Lake. During the 1980s there were only 29 aquatic plant species left in the lake. Now, as a result of water eutrophication, the sea cabbage flower is extinct in the lake (Kunming Dianchi Management Bureau, 2015). It has been replaced by *Eichhornia crassipes*, locally know as water calabash (Chinese: 水葫芦),

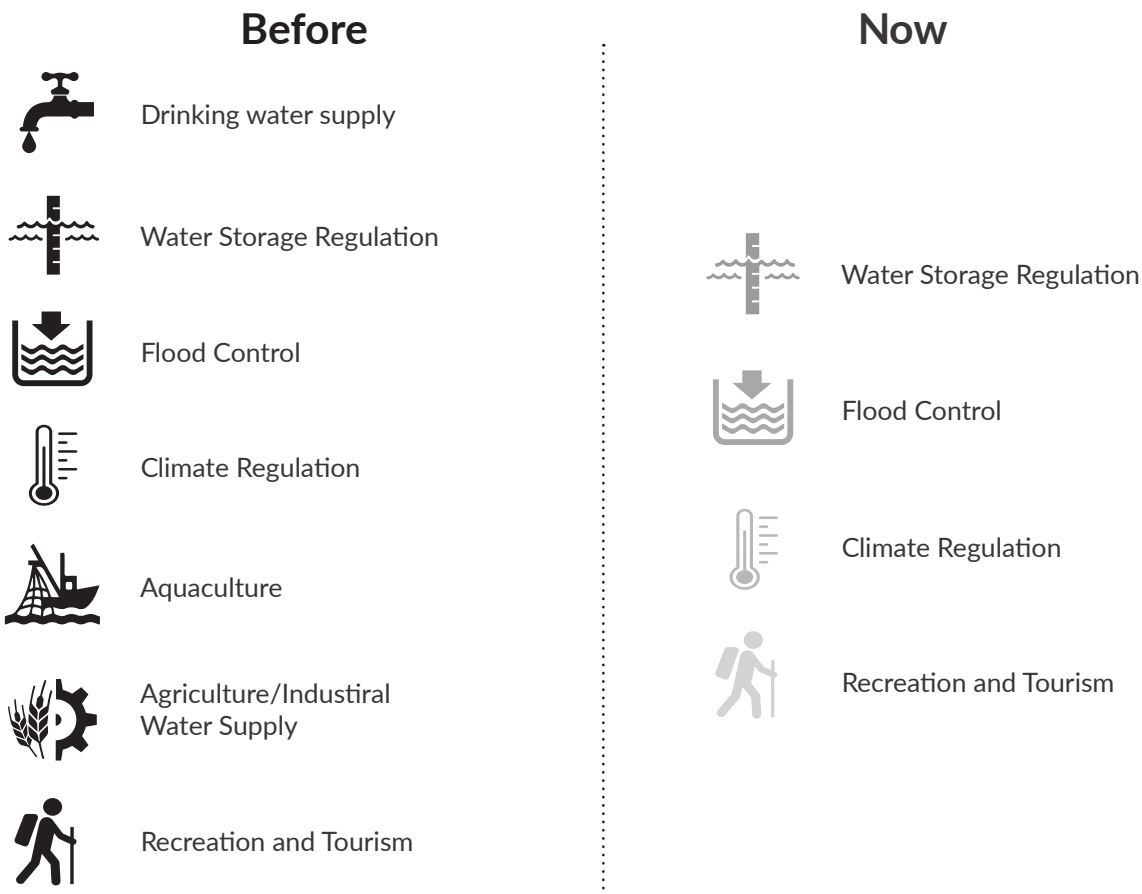


Figure 26. Ecological services of Dianchi Lake

an invasive species which was introduced to treat the water. However, the water calabash is growing too fast in the heavily nutrient-rich water and consumes all the oxygen in the water killing the other aquatic species, and creating secondary pollution. In addition, the range of fish species has also reduced. Dianchi Lake used to have a rich variety of fish species - over 23 species during the 1950s, including 15 native fish species. Carp was the most productive fish and was used as one of the major food sources by local people. Currently only four native species of fish remain in the lake.

In short, through the last four decades, the ecosystem of Dianchi Lake and its drainage basin has degenerated rapidly. During the 60s the lake served as a drinking water source, in water storage regulation, in flood control, in climate regulation, in aquaculture agriculture and in industrial water supply, and in recreational use. Now, its ecological services are reduced to only water storage regulation, flood control, climate regulation, and recreational use. Moreover, the aquatic ecosystem also deteriorated significantly. Over 46.3% of native fish species and over 84% of aquatic plant species have became extinct in the last 40 years.

3.4 Water Crises in Kunming

3.4.1 Water Pollution.

Dianchi Lake is the lowest point in the drainage basin. As a consequence, water draining into it collects all the nutrients and deposits them in the lake. After more than 20 years of uncontrolled water pollution Dianchi Lake became offensively excessed to as the “sewage tank” of the basin. It is now one of the most polluted lakes in China, receiving domestic sewage, agriculture runoff, and industrial wastewater as the three major factors that create the pollution (Kunming Dianchi Management Bureau, 2015). As the population and urban expansion increase dramatically in the drainage basin, nutrients such as nitrogen and phosphorus carried from agricultural runoff and domestic sewage are drained into the lake. In addition, industrial growth since 1987 has generated an enormous amount of industrial wastewater discharge into the lake without proper treatment (Huang, 2014). The awareness of water pollution was very late. In 1988, a large scale blue-green algal bloom occurred by water eutrophication in Dianchi Lake (Huang, 2014). The government finally realized how bad the situation was, and started to restore the lake. After 1988, Dianchi Integral Management Office, the former Kunming Dianchi Management Bureau, was established to commit to pollution control of Dianchi Lake (Kunming Dianchi Management Bureau, 2015). By the end of 1990 the first wastewater treatment plan was built and Kunming finally started to process the wastewater before discharging it into the

lake (Huang, 2014). According to Kunming Dianchi Management Bureau, by 2016 there were 21 wastewater treatment plants operating around Dianchi Lake with the total wastewater treatment capacity of 1.97 million cubic metres per day. Nevertheless, there are still about 200 million cubic metres of polluted water being drained into Dianchi Lake every year (2015). Combined with the shrinkage of the size of the lake, erosion, and decrease in aquatic species, the lake has limited ability to restore the water quality by itself.

3.4.2 Water Scarcity

More ironically, in addition to water pollution Kunming is also suffering from water shortages and from urban flooding. Despite having the sixth largest fresh water lake located downstream and 874 millimetres of precipitation annually Kunming is one of the most water insecure cities in the country. According to the article, *An Analysis on the Spatio-temporal Variability of Precipitation in Dianchi Basin*, the average freshwater resources per capita in China is about 2100 cubic metres per year. In Dianchi basin the freshwater resources per capita is less than 300 cubic metres per year (Liu, Li, Li, & Wang, 2015). And, according to the World Bank, the world average freshwater resource per capita is about 5,920 cubic metres a year (2014).

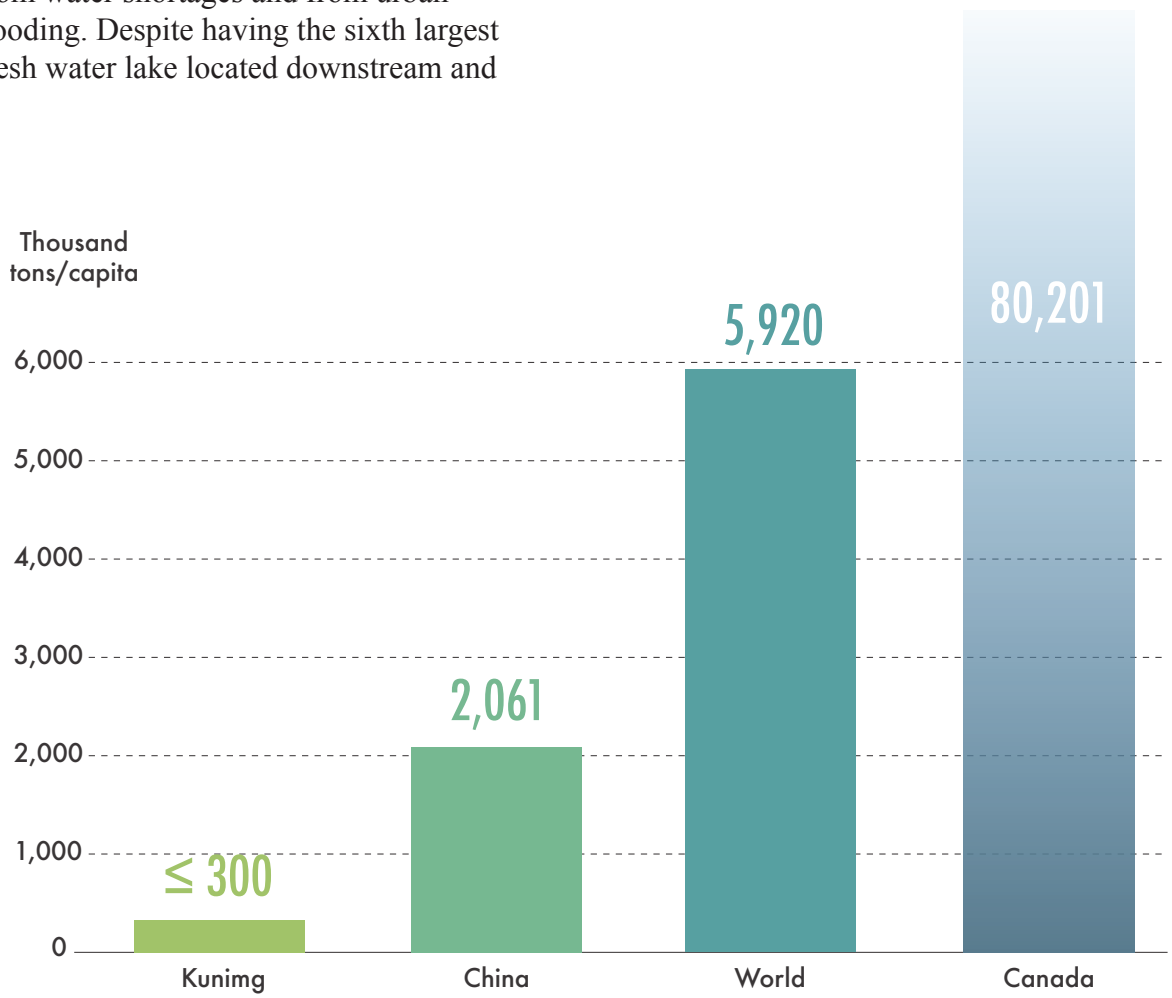


Figure 27. Renewable fresh water resource per capital 2014

3.4.3 Urban Flooding

Furthermore, rapid urban expansion and an impaired municipal storm water drainage network cause waterlogging during the rainy season. In recent years, torrential rainfall during the rainy season has had a negative impact on people's livelihood in Kunming. Incidents of rain water and sewage back-up, road closures, traffic paralysis, power blackouts, property damage, and even threats to life have occurred. For example, on July 19, 2017 heavy rainfall caused flooding in dozens of areas. Over 250 people were stranded, and 680 people were evacuated. Traffic was paralyzed for over 6 hours. Over 900 law enforcement officers were sent out for rescue and disaster management (Wang, 2017). With deterioration of Dianchi Lake's ecological functions and Kunming's rapid urbanization the city has fallen into a dilemma, too much water in the rainy season, and during the dry season not enough water for daily use.

Figure 28. Urban flood 2013

Figure 29. Urban flood 2015

Figure 30. Urban flood 2017

Figure 31. Urban flood 2018

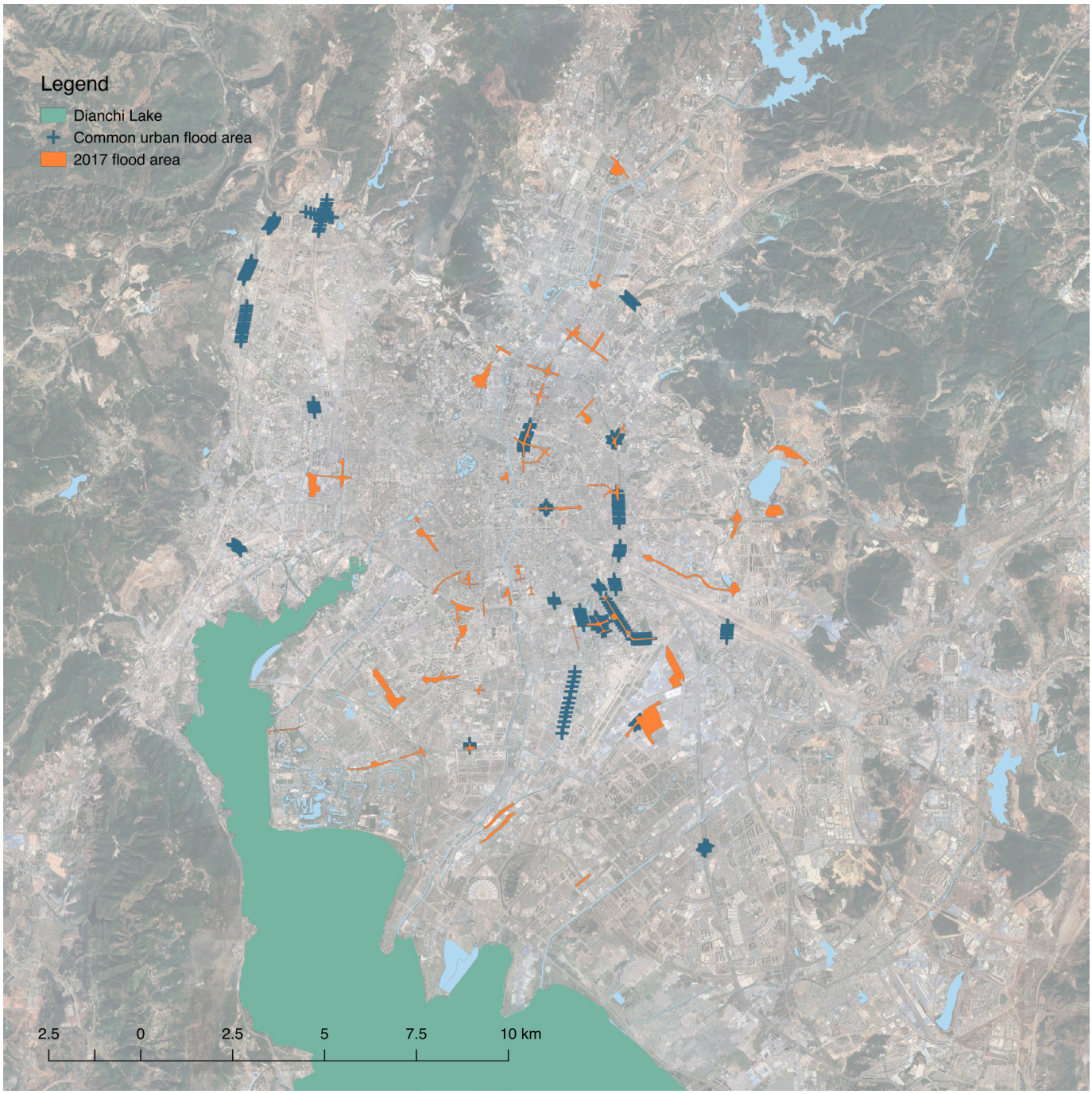


Figure 32. Urban flood map 2013-2017

3.5 The Effects of the Water Crises

After four decades of rapid development Kunming has become one of the largest cities in southeast China but at great cost to the environment. This non-sustainable pattern of development has backfired on Kunming's economy. According to Huang's article *The Dilemma of Dianchi Pollution Management*, since 1993 the central and municipal government has invested a total of over US $10 billion to try to restore the water quality of Dianchi Lake (2014). However, the efforts seem like trying to extinguish a cartload of burning firewood with one cup of water. The water quality is still oscillating between Class V and Class IV. In 2011, the municipal general budget revenue was US $4.73 billion (31.79 billion RMB); and the expenditure on Dianchi Lake restoration was about 2.19 billion USD (14.71 billion RMB) (Huang 2014). Moreover, in order to address water scarcity, the government implemented three major water diversion projects to bring water into the Dianchi drainage basin. From 1999 to 2007 the government invested US $596 million (4 billion RMB) into the Zhangjiuhe Water Diversion project, bringing in 250 million cubic metres of fresh water every year. Immediately after that, from 2007 to 2013, the government spent another US $605 million (4.06 billion RMB) on the Qinshuihai Water diversion project. This project provides another 274 million cubic metres of water every year (Kang & Zhou, 2013). Furthermore, from 2008 to 2013, another US $1.26 billion (84.26 billion RMB) was invested the Niulangjiang-Dianchi Water Diversion project, to pump 566 million cubic metres of water into the Dianchi drainage basin every year (Wang, 2016). In addition, pollution and water shortage, urban flooding are another factors which have affected Kunming's development. In 2013, during one four-day torrential storm, urban flooding had submerged almost 80 square kilometres in downtown Kunming. Over 40,000 people were affected; traffic was paralyzed for 49 hours; power supply shut down for 8 hours; 6,696 residential units were flooded; and over 38,000 square metres of underground facilities were damaged. The direct economic loss was over US $15.3 million (102.8 million RMB) (Zhang & Zhou, 2013).

Summary

The relationship between humans and water in the Dianchi drainage basin has evolved for over two thousand years. Tension has arisen as human activities have become more and more intensive. People reclaiming land from the lake for urban expansion, creating pollution from economic growth, and causing water shortages as the population was boomed. The relationship between people and the lake has become more and more complicated and intense. This practicum is trying to explore current water management strategies in the context of Kunming's urban development and to propose an integral water management policy through a landscape architecture approach that seeks to improve the relation between human and the lake.

CHAPTER FOUR

Methodology

To find an alternative solution to alleviate the tension between the city and the lake, this practicum developed a framework research method to identify the process, research for precedents, and forming and programming strategies.

4.1 Identify the Existing Water Management Strategy

Dianchi Lake receives all the surface water in a watershed, and it is affected by numerous types of natural process and human activity. In this highly urbanized lake watersheds, water quality is particularly affected by pollution discharged as a result of economic production and social activities. Before the 1990s, human activities drew freshwater from rivers, lakes, and reservoirs then discharged wastewater back downstream. Urban domestic sewage, industrial wastewater, and agricultural runoff were discharged into the water bodies without proper treatment. After the

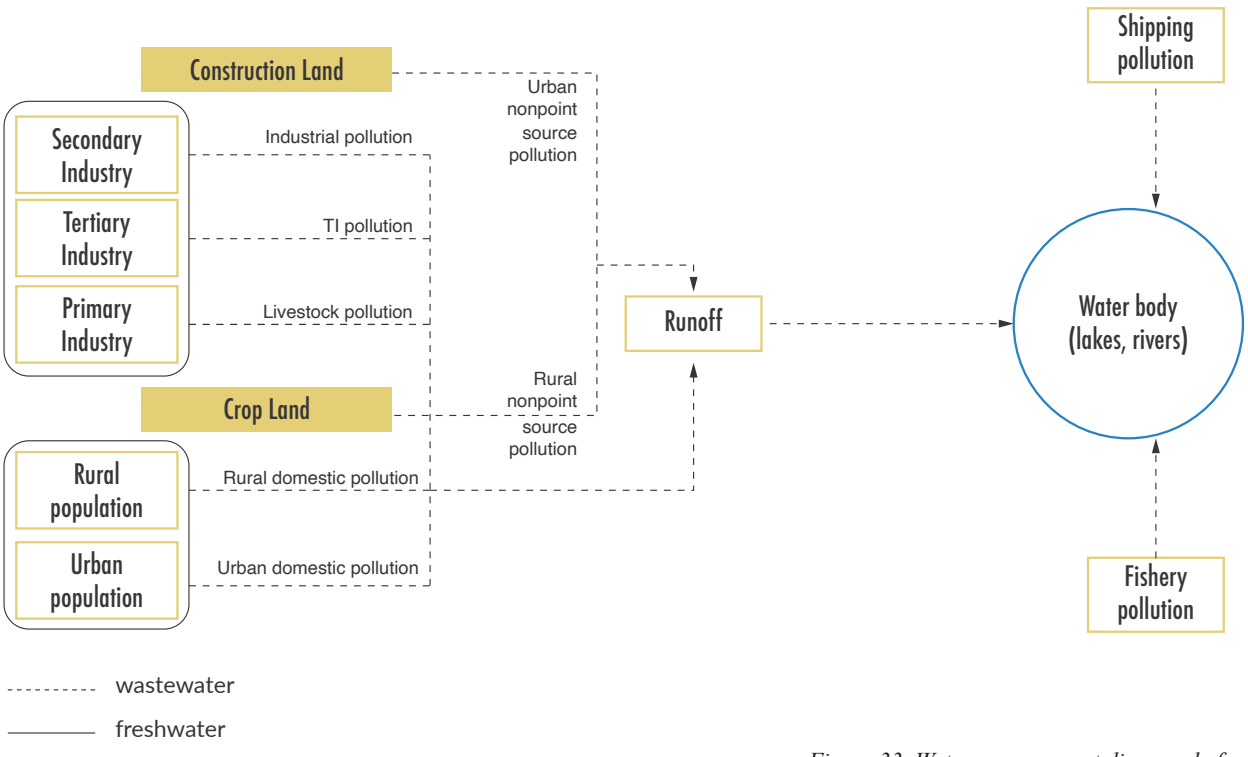


Figure 33. Water management diagram before 1990

1990s, the government implemented a more regulated wastewater management approach. Point source pollutants such as urban domestic sewage, industrial wastewater, and large-scale livestock farm wastewater, are collected through wastewater collection systems, and then treated by the wastewater treatment plants. Non-point source pollutions such as run-off from the built-up areas and cropland are partially collected by the pipe systems and treated by wastewater treatment plants. The majority of the runoff flows into water bodies directly. Later on, the wetland was reintroduced around the lake shoreline to process the runoffs (Liu, Benoit, Liu, Liu, & Guo, 2014). However, the water treatment system was always unmatched with the rapid urbanization process. As the city keeps expanding the water crisis in Kunming becomes more and more complicated.

In short, the traditional way of water management which captures water, conveys and uses it, and then drains to the lake is no longer meets the growth of the city of Kunming. An alternative model of water management should be developed to accommodate the urbanization process. A series of case studies is conducted through this practicum to explore a new approach to the water management strategy.

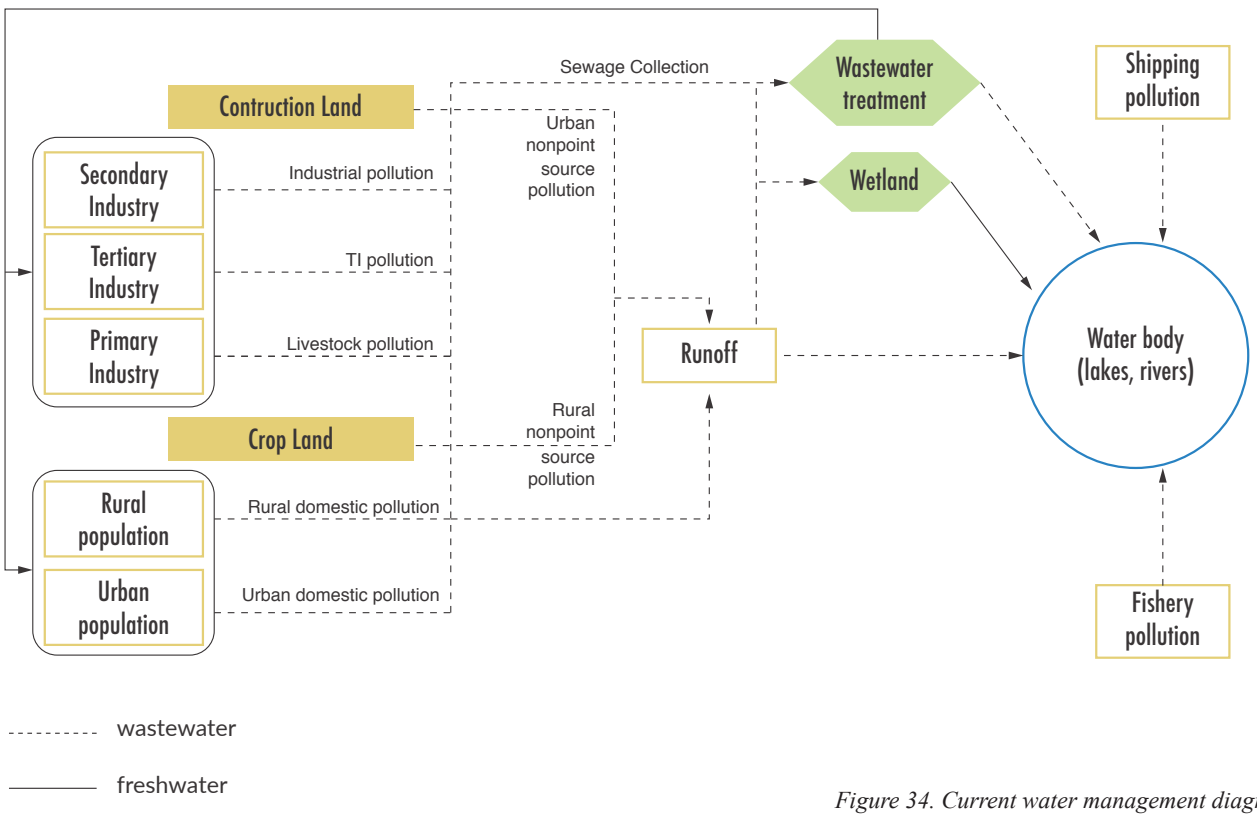


Figure 34. Current water management diagram

4.2 Water Management Case Studies

This practicum selects four water management-oriented landscape architecture projects to explore alternative solutions to alleviate the tension between water and city. The case studies starts with understanding the background and context of the projects and then focus on the genesis and progress of the project. Lastly, the studies summarize the social, ecological, and economic impacts that these projects create.

4.2.1 Toronto Ravine Strategy

Type of project: Landscape Management
Location: Toronto, Ontario, Canada
Project Size: the ravine network covers 300 km and over 11,000 hectares

Context: The Toronto ravine system is one of the most distinctive geographic features of Toronto. It is a network of river valleys and streams that form a series of riparian zones and urban forests that meander throughout the city. Through years of rapid urbanization, Toronto has put the ravine system under great pressure from population growth and the increased use of this resource for recreational purposes. The impact of climate change includes an increase in flooding and, loss of wildlife habitat in this particular area. The Toronto and Region Conservation Authority, the key stakeholders, along with the City of Toronto Parks, Forestry and Recreation Division has created a master plan for ensuring the well-being of this important environmental resource while at the same time creating connection between nature, culture and social welfare. The Toronto ravine strategy is centered on five principles: protect, invest, connect, partner, and celebrate. The strategy protects the entirety of the ravine system from the pressures of urban development; invests resources into the management of the ravine system; connects people with nature and the city's history in a safe and sustainable manner to grow common appreciation and understanding of the ravine system; works together with different sectors to protect and enhance the ravine system; and last but not least, celebrates the unique landscape feature as part of Toronto's cultural identity.

Funding: The need to create a program for the maintenance and upkeep of the Toronto ravine system is dependent on a variety of factors. Coordination and consultation among the various stakeholders, ranging from city officials to businesses and local communities is integral to the smooth running of the project but most importantly, the need to ensure that adequate funds are made available is significant. The funds required for the well-being of the ravine system include financial support needed for creating and implementing "management plans for Environmentally Significant Areas, development and implementation of best practices, expansion of partnerships, and monitoring and reporting on ecological health" (EX27.8 2017, p.5). The chief funding for the project will be made available through the various stakeholders, but in the earliest phases, the city has decided to first clear the existing capital backlog. Apart from this, the funding for the project will be dependent on the Toronto Water, Parks Forestry and Recreation (PFR), Transportation Services, City Planning and the Toronto and Region Conservation Authority (TRCA), all of whom invest in the ravine system through both capital and

operating budgets. (EX27.8 2017, p.7).

Site Analysis: The Toronto Ravine System covers almost 17% of the area of the city of Toronto and is made up of a variety of land and water bodies. The main components of the ravine system are "forests, rivers, creeks, streams, beaches, and parkland. It stretches through several residential neighborhoods." Further it also "supports a variety of wildlife from herons, deer, butterflies, mallards, and coyote as well as trout, tadpoles, and salmon in the wetlands" (The Unique Ravine System Of Toronto). The ravine system can be divided into four major groups made up of the three Rivers, the Don, the Rouge and the Humber. It also consists of the Highland Creek, apart from two smaller ravines called the Mimico and Etobicoke Creeks (Toronto Ravine Strategy p.7).

Project Background and History: The inception of this particular project can be traced to the realization that the Toronto Ravine system was not only a unique geographical feature but also one which needed rehabilitation and revitalization due to years of exploitation, for transportation, development, recreational and business opportunities. The creation of the project is an indication of the willingness of the City officials, local communities and various stakeholders to preserve this iconic geographical formation and to ensure that the development, social, recreational and environmental needs of the area and its people are sustained for future generations.

Genesis of Project: the idea of the project was mooted in May 2015 when city authorities initiated a workshop with 117 stakeholders titled the Ravine Strategy Workshop. This was followed by a public open house in June 2015 with 47 attendees where background information and discussion about the challenges and opportunities related to the

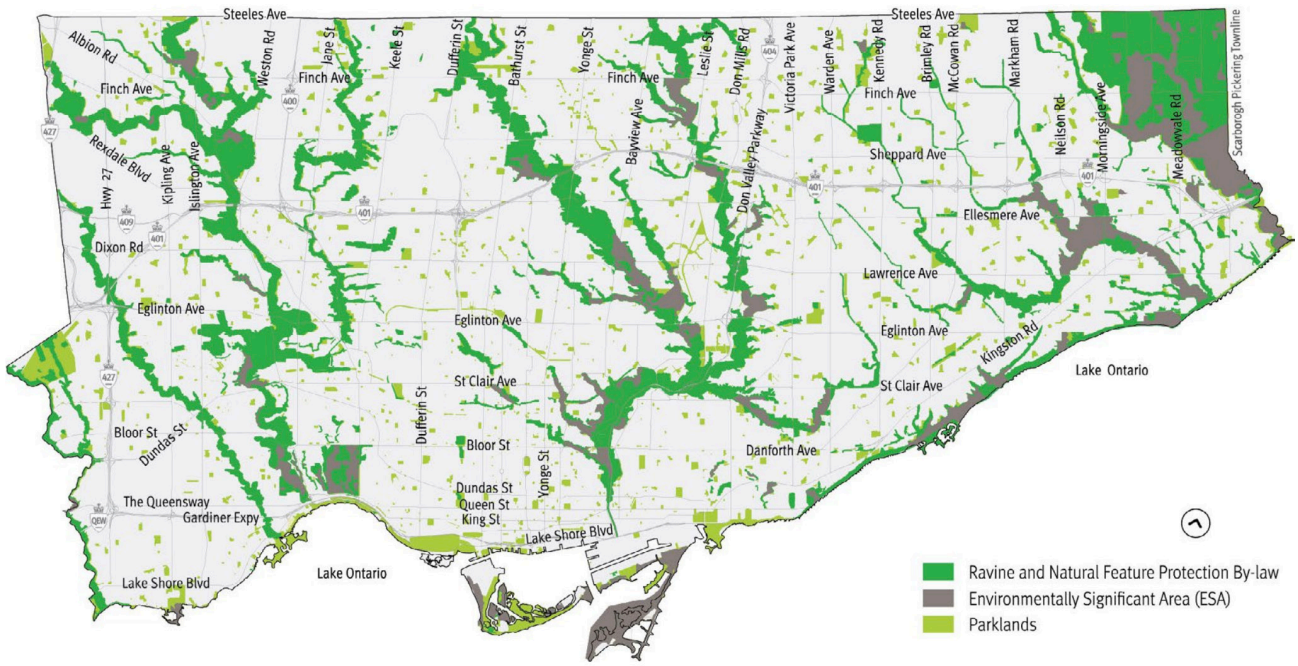


Figure 35. Toronto Ravine System

project were discussed in depth. This was supplemented with an Online Ravine Strategy Survey with 2702 responses (Toronto Ravine Strategy p.14).

Design, Development, and Decision Making Process: Design of the Toronto Ravine Strategy is based upon the principle of protection and sustainable use of this unique geographical feature. In order to ensure this, the development agenda looks at clear demarcation of Environmentally Significant Areas or ECAs so as to ensure that planning along with stakeholder engagement is carried out in a way such that it addresses the needs of the various communities, both the population as well as the natural environment, made up of a variety of flora and fauna. This will be done through the Capital and Planning Coordination Working Group for the Interdivisional Steering Committee which will be charged with ensuring that high quality planning, design construction and maintenance is implemented. It also seeks to integrate best practices for capital projects and ongoing maintenance of infrastructure and natural ecosystems, including trail accessibility, dumping and, later, an invasive species management (Toronto Ravine Strategy p.19). Between July and October 2015 an elaborate process of ongoing consultation was carried out with the City of Toronto staff and stakeholder groups which led to the first Ravine Strategy Advisory Group meeting in September 2015. After an update to the Parks and Environment Committee on Ravine Strategy in November 2015, and the Chief Planner's Roundtable in 2015, the project was presented to the Planning and Growth Management Committee in January 2016 and a Report to the Parks and Environment Committee in June 2016. This was followed by a period of Ravine Strategy Pop-up consultations and the whole strategy process was completed in September 2017.

Project Impact:
Environmental Impact: the ravine strategy seeks to maintain and improve the ecological health of the extensive network of blue and green infrastructure while providing ecological services to the city. The strategy will rehabilitate biodiversity through the network as well as providing water management capability to mitigate the water crisis throughout the city.
Social Impact: the strategy highlights the social function through creating connection, partnership, and celebration. It seeks to connect various parts of the ravine system with the public through pilot projects, by sharing stories about the development opportunities and historic site, and bringing indigenous communities along with present population.
Economic Impact: The strategy seeks to minimize the negative impact of the revitalization program on the environment and at the same time, through the creation of public private partnerships and the access to funds from the City, the strategy could leverage private investment and philanthropic support with proper government policy to ensure long-term benefit (Toronto Ravine Strategy p. 5).

Reflection: It is remarkable that as one of the most advanced metropolitan areas in North America, Toronto, has such a massive scale of green and blue network to provide ecological services to the city. The ravine strategy could enhance its capability to provide ecological benefit while at the same time create bonding with the public. From this case study it seems important to preserve and rehabilitate city-wide green

and blue infrastructure to provide ecological services, and at the same time, to create guidelines to ensure its extensive influence on environmental, economic and social issues.

4.2.2 Niulanjiang – Dianchi Diversion Project & Kunming Waterfall Park

Type of project: Water diversion, water supply, water quality improvement, flood control, landscape improvement, urban park
Location: Kunming, Yunnan, China
Project Size: Park size: 1.94 km² Water diversion length: 115.85 km

Context: Niulanjiang – Dianchi Diversion project is a cross-basin water diversion project which redirects the water from the Niulanjiang River into the Dianchi drainage basin. The Niulanjiang River is located at the northeast side of Yunnan province with flow the northeast. The water source control facility is located 173 kilometers northeast of Kunming. It dams up the river and holds 448 million cubic metres of water. The pumping station, and aqueduct system redirect the water to flow southwest into the Dianchi drainage basin. The total water transmission distance is 115.6 kilometres. As one of the Dianchi drainage basin water management strategies, every year the project transfers 566 million cubic metres of fresh water into the basin. The Kunming Waterfall Park is the outlet of the water diversion project which connects to the river system and water supply system in the Dianchi drainage basin. The Park combines the aspects of landscape architecture and civil engineering, and performs as the milestone and show case of the diversion project (Wang, 2016).

The Kunming Waterfall Park is located at the north side of Kunming. The Park water connects the Panlongjiang River and Jinzhihe River. The park is designed as a public park to show case the Niulanjiang – Dianchi Water Diversion project. As the outlet of the water diversion project the park formed with a 400-metres-wide artificial waterfall, with 12.5 metre of drop in elevation as the central landscape feature. The upper stream of the waterfall is an artificial lake and underground water storage facility. The water from the water diversion project is partially stored in the park and distributed through the water supply

Figure 36. Kunming Waterfall Park

network to the city. The majority of water will go through the waterfall to increase the oxygen level. It then washes down through the Panlongjiang River and drains into the Dianchi Lake to dilute the pollution. The park also serves as a regional park surrounded by a newly developed residential area (He, Liu, & Tang, 2016).

Funding: In May 2009, the Ministry of Water Resources of the People's Republic of China approved the Niulanjiang – Dianchi Water Diversion project as part of the 2006-2010 Dianchi Drainage Basin Water Pollution Management Plan Amendment Report (Chinese: 滇池流域水污染防治规划补充报告). In January 2012, the National Development and Reform Commission approved the preliminary design estimate. In February, the Ministry of Water Resource approved the preliminary design report with a total investment of US $1.26 billion (84.26 billion RMB) (Wang, 2016).

Project Background and History: Dianchi Lake is the sixth largest freshwater lake in China. The lake with its drainage basin is located at the center of Yunnan province. Kunming is the capital city of Yunnan province located on the northeast side of Dianchi Lake. Through the last 40 years the Dianchi drainage basin has experienced rapid economic growth and booming population. At the same time, Kunming and the drainage basin are suffering from severe water pollution, and extreme water scarcity. Since the ninth Five-Year Plan (1996-2000) the central and local governments have invested tremendous resources to restore water quality, and to solve the water scarcity problem. However, the results are very limited. From 2003, Yunnan province has report water scarcity issues in the Dianchi drainage basin to the central government, and decided to seek new water resources to solve these problems. A series of explorations and land surveys had been organized by the Ministry of Water Resources to search for new water sources outside the drainage basin. In 2007, the province proposed 14 water supply plans, and the Niulanjiang – Dianchi Water Diversion project was chosen. The construction of the project started at the end of 2008 (Wang, 2016).

In 2011, the outlet location of Niulanjiang – Dianchi Water Diversion project was considered as part of the north town development master plan. At the beginning of 2012 the proposal to construct the outlet facility as a showcase public park for the north town development was accepted by the local government. At the end of 2012 the proposal by Kunming Engineering Corporation was chosen as the final design. The construction of the project started immediately. The project was completed at the end of 2015, and the park is open to public since January 1st 2016 (He, Liu, & Tang, 2016).

Challenge: During construction of the Niulanjiang – Dianchi Water Diversion project the water level of the source was at 1790 metres above sea level. However, Dianchi Lake is at 1887.5 metres above sea level. In order to overcome the height differences a pumping station with four 2250 kw water pumps were installed to elevate the water 233 metres to the desired height. The aqueduct system has a total distance of 115.85 km and 90% is in tunnels. Many of the tunnels go through karst landform, which is permeable and soft. The construction of the tunnel implemented site-specific engineering solution to overcome the issue (Wang, 2016).

The Kunming Waterfall Park was originally planned on land with dramatic topographic change; and the site was only 66.4 hectares. The design team combined planning, landscape architecture, civil, hydraulic, and structural engineering to prepare the site design. In order to design the park as a regional public space for the north town area, and provoke greater social and economic benefit for this area, the design team also worked with local authorities to convince them to expand the site to 194.3 hectares (He, Liu, & Tang, 2016).

Goal of the Project: To reduce long term water pollution and ecosystem degeneration of Dianchi Lake. The water security within Dianchi drainage basin has been threatened. Since the ninth Five-Year Plan (1996-2000) the provincial government has dedicated tremendous resources to manage the water pollution. The provincial government believes, in order to restore the lake ecosystem, it is important to bring new water sources to accelerate the water exchange of Dianchi Lake and flush out the polluted water. With the goals set by the government, the Niulanjiang – Dianchi Water Diversion project is mainly used to wash off the pollutant water in Dianchi Lake, and provide fresh water supply to the drainage basin (Wang, 2016).

Kunming Waterfall Park is designed as a public park combined with the outlet facility of the water diversion project. The main goal of the park is to serve as a monument of Niulanjiang – Dianchi Water Diversion project at the same time as providing public green space for the new master plan of the north town. The plan of the park potentially increased the value of surrounding real estate development (He, Liu, & Tang, 2016).

Genesis of Project: Dianchi Lake is the sixth largest lake in China, with the volume of 1.56 billion cubic metres. The lake is located downstream of Kunming. The drainage basin has the surface area of 2,920 square kilometres. However, the Dianchi drainage basin has severe water shortage issues. With the rapid urbanization and booming population, the fresh water resource per capital is less than 300 cubic meters a year. In addition, Dianchi Lake is highly polluted. In order to address the water shortage and water pollution issues, the local government has proposed the central Yunnan water diversion strategy to supply the water usage and wash off the pollutants. After submitting the proposal to the central government, the Ministry of Water Resources organized several surveys, exploration and debits to look for water sources for the diversion strategy.

Design, Development, and Decision Making Process: From 2003, Yunnan province has reported water shortage in the Dianchi drainage basin to the central government, and a series of explorations and land surveys were organized by the Ministry of Water Resources to try to find a solution. In 2007, the province proposed 14 water supply plans, and the Niulanjiang – Dianchi Water Diversion project was chosen. In this proposal a dam with a power plant will be constructed at Dezexiang town as a water source control facility; pumping stations and a 115.6 kilometre long aqueduct system will transport 566 million cubic metres of fresh water into the Dianchi drainage basin. The outlet and water storage facility of the diversion project will be located at the north side of Kunming and has been designed as a public park. Construction of the diversion project started at the end of 2008. At the end

of 2013 the Niulanjiang – Dianchi Water Diversion project was completed and started to supply fresh water to Dianchi drainage basin (Wang, 2016). The project alleviates the water shortages in Kunming.

In 2011, the outlet location of Niulanjiang-Dianchi Water Diversion project was considered as part of the north town development master plan. At the beginning of 2012 the proposal to construct the outlet facility as a showcase public park for the north town development was accepted by the local government. A land area of 66.4 hectares was planned as the site for the park. After consideration of the economic benefits of the park, the local government granted a land of 194.3 hectares as the park site. At the end of 2012, Kunming Engineering Corporation proposed a design combining the function of water supply, flood control, water quality improvement, river channel regulation and landscape improvement, this was chosen as the final design. Construction of the project started immediately. The project was completed at the end of 2015, and the park was open to public from January 1st 2016 (He, Liu, & Tang, 2016).

Project Impact:
Environmental Impact: The Niulanjiang-Dianchi Water Diversion project provides clean water in Dianchi Lake, accelerates the water exchange rate, and washes off polluted water out of the basin (Wang, 2016). However, the water diversion project also reduces the volume of flow in the Niulanjiang River, and the effect downstream river is unknown. In addition, the washed-off pollutants from Dianchi Lake will flow downstream into the Yangzi River system, the effects of this project downstream are also unknown.
Social Impact: The water diversion project provides sufficient water supply to Dianchi drainage basin to allevitate the water shortage issue in Kunming. However, as the city of Kunming keeps expanding, and this water diversion project can only solve the water shortage temporarily. Kunming Waterfall Park has become the central piece of the north town development plan. The park became a popular outdoor recreational space for residents, and the 400 metres long waterfall also became a tourist attraction for visitors. In addition, the park and the water diversion project function as fresh water supply, water quality improvement, river/channel regulation, and flood control infrastructure to the city (He, Liu, & Tang, 2016).
Economical Impact: Kunming Waterfall Park has created an enormous economic impact to the surrounding area. The land value has increased rapidly. In 2013, at the beginning of the construction of the park the surrounding land value was 2.5 million RMB per hectare. In 2016, after the park open, the land value of surrounding area raised to 15 million RMB (He, Liu, & Tang, 2016).

Reflection: The water diversion project alleviated the water supply pressure for the city at the same time increased the water quality of Dianchi Lake. The newly constructed park provides public open space for the new residential development at the north part of the city, and increased the property value of the surrounding area. However, the water diversion project is just a temporary solution of the city's water shortage problem. In addition, the project increased the inflow to Dianchi Lake and flushed the pollutants to the lower reaches and could increase the risk of water pollution to the other watershed.

4.2.3 Shanghai Houtan Park

Type of project: waterfront restoration, , water quality improvement, public park, landscape improvement
Location: Shanghai, China
Project Size: 14 hectares
Designer: Turenscape

Context: Houtan Park was built on a brownfield, which was formerly constructed as a steel factory and shipyard along the Huangpu River waterfront in Shanghai. After the factory and shipyard moved out, this 14-hectare linear land was left as a landfill and lay-down yard with few remaining industrial structures on site. During the Shanghai Expo, the site was converted into a waterfront park that showcases sustainable design and the restoration of the post-industrial landscape. The park design combines constructed wetland, ecological flood control, reclaimed industrial structure, and urban agriculture to achieve an overall restorative design strategy to treat polluted river water and recover the deteriorated waterfront.
Funding: In 2004, the central government established the Shanghai World Expo Organizing Committee (SWEOC) to dedicate for hosting the event. The construction of Houtan Park is funded by the SEWEOC with the construction budget of US $15.7 million (Turanscape, 2009).

Project Background and History: The site was formerly owned by a steel factory and shipyard. After the bankruptcy of the factory and shipyard this brownfield was abundant, and it was used as landfill and lay-down yard for industrial material. Few industrial structures were remained on site. After Shanghai won the bid to host Expo 2010 in 2002, an area of 5.28 square kilometres of riverfront along Huangpu River has been established as Expo campus. Houtan Park is planed as part of the core green space for the Expo. A design competition was held for the park design. The Beijing based landscape architecture firm Turenscape won the competition and the park started construction in 2007 (Turanscape, 2009).

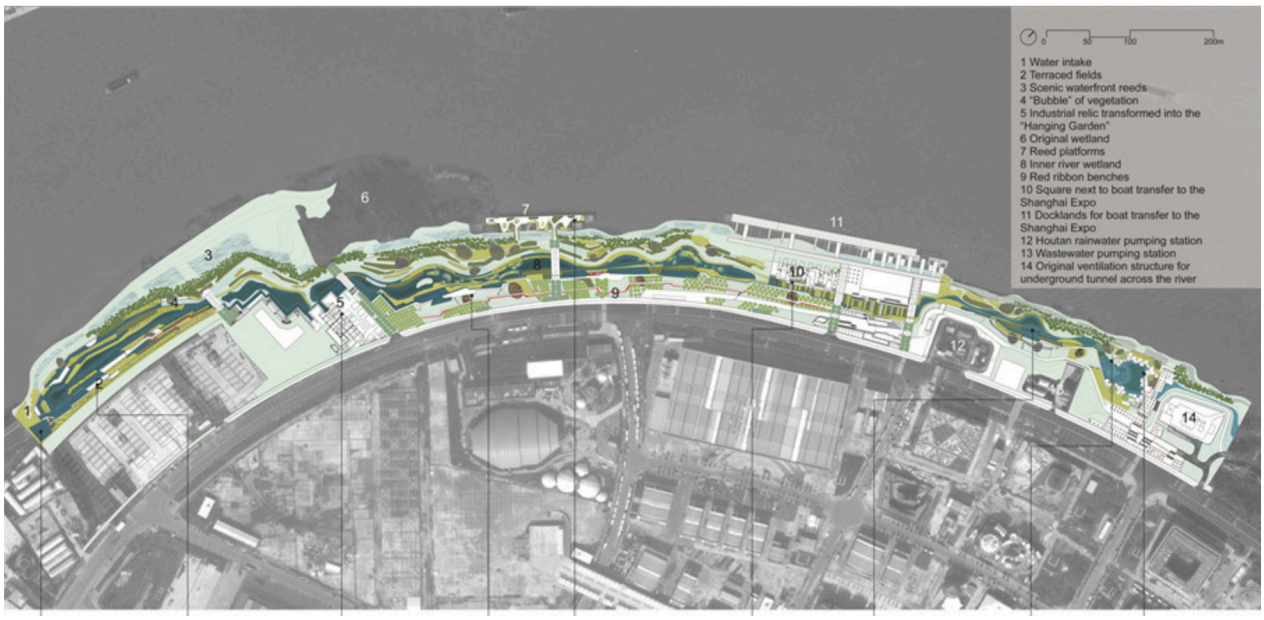


Figure 37. Houtan Park Plan View

Goal of the Project: As part of the Shanghai Expo, the park design follows the theme, "Better City, Better Life", to create a showcase of sustainable technologies, and demonstrate the restoration of post-industrial landscapes. The goal of the project is to accommodate the large influx of visitors during the event from May to October while providing opportunities to showcase green technologies, and transform a deteriorated space into a pleasant landscape. After the Expo the site could transition into a permanent public waterfront park for residents' daily use (Turenscape, 2007).

Site Analysis: Regenerative design strategies were used to transform the site into a living system that provides comprehensive ecological services including: flood control, water treatment, habitat formation, and food production. The site has been designed as a showcase project to demonstrate ecological culture for the 2010 Shanghai Expo. Along the Huangpu River bank the 1.7-kilometre-long, 5 to 30 metres wide linear constructed wetland was designed to create a reinvigorated waterfront as a living machine to treat contaminated water from the river and to provide open space for the general public. Cascades and terraces are used to oxygenate the nutrient rich water, remove nutrients, and reduce suspended sediment while creating pleasant water features. A variety of wetland plants were selected and placed to take up pollutants from the water. Field test indicates that 2,400 cubic metres of water can be treated each day. Water quality was raised from Grade V to Grade II.

The vegetated waterfront also worked as a riparian zone to protect the Expo site. The meandering valley along the wetland creates a series of thresholds creating visual interests and refuges from the bustling Expo site. Moreover, the park also provides opportunities for recreation, education and research purposes. The terrace design of the

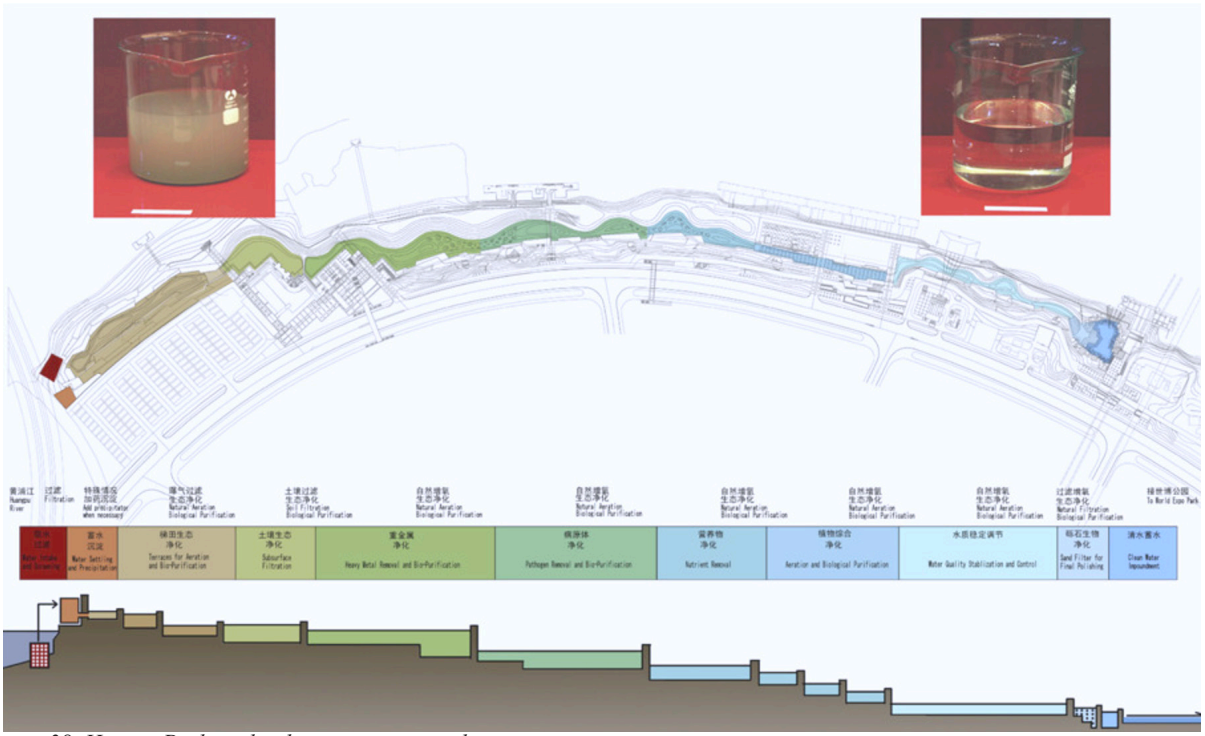


Figure 38. Houtan Park wetland water treatment diagram

wetland alleviates the elevation difference between the city and the river, safely reconnecting people with the waterfront.

Within the ecologically regenerated landscape there are layers of agricultural and industrial past of the site and future of the post-industrial eco-civilization. The terraces were created to break down the elevation changes from the water level to the road, and slow the runoff directed to the stream in the constructed wetland. These terraces are also the reminiscent of the agricultural heritage prior to industrial development of the neighborhood. Crops and wetland plants were selected to create an urban farm allowing visitors to witness the changes of the seasons through the changes of the crops and plants. It also provides a premier educational opportunity for people to learn about agriculture and urban farming (Archdaily, 2011).

Challenges: The first challenge through the design of the park was restoring the post industrial site. The site was a brownfield littered with industrial debris both in the surface and buried throughout. The water of Huangpu River is highly polluted. Graded as Below Grade V, the water from the river is not suitable for any use. The primary design challenge was to transform this degraded landscape into a safe and habitable public space. The second challenge was to solve the issue of flood control. The existing river bank was a 6.7 metres tall concrete floodwall which was designed to protect against 1,000-year flood event. The 2,1-metre daily tidal fluctuation of the river creates a muddy and littered shoreline along the rigid concrete wall, which makes it in accessible to the public. A regenerative design proposal was needed to create alternative flood control solution while improve accessibility to the water. The third challenge is the site condition. The site was a narrow strip sit in between the Huangpu River and an urban expressway. The water frontage is over 1.7 kilometres but with a narrow width of 30-80 metres (Turenscape, 2007).

Programed Elements:

Ecological Landscape

The design preserved 4 hectares of natural wetland along the Huangpu River. The existing and proposed vegetation community remove pollutants, prevent bank erosion, and create wildlife habitats. The existing concrete levee was reconfigured as a tidal wetland, planted with native wetland species to ecologically improve flood control ability.

Purification wetland

The water quality in Huangpu River is classified as Below Grade V, which can not be used for any purpose. In the park design, water from Huangpu River is pumped to the constructed wetland for purification process. The water flows through a series of water cascades to get oxygenate, then the water is biologically treated to Grade II through a series of wetland cells that facilitate settling, aeration, and vegetative and microbial processes. The treated water is used for landscape irrigation and other non-potable uses.

Resilient flood control

The constructed wetland also acts as a buffer between the Huangpu River and city of Shanghai to prevent flooding up to a 1000-year event.

Valley landscape

The valley formed by the constructed wetland was designed to form a peaceful pastoral landscape, a quiet oasis within the

Figure 39. Ecological landscape

Figure 40. Valley landscape

Figure 41. Purification wetland

Figure 42. Resilient flood control

bustling metropolis. Platforms, industrial structures and stairways are connected by boardwalks along the valley to guide the visitors strolling through the wetland (Turenscape, 2007).

Role of Designer: Landscape architects served as the leading designers and prime consultants for the park design. They consulted and coordinated with several other professionals including, architects, urban planners, hydrological engineers, lighting engineers, and researchers to deliver the comprehensive post industrial landscape(Rottle,et al., 2011).

Project Impact:

Environmental impact: the constructed wetland in the park is able to treat up to 634,000 gallons of polluted river water each day. The water quality increased from Below Grade V to Grade II using only biological processes. At the same time, the park design increased the biodiversity of the site dramatically, over 93 species of plants and over 200 species of animals were observed on site. In addition, the extensive wetland, perennial plants and trees in the park can trap about 242 tons of carbon.

Social impact: the park provides recreational and educational opportunities to the 590,500 visitors during the 2010 Shanghai World Expo, and demonstrate the sustainable urban regeneration design strategy to echo the “Better City, Better Life” theme of the Expo. After the event, the park continues to provide water management, ecological, recreational, and educational benefits to city residents and visitors.

Economic impact: During the construction of the park, the design reclaimed roughly 37 tons of steel, and 34,000 post-industrial bricks found on site to reduce waste saving $17,300 on construction cost. During the

World Expo, the park's wetland treated 264,000 gallons of water each day, the treated water has been used for irrigation of the landscape and non-potable purpose through the campus. The reuse of water saved $116,800 in the water costs. After the Expo, Houtan Park's wetland purification system keeps treating polluted water from the Huangpu River (Rottle,et al., 2011).

Reflection: The regenerative design strategy of Houtan Park provides a precedent to demonstrate how urban water can be managed through landscape architecture. The constructed wetland, which adapted phyto technology, demonstrates a incredible use of plants as natural purification media to treat polluted water through out the site. In addition, the whole water management process of the park provides educational experience to the general public. Since Kunming suffers from decreased water quality and frequent urban flooding, the regenerative design strategy of Houtan Park can be adapted to site-specifically provides a solution for the water management issues in Kunming.

4.2.4 Conclusion

In conclusion, from the case studies, it seems that landscape architecture has the potential to alleviate the tension between water crisis and urban development. A landscape architecture approach is able to capture stormwater and urban runoffs; convey and clean the water through phyto-technology, and reserve the water in water bodies for future use or slow release. Managing urban water by a landscape architecture approaches also has the benefits of improving biodiversity, increasing social interaction, mitigating flood events, increasing property value, and enhancing cultural identity. Taking a landscape architecture approach on an extensive scale, constructing an integrated network of green and blue infrastructure, can help to manage the water crisis more comprehensively.

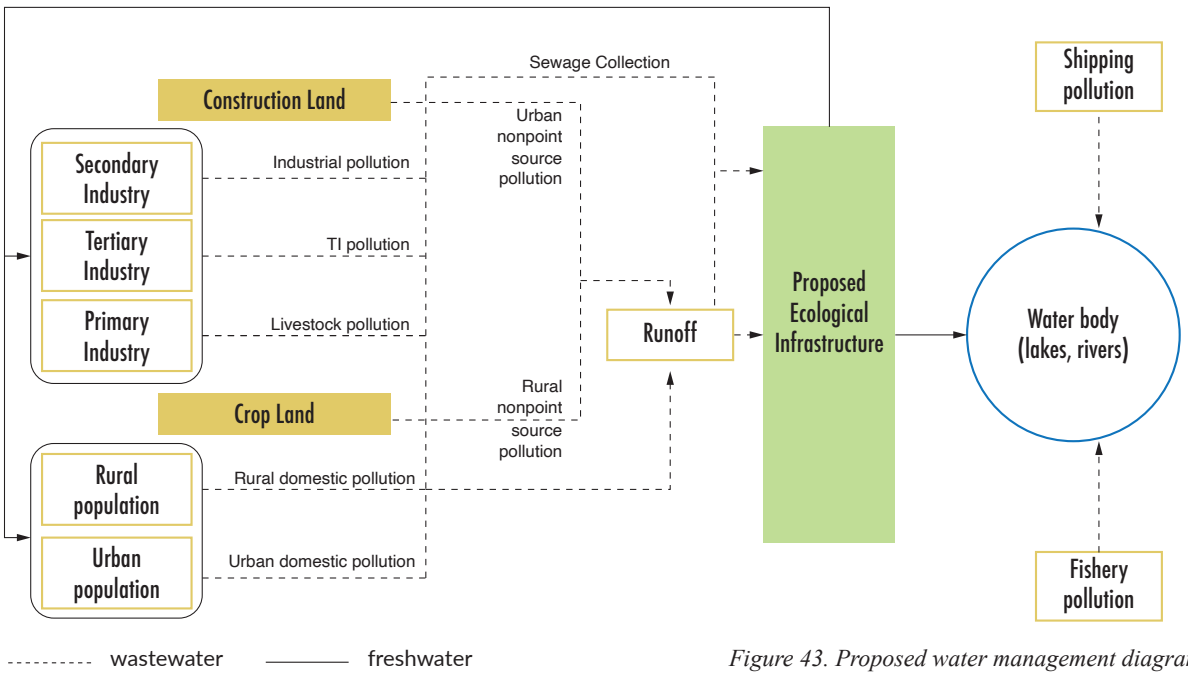


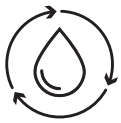
Figure 43. Proposed water management diagram

4.3 Programing of Ecological Infrastructure

This practicum, will design an extensive network of green and blue infrastructure through the city of Kunming. This city-wide ecological infrastructure will provide three primary ecological services, restore local ecology, improve people's wellness, enhance cultural identity.

4.3.1 Restoration of local ecology

The network should be able to restore and enhance the environment, sustaining healthy and resilient ecosystems within the drainage basin.



- Water Management
The network should utilize existing city-wide public open spaces, parks, greenbelt, and water bodies to capture excessive stormwater and runoff, as well as provide water storage, and treatment. Besides, new water management features such as green roofs, rain gardens, bioswales, waterfront riparian zones, and wetland parks should be constructed to connect with existing water management facilities to form an integrated network for water treatment.

- Biodiversity
Not limited to preservation and conservation. Pioneer and native plant species will be introduced through the proposed network to rehabilitate and extend habitat for wildlife.

- Risk Mitigation
The network of green and blue infrastructure should also capture and store stormwater to minimize flood risk, rehabilitate contaminated sites (i.e., brownfields, vacant lots) and provide water storage space to alleviate water scarcity.

- Climate Regulation
Strategic implementation of urban forests and water systems should be able to create regional micro-climate, reduce the urban heat island effect, improve air quality, balance humidity, as well as improve the overall environmental health of the city.

- Food Production
Community gardens and productive landscapes can be promoted through green infrastructure around residential areas. Urban agriculture can provide a local food source and improve community interaction and local business opportunities.

4.3.2 Improvement of Wellness

In addition, this water management based ecological infrastructure should also be able to provide ecological services to benefit peoples' wellness.

- Community Building
Implement public open spaces through the ecological infrastructure, create gathering spaces to facilitate social interactions. Provide public space for programming community events such as farmers' markets, concerts, performances.

- Active Living
Construct a network of trails and pathways system to connect public open space to encourage active transportation modes, outdoor activities, and improve residents' health. At the same time, reduce vehicular transportation demand and carbon emission.

- Heath & Well-being
Design public open space such as gardens, plazas, and parks within the ecological infrastructure to reconnect people with nature. Promote mental and physical health, especially for the elderly and for the children.

- Learning & Playing
Restore and implement natural habitats to provide opportunities for people of all ages to learn about the regional ecosystem. The city-wide water network also offers opportunities for people to understand the water management processes, as well as the historical heritage. A variety of potential programing and open space design will be integrated to help the mental and physical development of children.

- Property Value
Implementing public space around residential areas could potentially increase property value, and stimulate local business and social variety.

4.3.3 Enhancement of Cultural Identity

Public space and facilities created within the ecological infrastructure should also be able to promote local culture.

- Public Events

Gathering spaces such as plazas, stadiums, outdoor theaters, sports fields are implemented within the network. These public spaces and facilities will host public events such as concerts, exhibitions, sports events, and festivals.

- Cultural Heritage

Kunming, as a historical city, has a significant influence on the contemporary history of China. Furthermore, Kunming is also embracing diverse cultures from different ethnic groups. Among the ecological infrastructure, cultural and historical sites will be preserved, highlighted, and connected through trials, pathways, and corridors to form a local cultural learning network.

- Destination & Tourism

Kunming has a well known reputation for its pleasant climate and diverse culture. The network of public event spaces and cultural heritage formed through the ecological heritage will have the potential to promote further tourism.

4.4 Mapping of Ecological Infrastructure

To construct the ecological infrastructure, which provides ecological services such as restoring local ecology, improving wellbeing, and enhancing cultural identity, a city-wide mapping exercise is carried out. Remote sensing data, GIS data, and on-site investigation were applied to map-out the ecological infrastructure.

4.4.1 Mapping the Water Network

Raw data of water bodies and elevations were collected for further processing. Elevation data of the drainage basin was processed in Global Mapper to generate the layer of the sub-catchment basin, and the layer of natural water flows formed created by elevation change (Map 2, Map 3). A map of urban flood areas was created by the research of flood reports for the last six years (Map 5). Furthermore, a series of on-site investigations was undertaken in order to evaluate the existing water bodies.

The investigation found that many of the existing rivers and streams are highly canalized; some of them are even covered or capped for land development purposes. Constructed areas are built a long them (Figure 44). Only a few sections of these rivers and streams have artificial riparian zones which have been restored during the last decade (Figure 45). Reservoirs are under stress of water shortage (Figure 46). In the urban area, lakes and ponds are constructed as parks and public spaces with high ornamental and recreational value (Figure 48). Most of the urban water bodies are isolated from the river system. Some of

Figure 44. Canalized stream

Figure 45. Artificial riparian zone along the canal

Figure 46. Songhuaba Reservoir

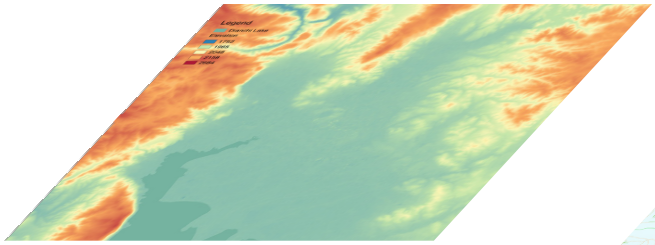
Figure 47. Wetland along Dianchi Lake

the water bodies have restricted access to the public. Wetland parks along the Dianchi Lake provide a significant ecological function to the lake and surrounding area (Figure 47). The wetland parks treat runoff water before the water reaches the lake. The wetland parks also provide recreational spaces and create habitat for wildlife.

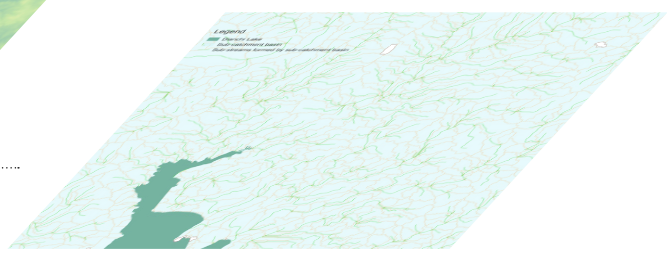
After investigating the sub-catchment basin and sub-stream layer(Map 3), existing water bodies layer(Map 4), and urban flood layer (Map 5) they are overlapped to develop a new water network. Based on the overlapping layers, the existing water network will be redirected and extended; new riparian buffer zones will be restored along the river bank to increase the capacity of the stormwater catchment. In addition, bioswales and rain gardens will be designed around the flooding area to absorb and hold the stormwater during heavy rainfalls. Water will then be released to nearby rivers or streams. Isolated lakes and ponds will be connected to the city-wide water network through the extended rivers to store excess water.

The proposed water network should not only provide water regulation through the city, but also cooperate with water treatment facilities to treat the water, and form parks, waterfronts, and plazas to create recreational space for the public.

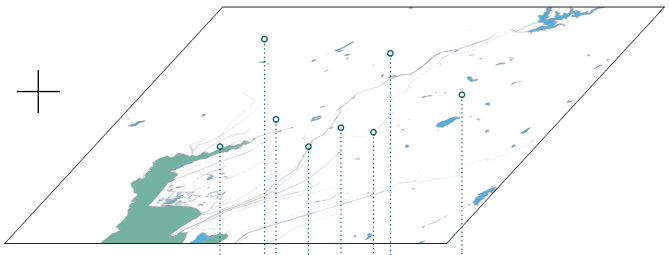
Figure 48. Daguanlou Park on the north shore



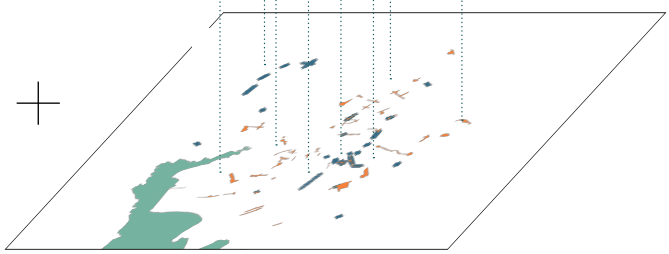
Topography



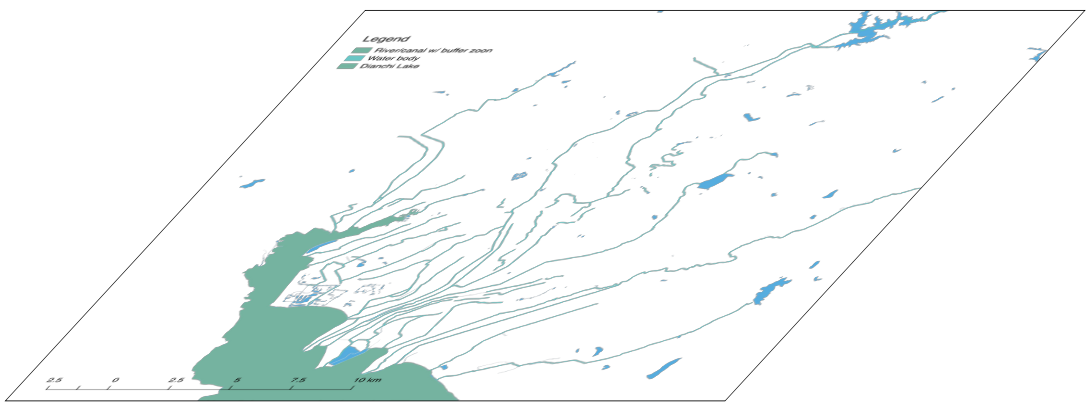
Catchment Basin & Water Flow



Existing Water Body



Urban Flood Map (2013-2018)



Proposed Water Network

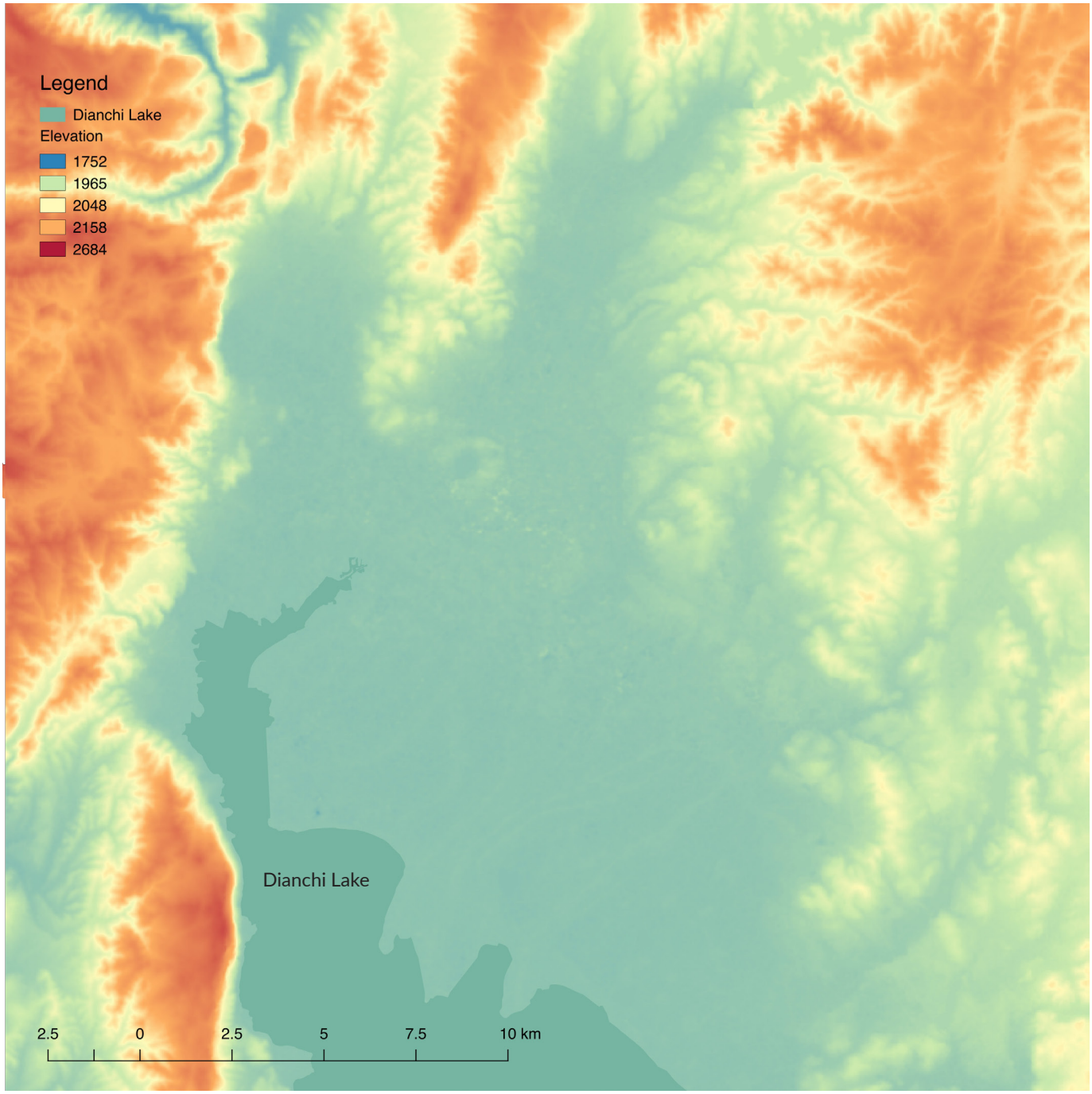
Figure 49. Blue infrastructure layering

AERIAL VIEW

Map 1. Aerial view of Kunming

Aerial view demonstrates the geolocation of Kunming and its relationship with Dianchi Lake.

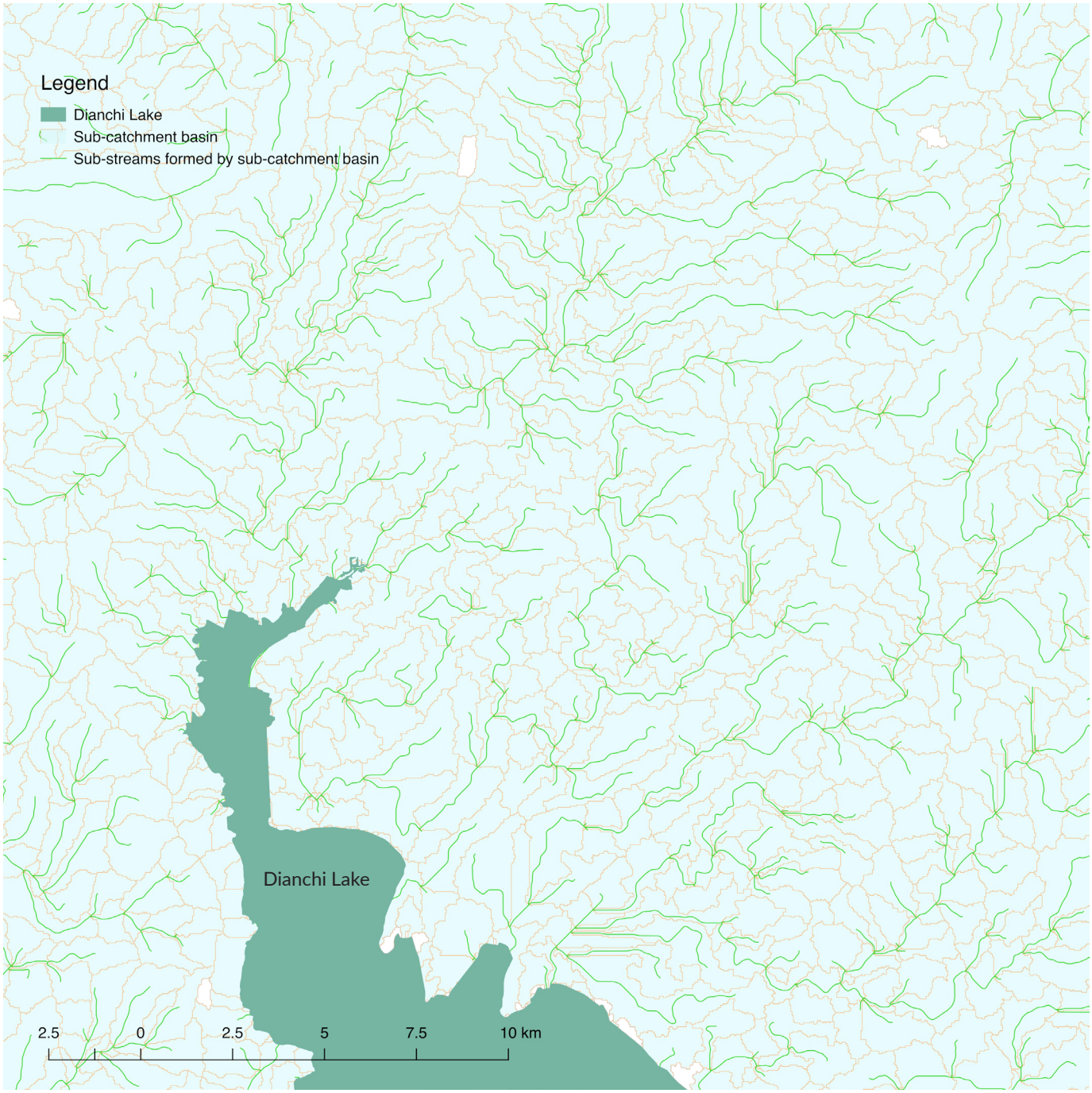
TOPOGRAPHY



Map 2. Topography map

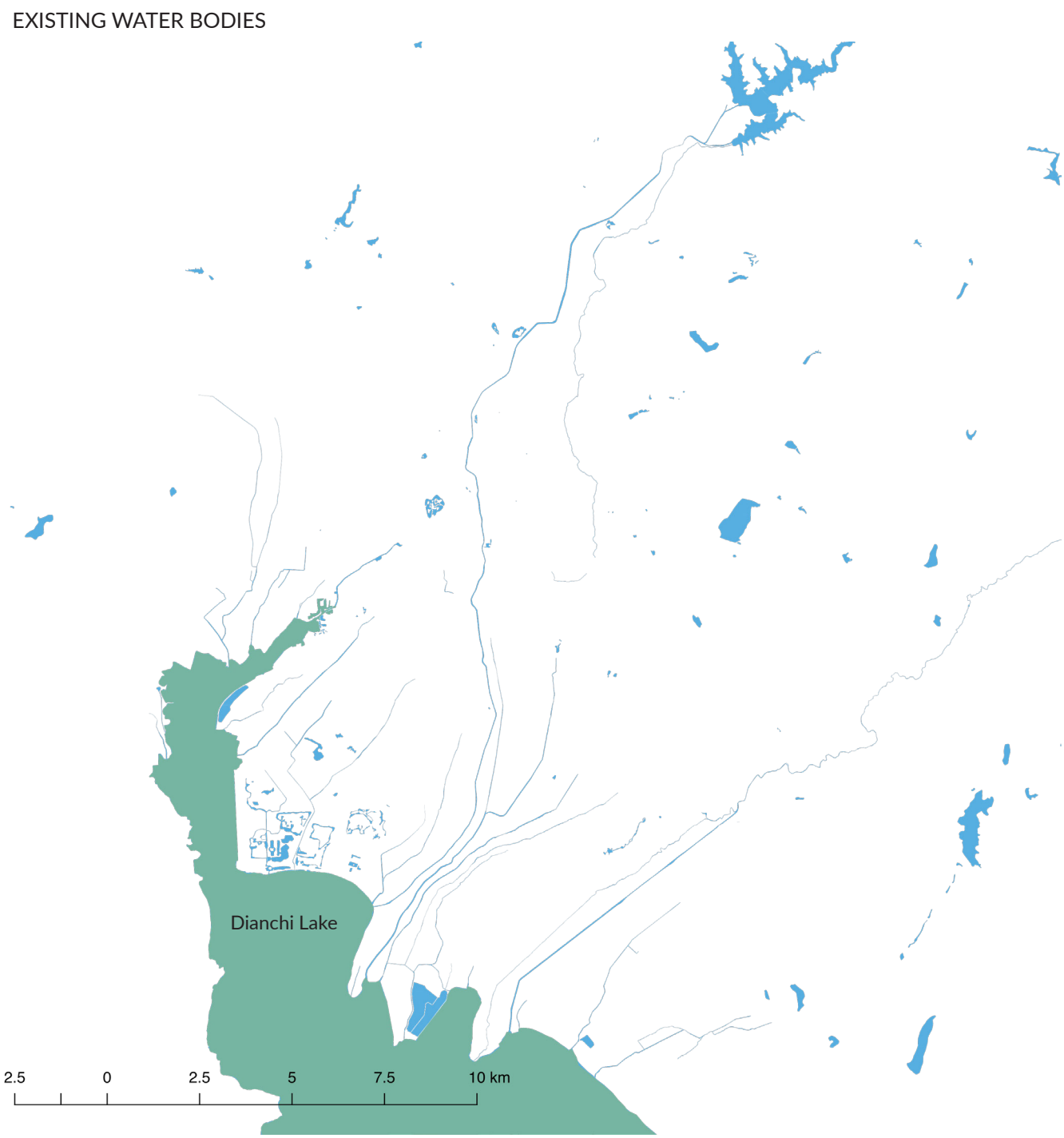
DEM file was collected to demonstrate the topographic change within the drainage basin.

CATCHMENT BASIN



Map 3. Sub-catchment basin in Kunming

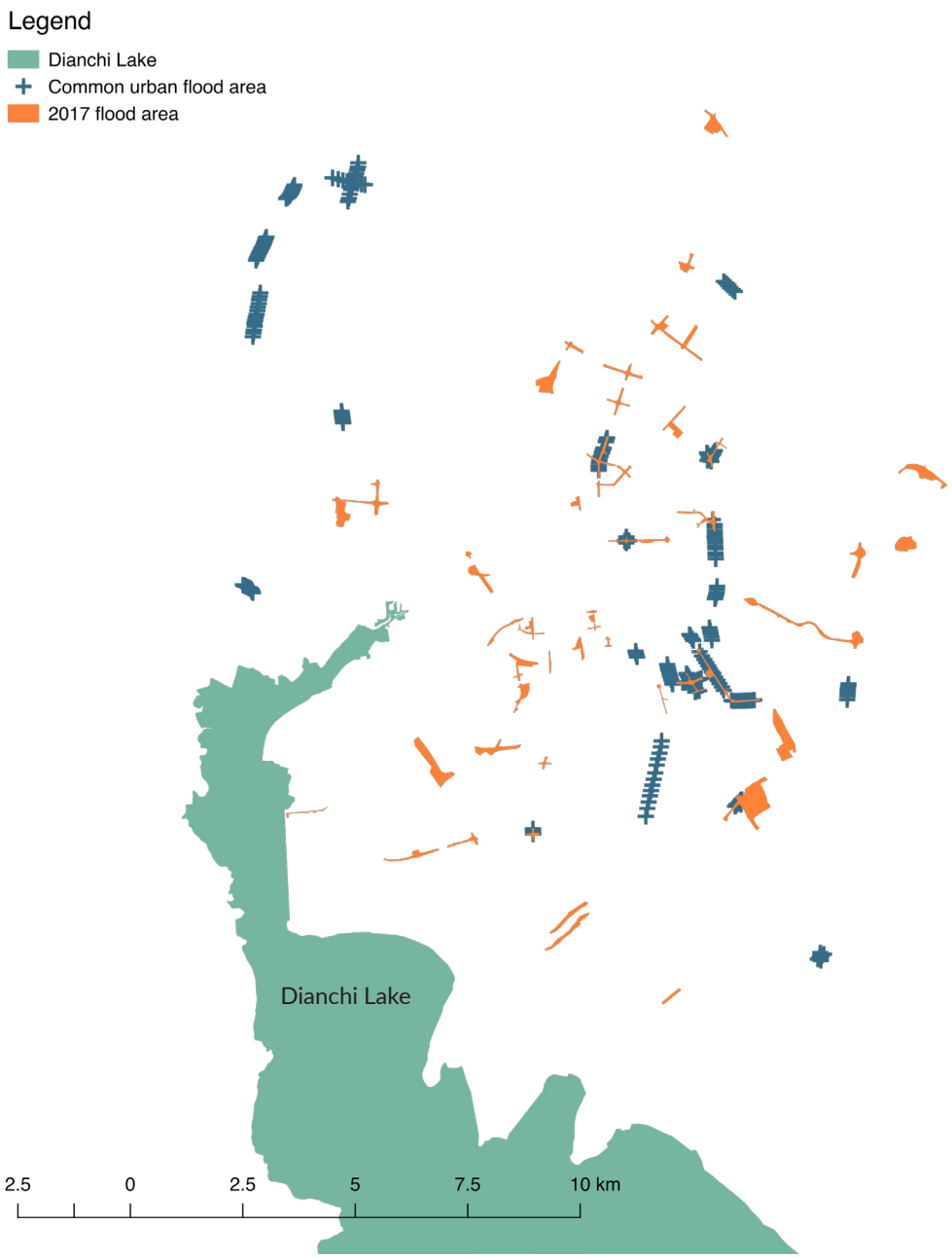
By using ArcGIS a map of sub-catchment basin was generate from the topographic map to estimate the potential water ways formation within the basin.



Map 4. Existing water bodies

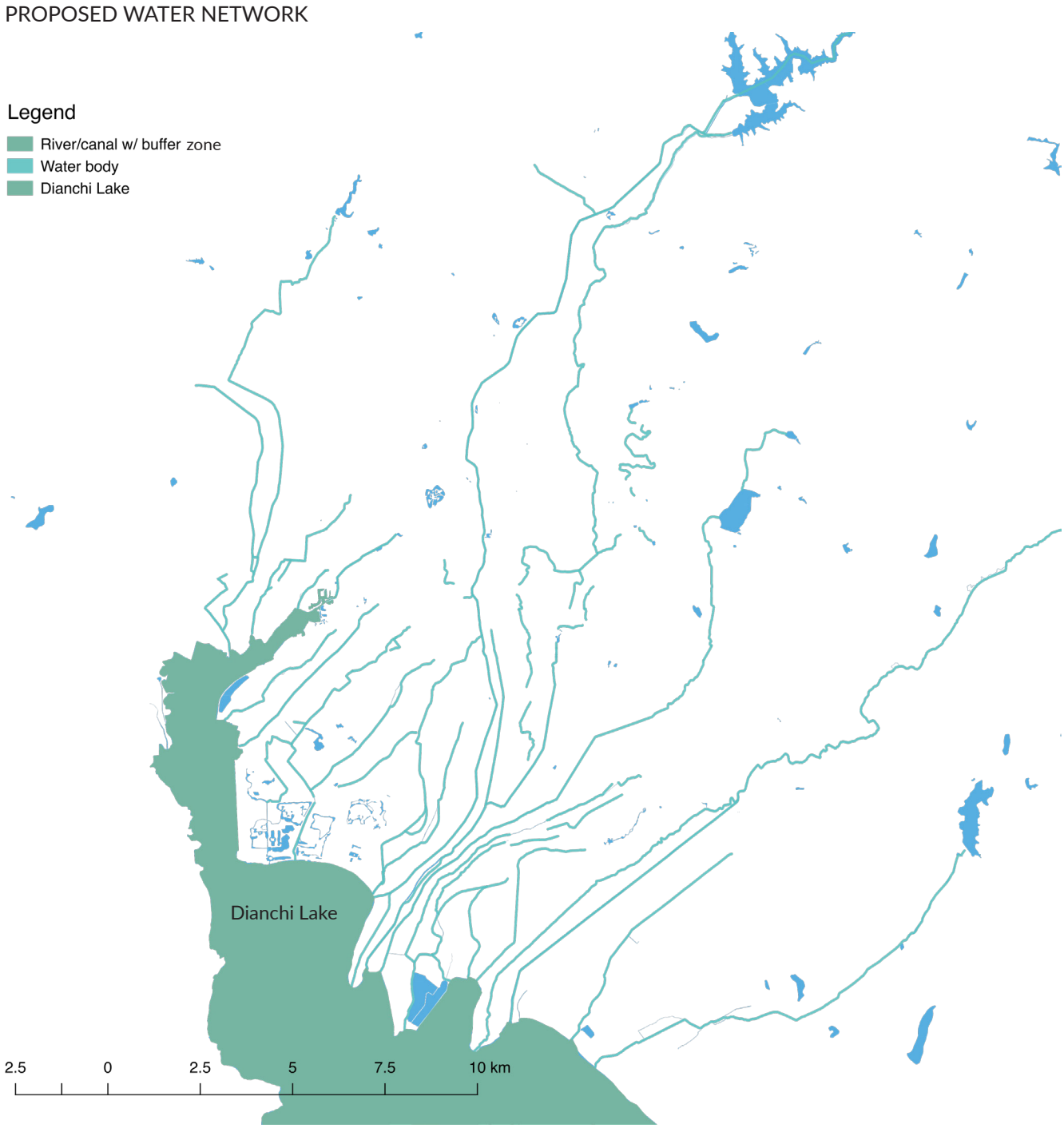
A map of existing water bodies indicates many rivers have been partially straighten to make the water drain to the lake efficiently. Only few of the rivers connect with water bodies (lakes, pounds and reservoir)

URBAN FLOOD



Map 5. Urban flood map

A map of flooding area for the past five years (2013-2018) was created based on the news reports.



Map 6. Proposed water network

By overlaying the flood may and sub-catchment basin map to find out potential water trapping area. Then based on the existing water bodies map to extend and reconnect the water bodies, and establish buffer zones (riparian zone) to improve the water network.

4.4.2 Mapping the Green Infrastructure

The the ecological infrastructure will combine the water network with green corridors and public open spaces to achieve the aim of integrating ecological services. Data of parks and green spaces, transportation networks, land use, and vegetation coverage are collected for further evaluation.

First, an investigation of existing parks and green spaces was conducted. Most of the parks and green spaces (greenbelt along roads, roundabouts, gardens) are designed for ornamental and recreational use (Figure 50). They have limited capacity to manage the stormwater. Only a few parks such as The Jade Lake (Figure 51), and Crescent Pond in the city, and the wetland parks along Dianchi Lake have strong ability to provide ecological services such as water regulation, biodiversity, risk mitigation, and social interaction. Based on the on-site investigation, improvement, and redesign of existing parks and green space should take place to adapt stormwater capture, storage, and treatment functions. Second, based on the current land use layer, vegetation coverage layer, and on-site investigation, vacant lots, brownfields, former industrial warehouses, and some of the urban slums will be redesigned as plazas, sports fields, parks, urban forest, and green corridors to connect with existing green spaces. In addition, green roofs, permeable parking areas, and rain gardens should be promoted through the city to enhance stormwater management ability. Lastly, to enhance the local culture, historical sites and buildings are adapted into the plan (Figure 52).

In conclusion, the proposed green infrastructure will connect with existing green infrastructure, and cooperate with the proposed water network to create a city-wide ecological infrastructure (Figure 54).

Figure 50. Road Greenbelt

Figure 51. Kunming Jade Lake Park

Figure 52. Kunming Golden Horse Arch

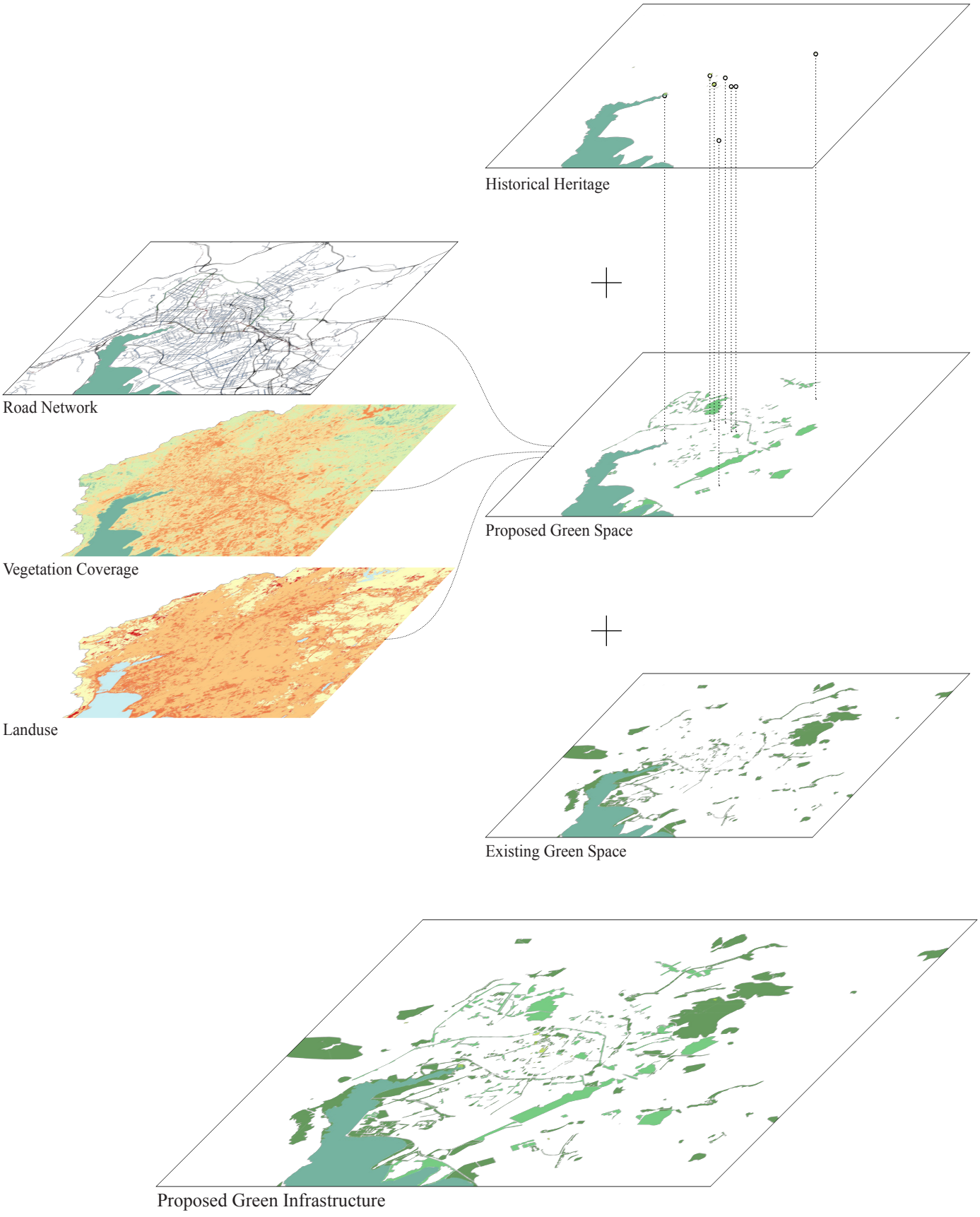
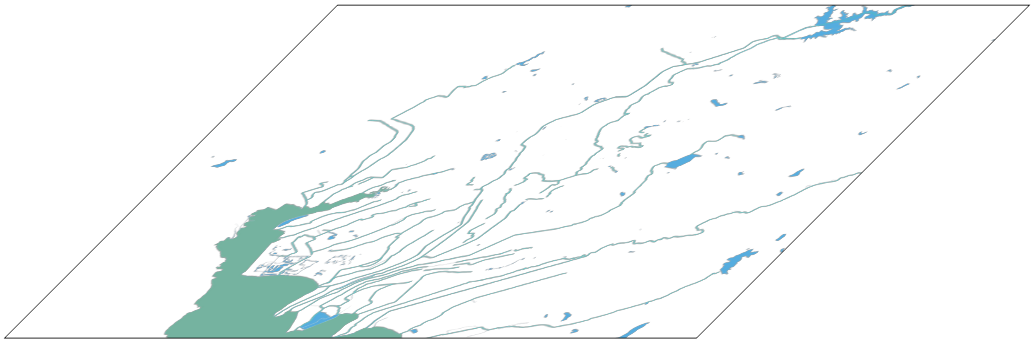
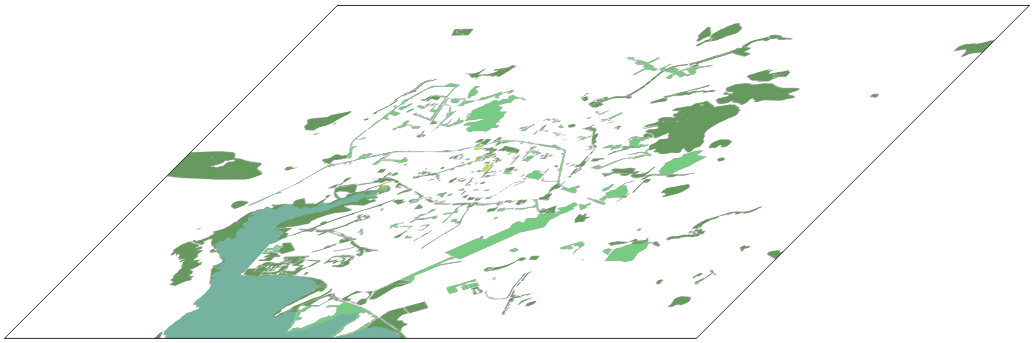


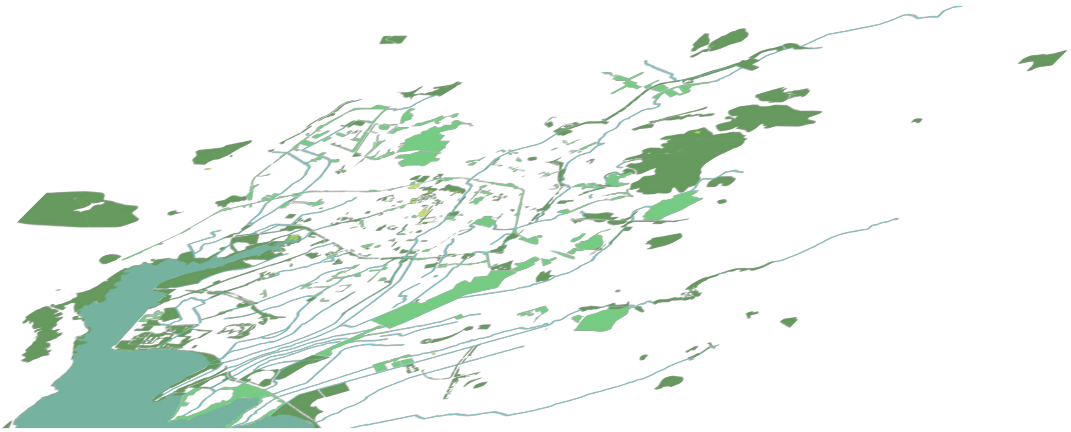
Figure 53. Green infrastructure layering



Proposed Water Network



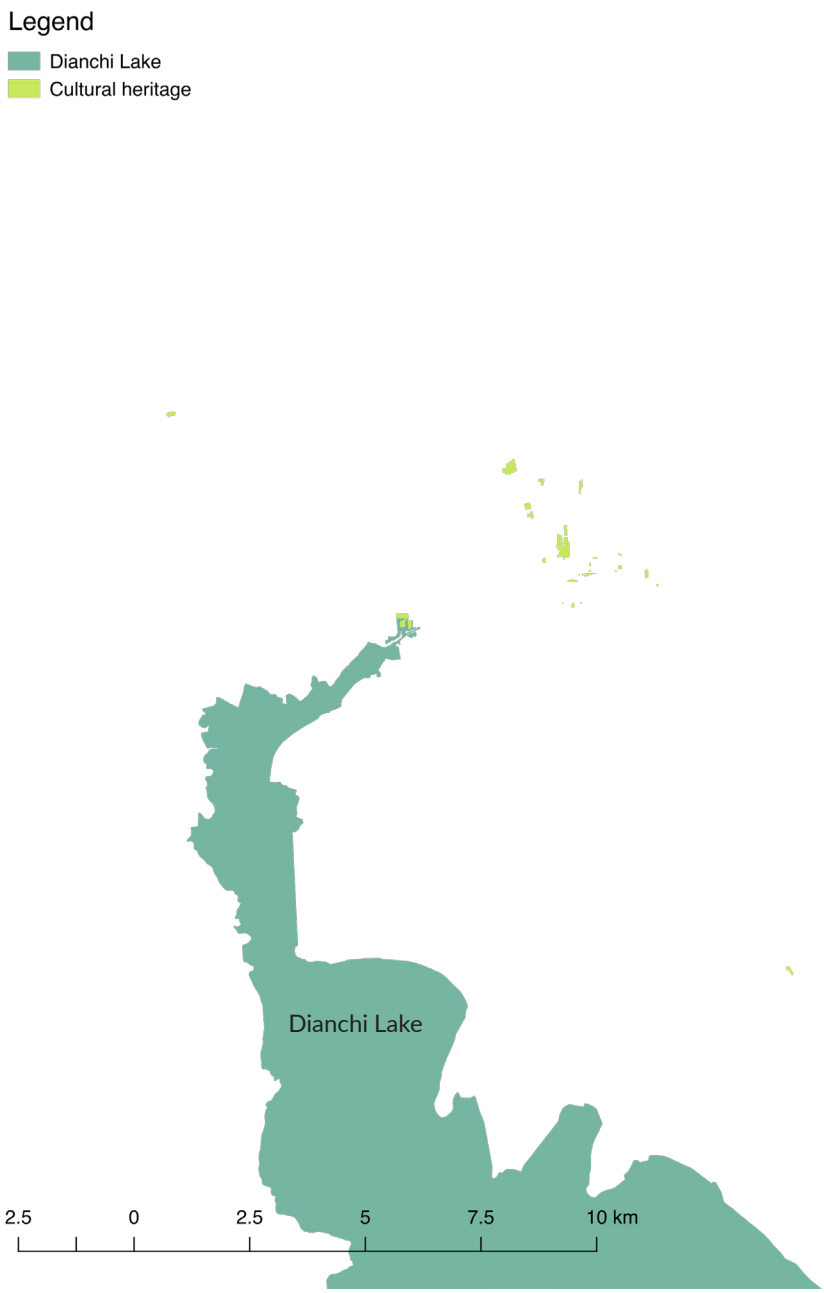
Proposed Green Infrastructure



Proposed Ecological Infrastructure

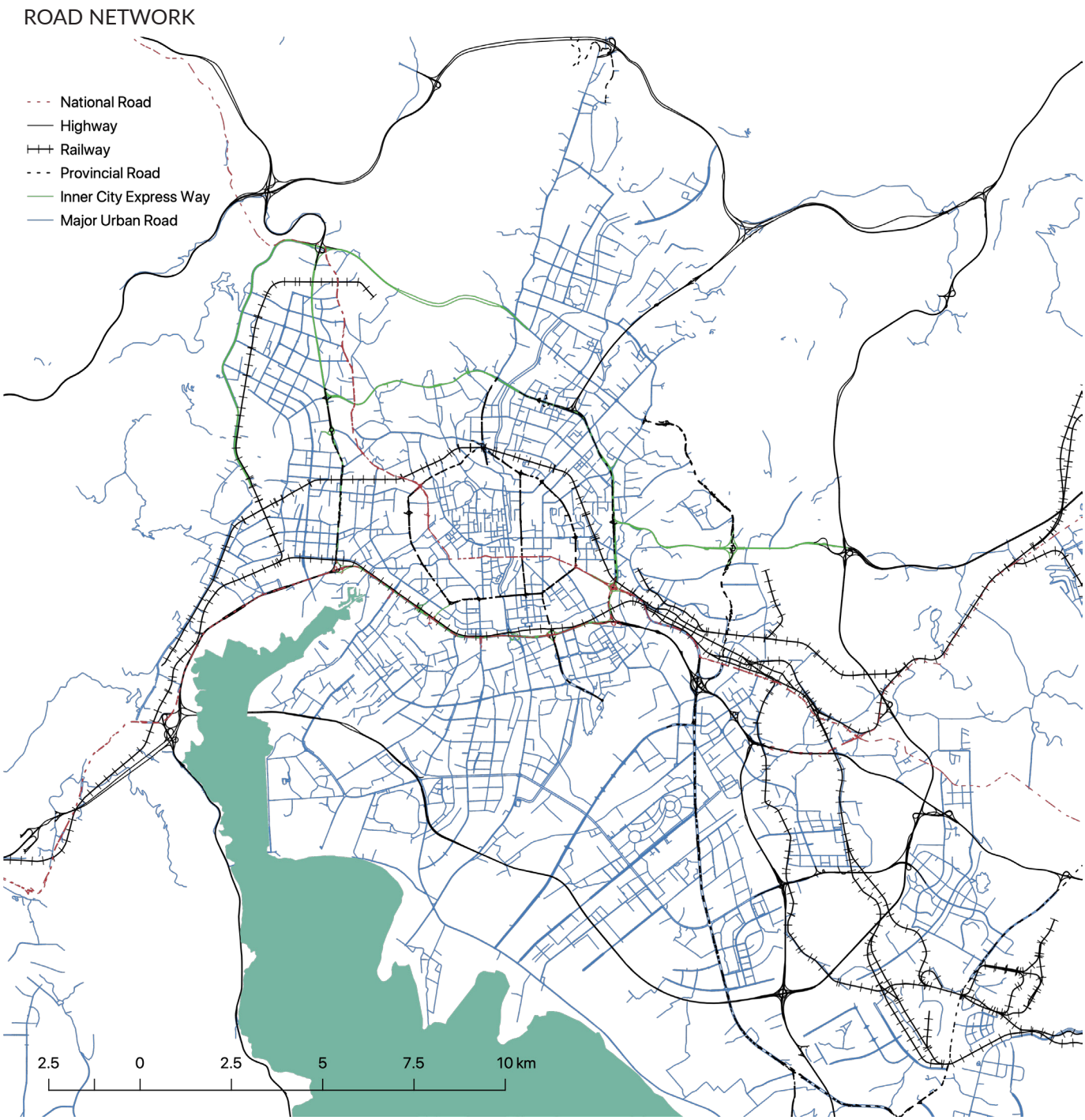
Figure 54. Ecological infrastructure layering

CULTURAL HERITAGE

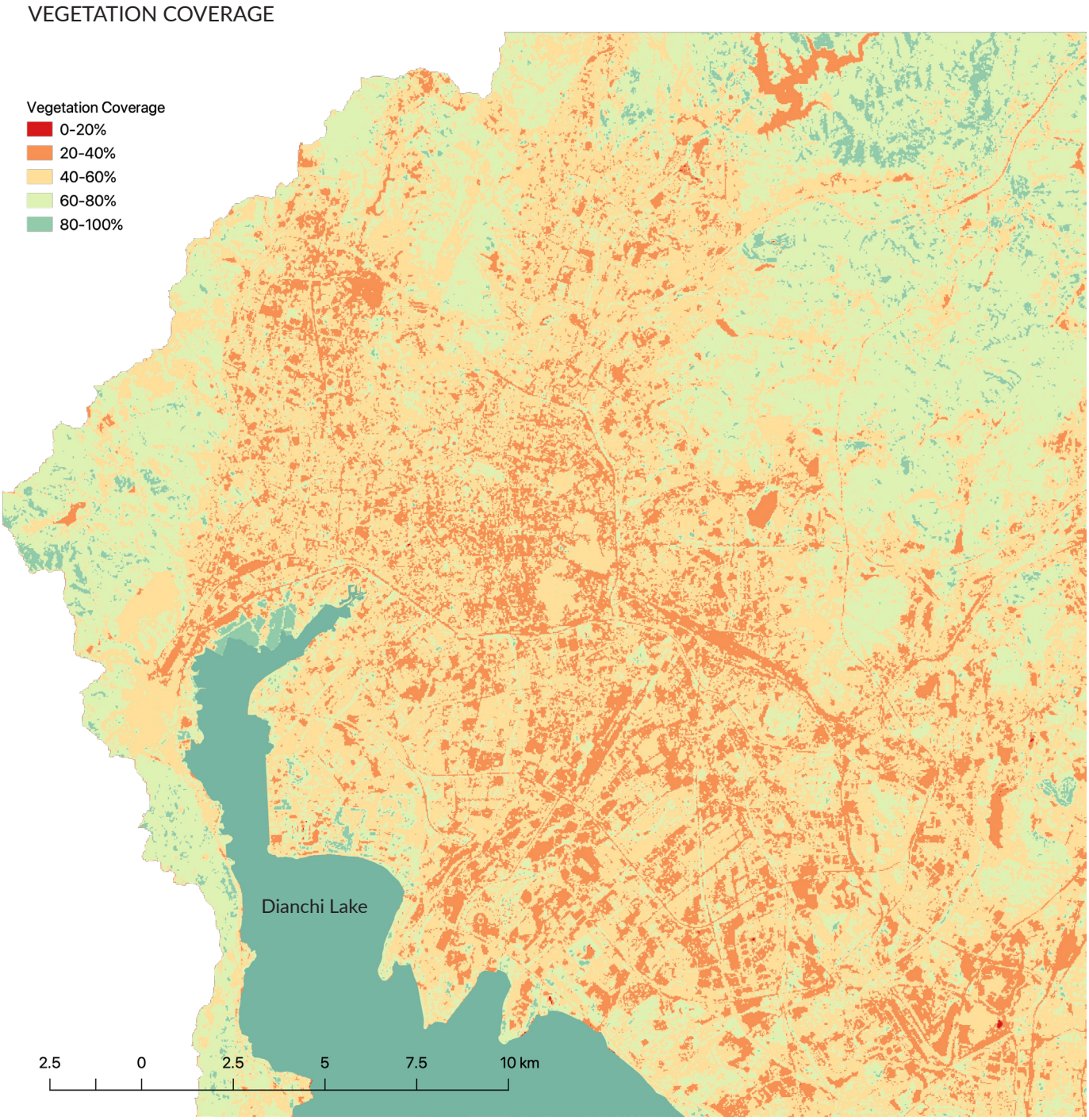


Map 7. Cultural heritage site

The cultural heritage sites is one of the most important part of Kunming's cultural identity. Including the cultural heritage site within the green infrastructure can diversify the visiting experience and provide educational purpose to the visitors.

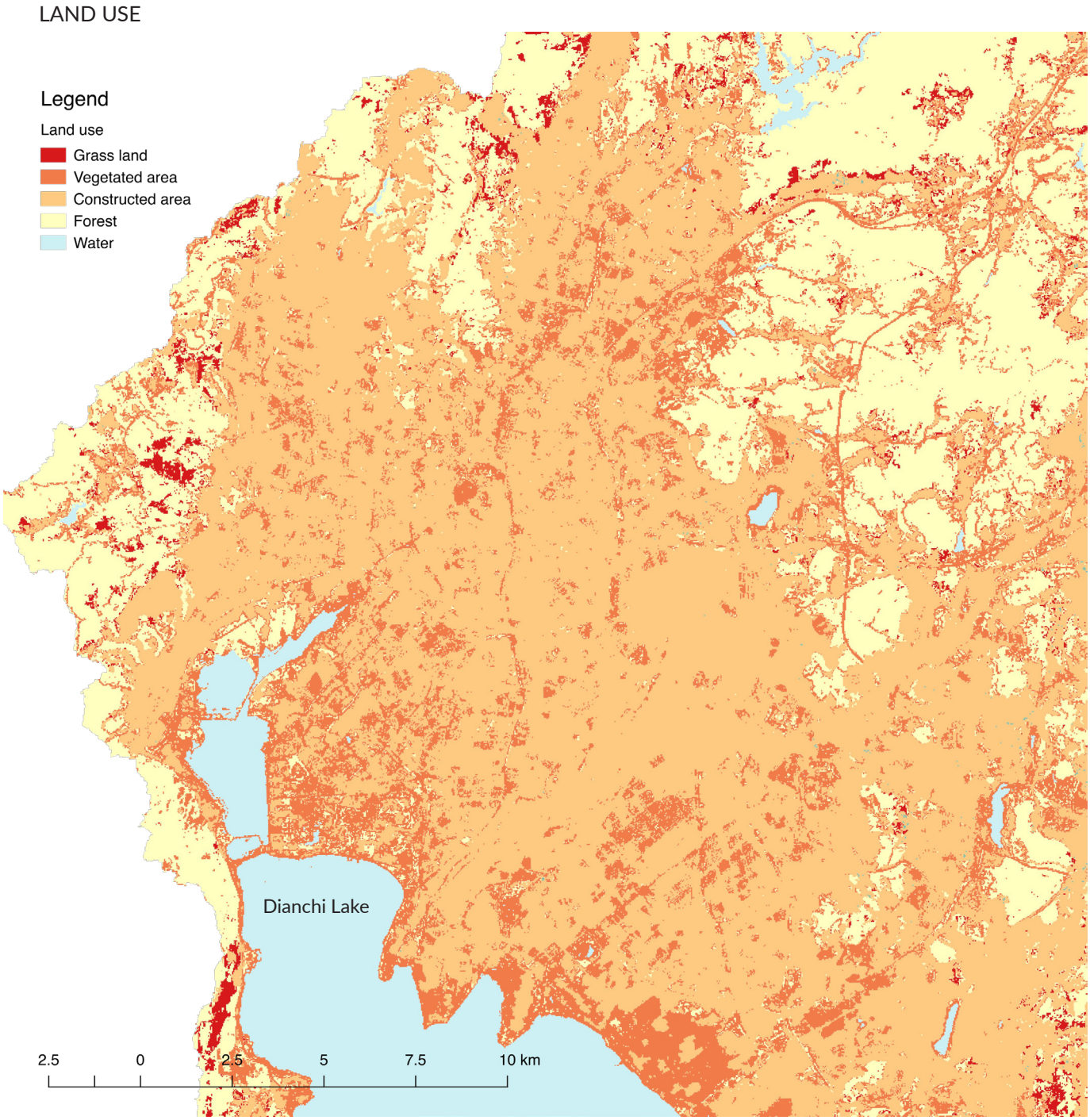


Map 8. Road network



Map 9. Vegetation coverage

In the urban area the vegetation coverage is effect the pattern of the road network and the land development.



Map 10. Land use

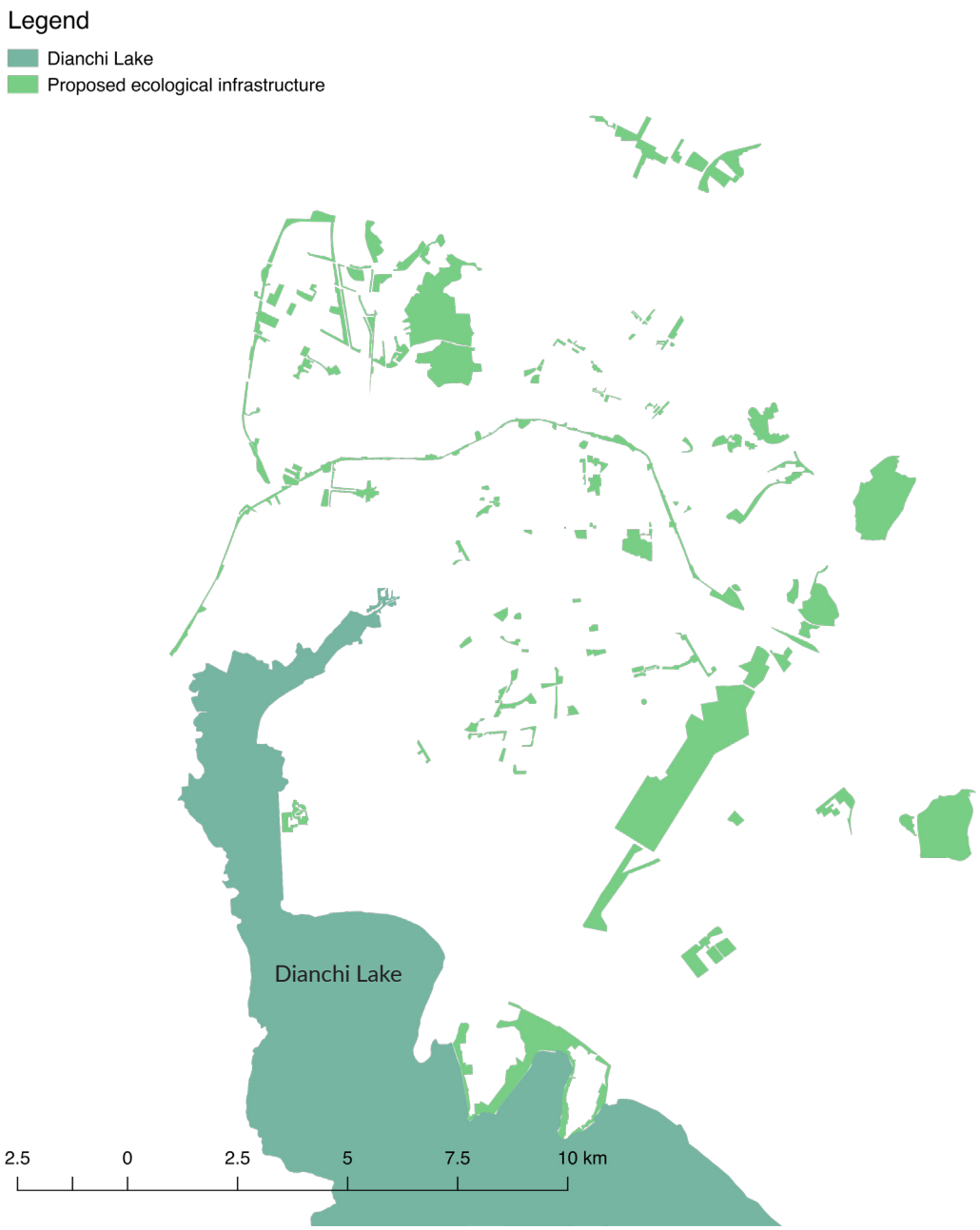
In the urban area the majority of the land is constructed for urban development, the majority of the vegetated areas are artificially established with new residential development.

EXISTING GREEN SPACE

Map 11. Existing green space

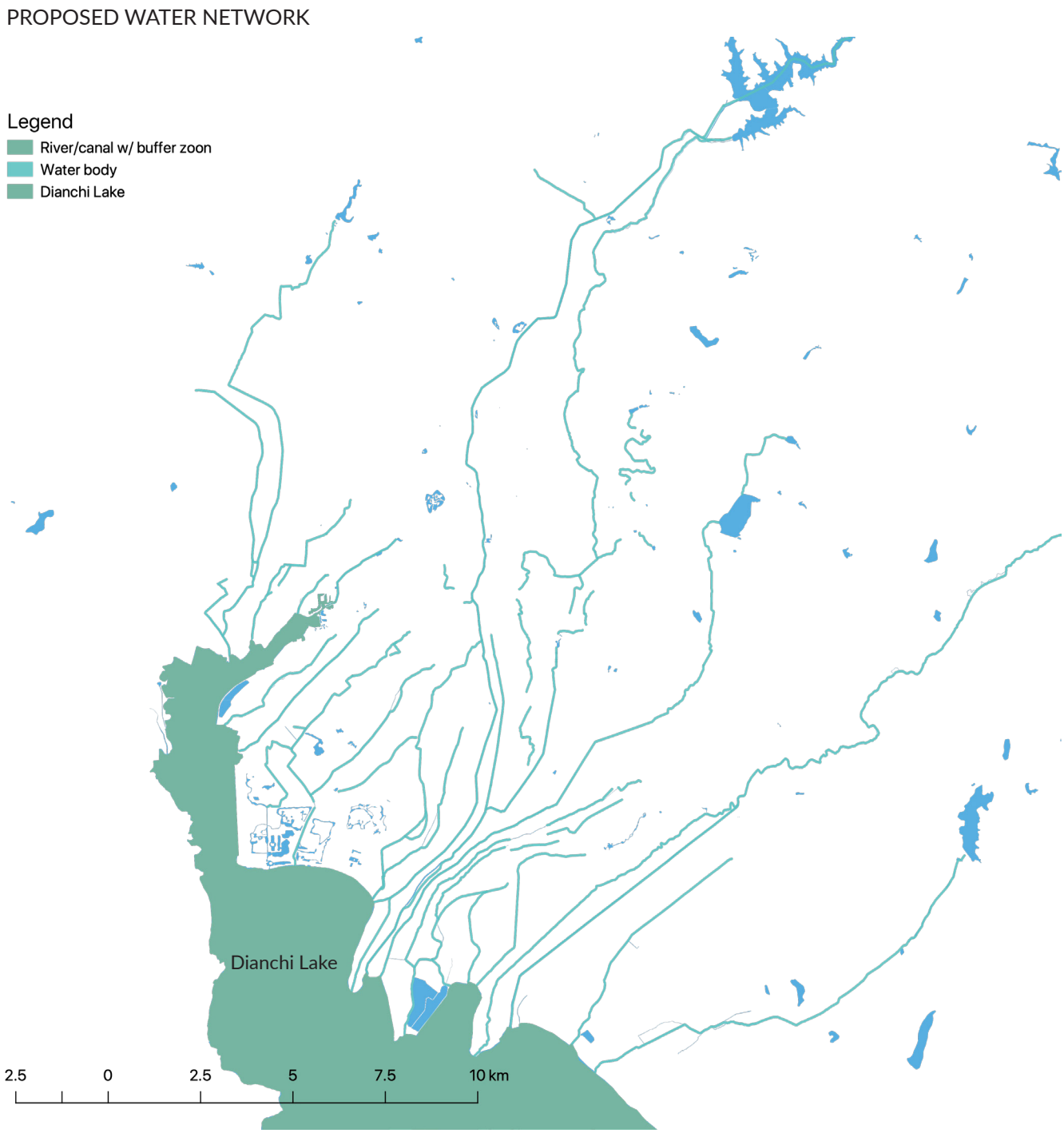
The majority of public green spaces are formed by parks, reestablished wetlands, and green belt long some major roads.

PROPOSED GREEN SPACE



Map 12. Proposed green space

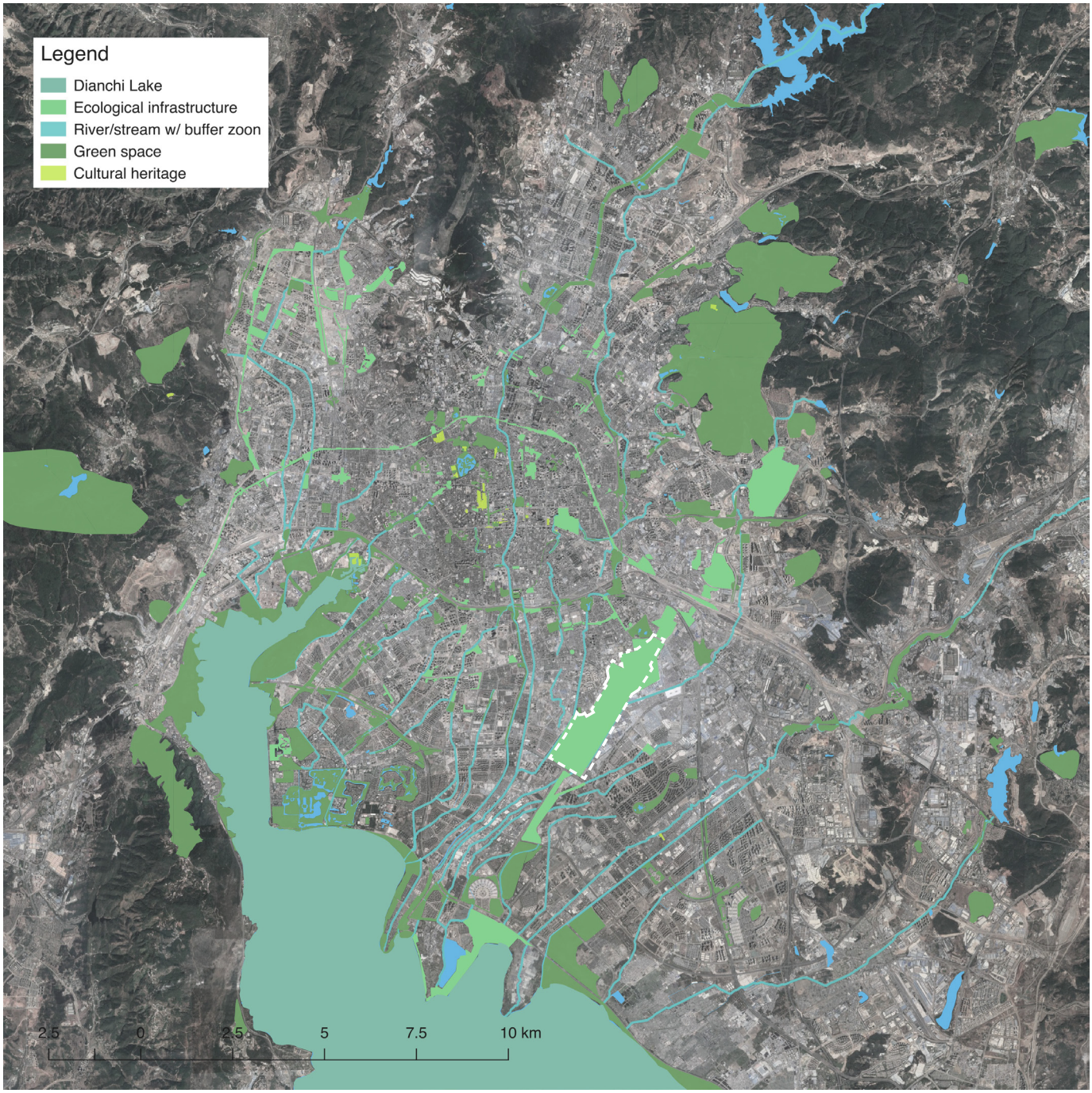
The proposed green space converted brownfeilds, frequent flooding areas, railway corridors, cultural heritage and sports fields into public green space. In addition, the proposal also adapt the urban land use policy to plan to transform designated land into green space.



Map 6. Proposed water network

Overlaying with the proposed water network, to create a comprehensive network of blue and green infrastructure.

PROPOSED ECOLOGICAL INFRASTRUCTURE



Map 13. Proposed ecological infrastructure

4.4.3 Adapting the Land Use Policy

One of the problematic physical challenges for implementing this ecological infrastructure is the conflict between the existing land use and proposed infrastructure. To solve the challenge, the planning of the infrastructure should also adapt to land use policies in China. According to the *Interim Regulations of the People's Republic of China Concerning the Assignment and Transfer of the Right to The State-owned Land in The Urban Areas*, Article 12, lands in urban area are owned by the government. The government can assign the right to use the property to the private sector for a certain amount of time based on the type of usage. "70 years for residential purposes; 50 years for industrial purposes; 50 years for the purposes of education, science, culture, public health and physical education; 40 years for commercial, tourist and recreational purpose and 50 years for comprehensive utilization or other purposes" (People's Republic of China State Council, 1990, Article 12). Therefore, after the lease terms expired, the government will be able to take back the land to re-zone the area for ecological infrastructure.

CHAPTER FIVE

Redesign of the Former Airport

Figure 55. Wujiaba Airport 1920s

Figure 56. 1940s Wujiaba Airport Expansion

Figure 57. AVG at Wujiaba Airport

Figure 58. People Travel Through Wujiaba Airport During 1980s

Figure 59. Wujiaba Airport 2000s

5.1 Site Analysis

Through two weeks of site visiting and investigation, the former airport, a part of the ecological infrastructure, is chosen for the site-specific design to demonstrate the proposed water management strategy. Wujiaba airport was the primary airport for Kunming. It had served Kunming since 1922. In 2012 the airport was closed and moved out. After the airport moved out, the city was seeking new development for the site and surrounding area. The rich history and unique context of the site make this place a potential location to demonstrate the ecological function that the infrastructure can provide.

5.1.1 History of the Airport

As mentioned earlier, during the Ming and Qing dynasty, a large amount of marshland merged along the shoreline. Kunming expanded towards the coastline, people reclaimed marshland and converted it into farmland (Kunming Dianchi Management Bureau, 2015). Wujiaba was a village located on the southeast side of Kunming. At the end of Qing dynasty, the land around Wujiaba was expropriated to build a training ground for the military. After the demise of Qing, during the warlord politic period, the local governor established the first airport and aviation school in Yunnan Province(Figure 55). It is also one of the first airports and aviation schools in China. During WWII Kunming served as the most important transportation hub in Southeast Asia. Military and civilian supplies were collected from southern Asia and distributed to China through Kunming. Wujiaba airport was used as the air force base for the American Volunteer Group (AVG) to operate airlift and defense

missions (Figure 57). After the war, the airport was taken over by the central government and operated for both military and civilian use. As the city grew the airport kept expanding, and it became one of the busiest airports in the country. It has been the gateway airport to connect China with Southeast Asia. Every year millions of travelers and million of tons of cargo go through this airport to be distributed across China and Southeast Asia. With the city expanding, Wujiaba airport became surrounded by the city. At the same time, the airport reached its maximum capacity. To accommodate the growth of the city, and upgrade the airport capacity, a new airport has been built. In 2012, the airport moved to its new location (China Yunnan TV, 2014). The old airport, which served the city for 90 years, was been closed down permanently.

Figure 60. Wujiaba Airport 1940s

Figure 61. Wujiaba Airport 1980s

Figure 62. Wujiaba Airport 2000s

5.1.2 The Evolvement of the Airport Landscape

The development of the old airport lands and surrounding area was spontaneous. When the airport was built, it was converted from training ground to an airfield. During WWII, to accommodate airlift operations, the airport was expanded, and the surrounding farmland was taken (China Yunnan TV, 2014). After economic reform in China, the city developed toward the Dianchi Lake, especially towards its southeast side. With the city growing, the airport became busier and busier. Many service buildings and warehouses were built around the airport to have closer proximity to the transportation hub. Local farmers leased their land and houses for the expansion of the industry. When the airport reached its maximum capacity, the

surrounding area was mainly occupied by a mix of high density residential and industrial but low rise built-up area. Only a few farm remained (Figure 63). On the northwest side of the site are service buildings, formal residential buildings and commercial buildings which served the airport and its staff. Most of the north, east and southeast area are occupied by industrial warehouses. Urban slums are woven into these areas to provide living space for warehouse workers and other low income people. The airport and its surrounding area formed its own operating system through time. With the airport moving out in 2012, the operating system of the airport and surrounding area was transformed. Most of the service buildings and warehouses are now abandoned and left idle.

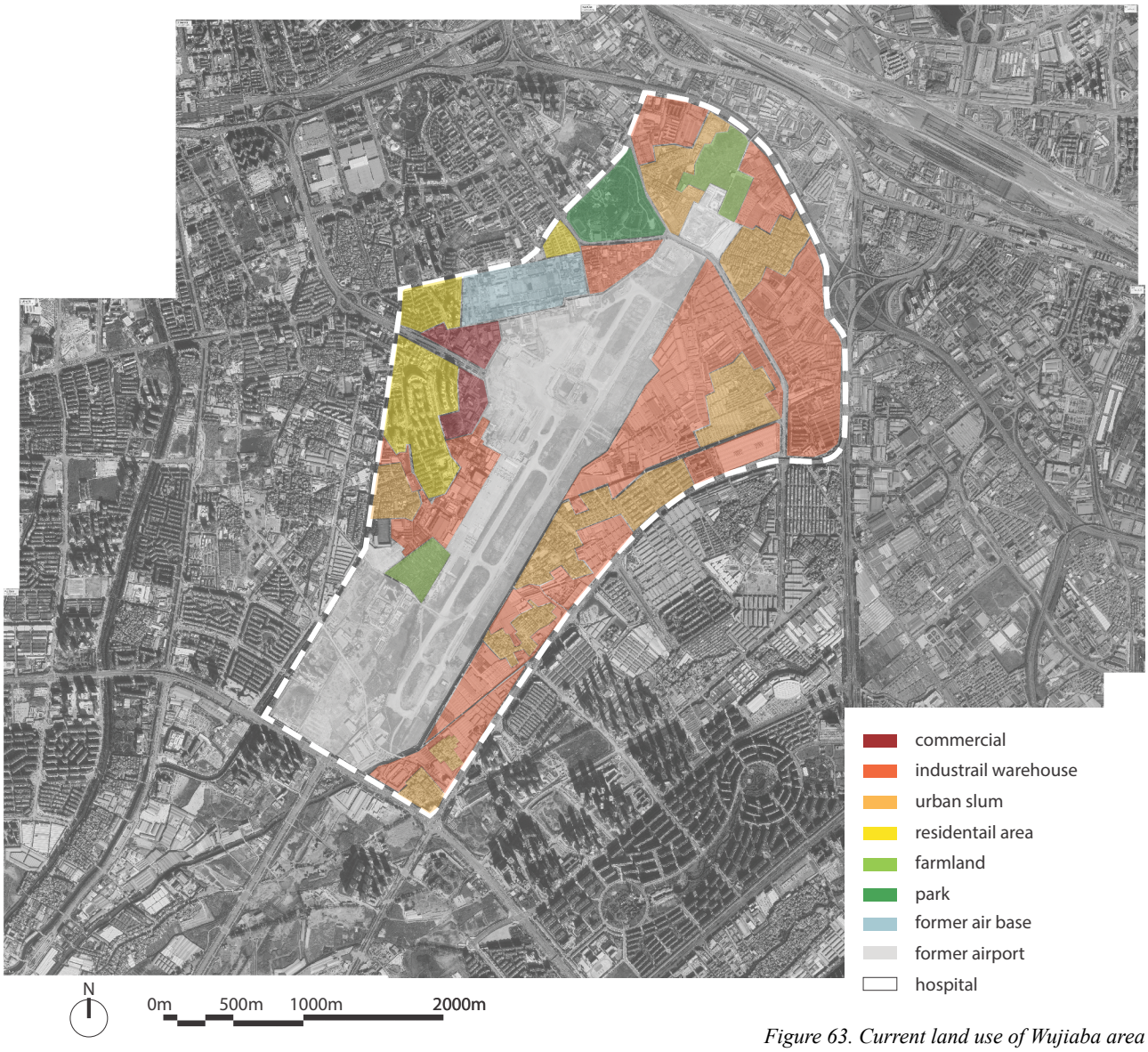


Figure 63. Current land use of Wujiaba area

5.1.3 Municipal Master Plan

Since the airport moved out, the city has been trying to regenerate the airfield and its surrounding area. The municipal government initiated a master plan development, which covers 986 hectares of land and designed to accommodate 220,000 residents. In 2014, the municipal government released the preliminary plan. In the plan, the airport and surrounding area were designed as a residential dominated mixed-use district. Commercial and mixed-use areas are located along with the central landscape. Supporting facilities such as hospitals, educational institutes, sports and recreational facilities, and cultural facilities are woven into the district (Figure 64, Figure 65). A case study on redesigning the airport landscape was carried out in order to understand the complexity of the airport regeneration and to explore the possibility of incorporating the airport design with the proposed ecological infrastructure.

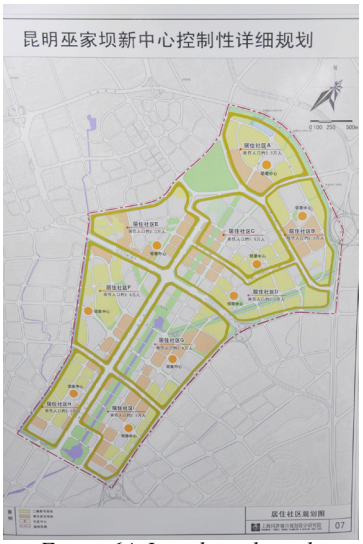


Figure 64. Initial residential area planning

Figure 65. Initial land use planning

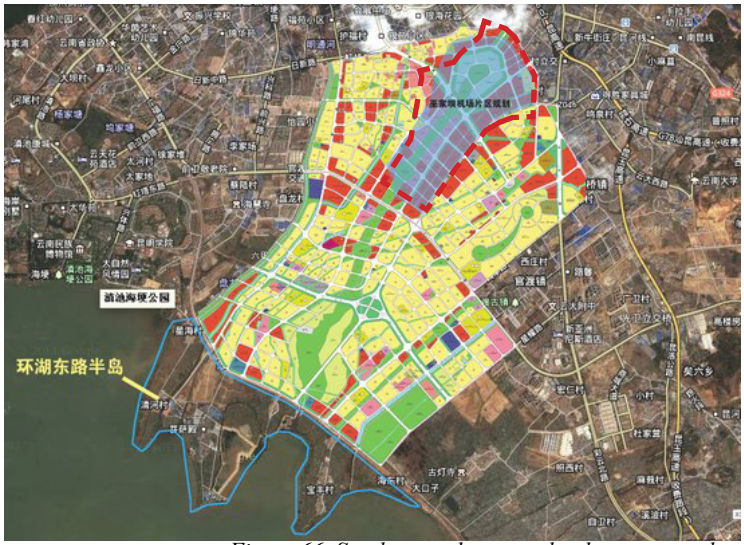
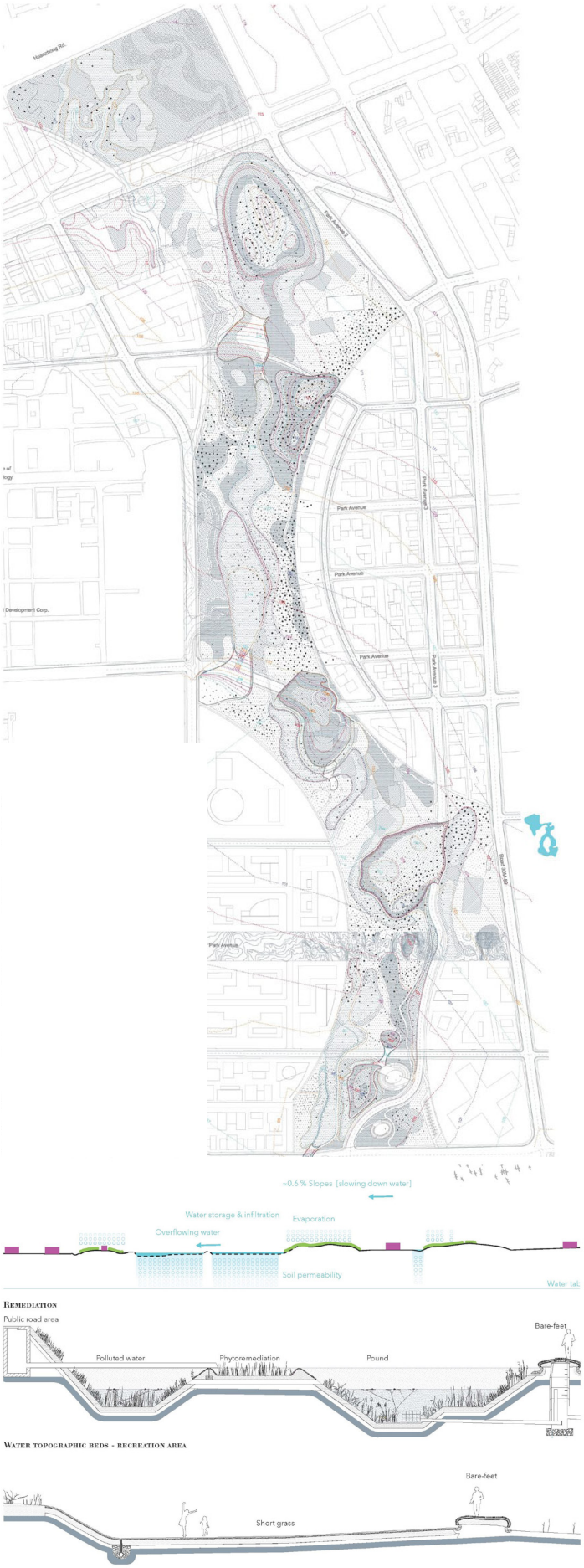


Figure 66. Southeast urban area land use mater plan

Figure 67. Site context



5.2 Airport Re-development Case Studies

With the nature of the airport landscape taking over a large amount of space, the post-aviation airport landscape can create multiple impacts. This research of precedents seeks to understand the redevelopment process and the opportunities that can be created.

Taichung Gateway Park

Taiwan, urban park, 70 hectares.

Designed by Mosbach Paysagistes and Philippe Rahm architects, the design follows Stan Allen Architect's master plan for revitalizing the former Shueinan Airport and surrounding area. The airport located in downtown Taichung, the third-largest city in Taiwan, served for military and commercial flights during the era under Japanese rule. In 2004, the airport was decommissioned. In 2007, the local government outlined the vision to redevelop and urbanize this area with a 70-hectare urban park as the central feature. The proposal seeks to create a green corridor that mitigates the extreme heat, humidity, and pollution, and provides an urban oasis for citizens. Different strategies such as land formation, varying vegetation, water features and, atomizers are used to reduce the heat, humidity, and pollution. Rainwater is captured and treated by vegetation throughout the site. Wind turbines are installed in the northern part of the park to supply the park's energy needs (Dümpelmann & Waldheim, 2016).

Reflection: The design of using vegetation and landform to create a microclimate, and use renewable energy as the power source can be adapted into the practicum.

Figure 68. Taichung gateway park by Mosbach Paysagistes and Philippe Rahm Architect

Stapleton Airport Redevelopment

Denver, residential development, 1,900 hectares

Stapleton international airport was the primary airport located on the northeast of Denver, Colorado. With development of the surrounding area and the expansion of the airfield, the airport reached its maximum capacity during the late 1980s (Webb, W., Lewid, H., Martin, R., & Atler, L, 1995). After the airport closed in 1995, a master plan for redeveloping the site to integrate with Denver's urban fabric was beginning to take shape. The design guidelines developed by the Stapleton Development Foundation sought a new urban development vision that focused on defining "centers for services and civic uses, walkable scale, access to nearby employment, diverse transportation options, and strong connections to parks and nature." (Dümpelmann & Waldheim, 2016) Several design firms contributed to the master plan. Following the design guidelines green spaces such as parks, streetscapes, and greenways; open space facilities such as amphitheaters, pools, and plazas were implemented around residential development (Dümpelmann & Waldheim, 2016). Topography was manipulated to create a green corridor to go through the center of the site. Wildlife habitats and native landscape were established along the green corridor while using the topography to create a cost-efficient stormwater management system (Andropogon).
This airport redevelopment is one of the largest master-planned communities in the country and covers 1,900 hectares of land with 25,000 residents and 30,000 jobs. The airport control tower has been maintained as a landmark for the community (Dümpelmann & Waldheim, 2016).

Reflection: The development history of Stapleton Airport has some similarities with Wujiaba Airport. The strategy of programming a variety of public spaces to connect residents with nature, and using landforms to manage stormwater, and establish wildlife habitat can be introduced to the Wujiaba Airport redevelopment.

Figure 69. Stapleton airport redevelopment master plan

Orange County Great Park
Orange County, suburban park

The Orange County Great Park is located on the former Marine Corps Air Station El Toro near Irvine, California. In the design proposal by Hargreaves Associates water is the driving force that determined the form and program within the park design. Sustainability is the functional imperative that frames five design elements, water, nature, activity, culture, and infrastructure, to cooperate (Hargreaves.com, 2019). Four primary landscape types: native oak grassland, irrigated fields, riparian corridors, and productive landscape are designed based on the water network system across the site. The native oak grassland is the main landscape type, connecting each part of the park. Irrigated fields are scattered among the park. The productive landscape is the memory of the agricultural heritage of the region and it functions as a self-sustaining model for the park and surrounding neighborhood. Riparian habitats occupied the drainage corridors. Large open spaces designed to accommodate public events and sporting activities are distributed throughout the park (Dümpelmann & Waldheim, 2016).

Reflection: The idea of using water as the central design element to connect different landscape features and providing cultural and educational opportunities can be incorporated in the site design.

Figure 70. Orange County Great Park by Hargreaves Associates

Summary

In short, through this examination of precedents it is suggesed that revitalization of the decommissioned airports offers opportunities to experiment with new models for urban development, social engagement, and ecological succession. Although the designers, city governments, and developers attempt to use decommissioned airfields to catalyze urban development, and shaping the future urban landscape, the enormity, openness, and flatness of the site, and the detachment from the surrounding area often present difficulties for their adaptation and reuse. It is necessary to develop ways to reduce these difficulties. Airfield revitalization should have a central objective of that benefiting the social, environmental, or economic aspects of the region. A range of other functions should also be implemented in parallel with the revitalization process to diversify the benefits of the site for the surrounding area. Through the design process, landforms can be created to help organize space, alleviate the emptiness of the airfield, and manage the site drainage. Unearthing and layering the history of the site can encourage social interaction, and restore wildlife habitat which creates educational experiences, and preserves natural and cultural heritage. Introducing specific plant species to remediate contaminated soil and water through the site can alliviate site contamination, improve site ecosystems, and also provide educationsl experiences. Design methods like these can help to fulfill the revitalization objective and integrate the site with its context.

5.3 Schematic Design and General Strategy

The water-management-based ecological infrastructure that was proposed in the preceding chapter will determine the primary functions of the site. Combined with the lessons learned from the examination of precedents, other functional design and programs will be implemented to promote social interaction and cultural awareness.

5.3.1 Preliminary Plan

Following the initial planning idea developed by the city, the Wujiaba airport redevelopment area will be designated as a high-density residential oriented, mixed use zone with commercial and recreational development. The majority of the airfield will be converted into an ecological corridor with recreational and cultural infrastructure connecting with the existing park on the north, and the proposed ecological infrastructure on the south. Large scale

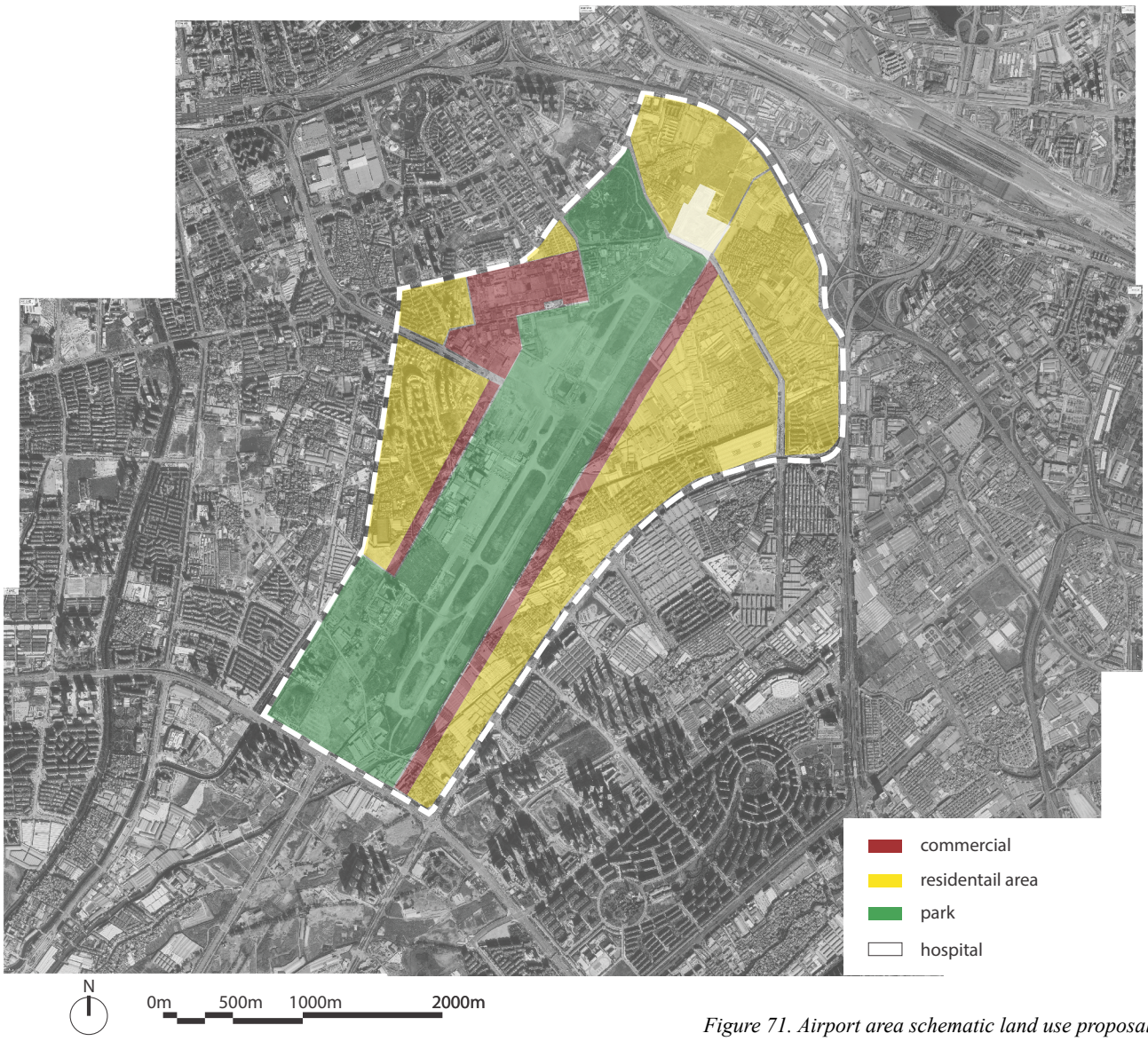


Figure 71. Airport area schematic land use proposal

mixed-use commercial development such as shopping centers, office buildings, and movie theaters will occupy the former military base. Small scale commercial development such as strip malls, restaurants and, grocery stores will be scattered along the southeast side of the park for the daily use by the residents. (Figure 71)

5.3.2 Traffic Configuration

The 4.3 kilometre long northeast to southwest oriented airport determined the layout of the road network around the area. The major roads run in a north-south direction, and the only east-west major road connections are located on the north and south ends of the airport. The east-west traffic accumulates on these roads, creating constant traffic congestion. The Wujiaba airport revitalization is primarily a residential development with 200,000 residents, which could create enormous additional pressure on the existing road network. A new network of roads is proposed to alleviate the pressure on the existing roads. Two major north-south roads will run through the former airfield connecting to the existing road network. The two north-south oriented roads guide the traffic through the central green corridor providing a scenic driving experience through the urban forest. One six-lane east-west oriented road will be built across the upper side of the site to increase east-west connection. Several 4 to 2 lane east-west oriented roads are proposed to accommodate local traffic. Moreover, public transportation such as bus routes, and subway routes will be promoted in the new traffic network (Figure 72, Figure 73).

Figure 72. Proposed traffic map 1

Figure 73. Proposed traffic map 2

5.3.3 Functional Programing

This practicum focuses on the revitalization of the airfield. The land use of the site follows the schematic plan. With the site context and history in mind, different types of land use are arranged along the green corridor. From north to south, the active recreation area, and cultural and leisure areas are located on the north end of the site based on context and local custom. A small scale linear commercial area is arranged along the east side of the green corridor. On the west side, the former terminal and service building area are designated as a large scale mixed-use commercial area, and cultural and leisure area. On the south side, the last patch of remaining agricultural land will be kept and redesigned as a productive landscape. On the southwest corner of the site, some residential development has already taken place. The southwest corner will be designated as a residential area with a stream running through it. The central axis of the green corridor will be designed as the major water management landscape. The canal running from the northeast of the site will be directed into the central water management corridor. Canal water, stormwater, municipal wastewater, and runoff will be treated in the central landscape through various methods. The treated clean water will be reused or released to flow downstream.

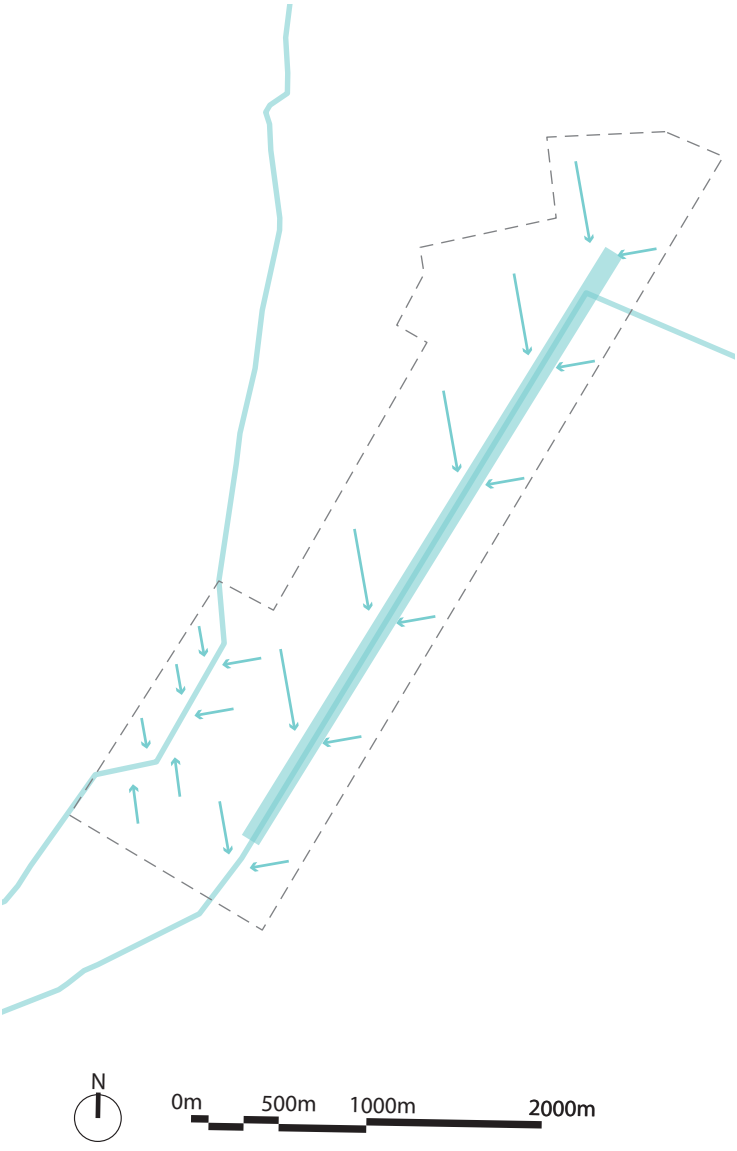


Figure 74. Proposed drainage schematic plan

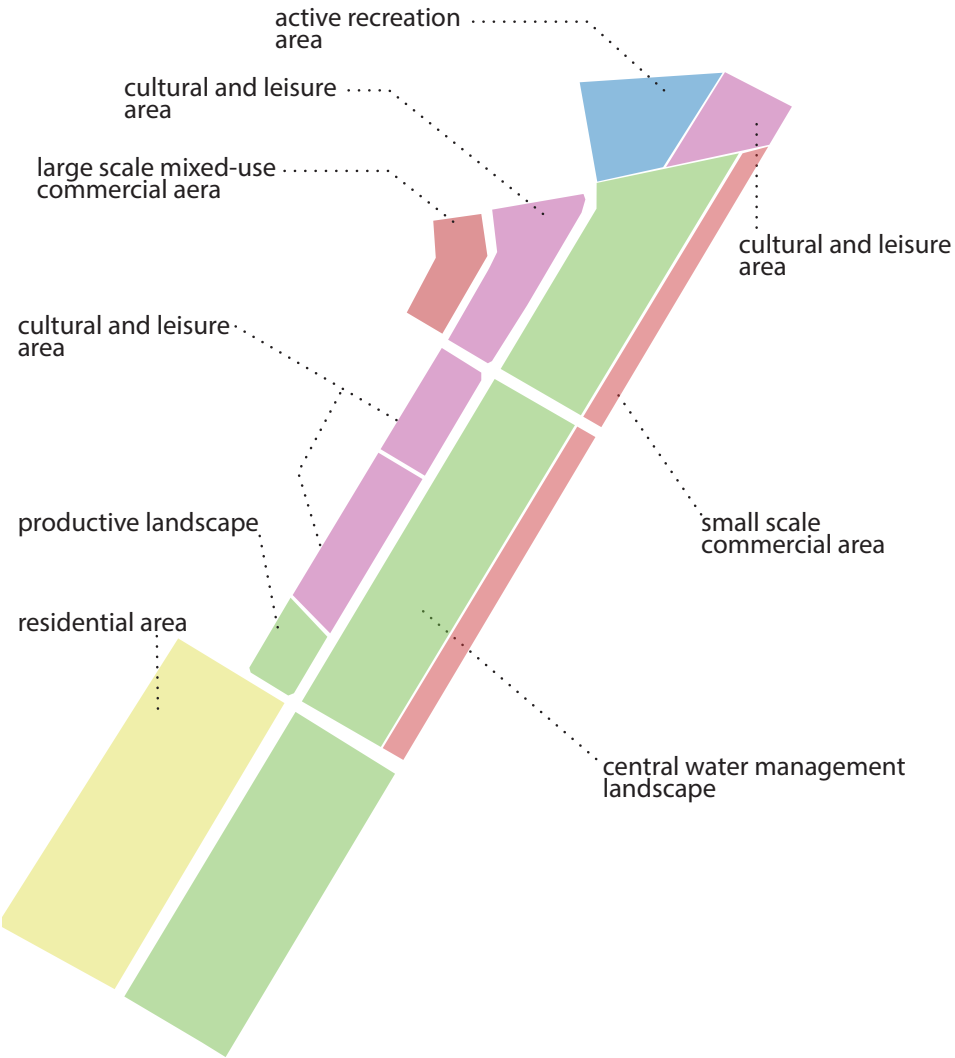


Figure 75. Proposed land use plan

5.4 Site Design

The design concept is to have a central linear water management oriented landscape design to collect, clean, store and reuse the water, while other functional modules will be arranged around the central corridor to achieve comprehensive social, economic and ecological services. Moreover, the redevelopment of the former airport connects to the city-wide ecological infrastructure for water management. The narrative of the design will start from the functional modules and move from north to south and demonstrate the central landscape.

Figure 76. Site Plan

Figure 77. Annotated site plan

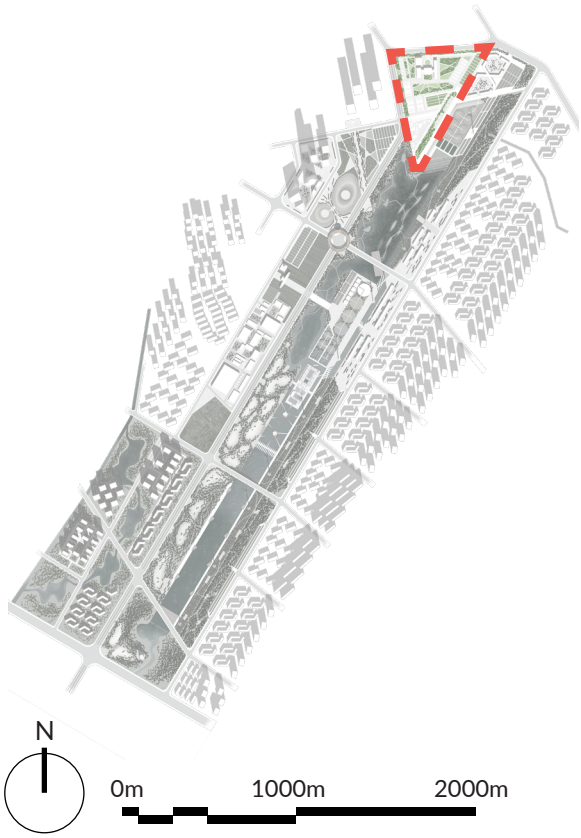


Figure 78. Annotated site plan 1

5.4.1 Ecological Service Module

Sports Park

The district sports facilities such as swimming pool, tennis courts, and badminton courts are located on the north side of the airport. After several years of development, the sports facilities were out of date, and the south side of this area was converted into industrial warehouses. The design proposal reclaims this area for active living. The existing indoor swimming pool, and indoor badminton buildings will remain. The industrial warehouse will be demolished for new sports fields and green space. Three soccer fields, six outdoor basketball grounds, eight tennis courts, and parking space will be implemented in this area. A go-cart race track will be located on the south side of the sports park. The decommissioned taxiway will be partially retained and converted into a drag-race strip. The sports park is designated to encourage citizens to visit the site and promote health and well-being, and active living.

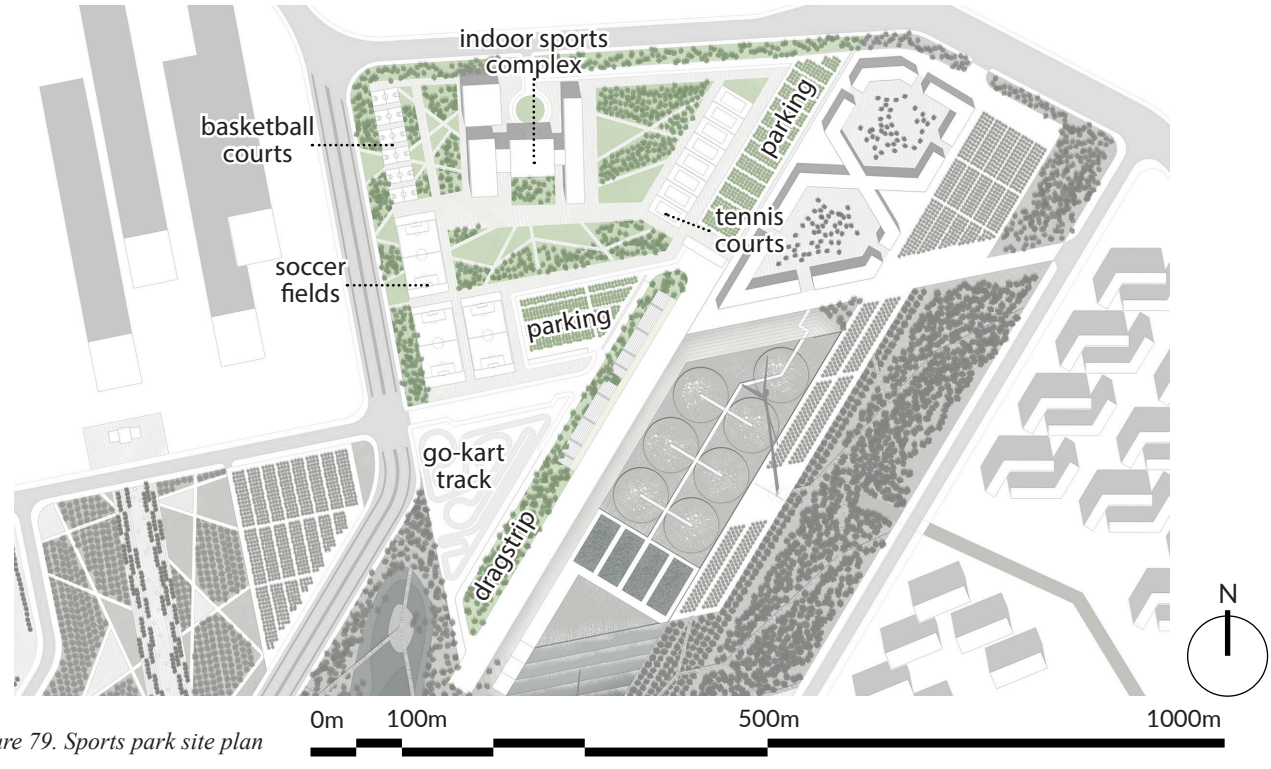


Figure 79. Sports park site plan

Farmer's Market

At the end of the runway outside of the airport was an area for self-organized farmer's markets for decades. During the weekend hundred of thousands of people from the surrounding area gathered around this area to sell and buy goods. After a major road was built on the north side of the airport, conflict between traffic and the local market started. During the weekend the market partially occupied the road causing traffic congestion. In order to solve the issue, the north end of the runway will be transformed into a farmer's market. A three story building in the shape of an "8" will form two courtyards for the different market events. Permeable parking spaces will be located on the east side of the market. Dawn Redwood tree (*Metasequoia glyptostroboides*) will be planted in a grid which allows cars to park in-between them. The tree canopy can provide shade to the vehicles, and the permeable surface can capture the rainwater. This parking design strategy will be applied through all parking space in the project.

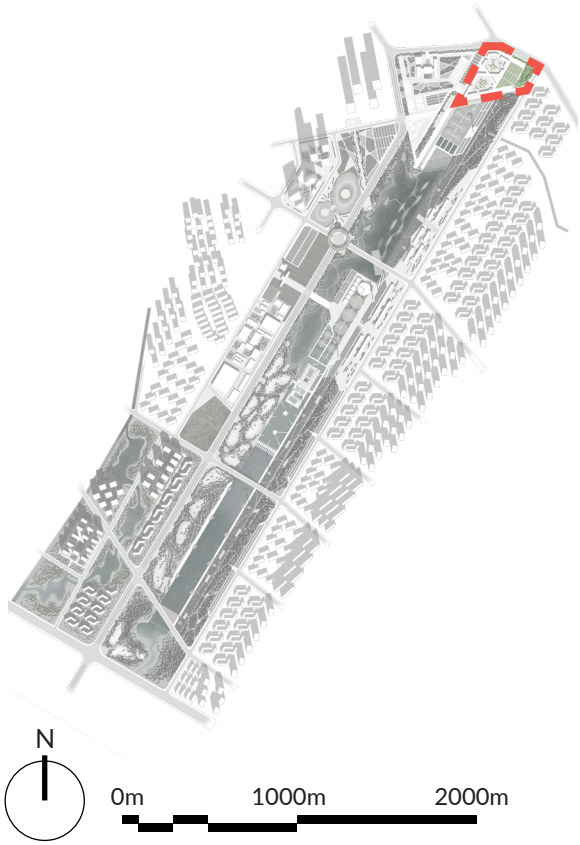


Figure 80. Annotated site plan 2

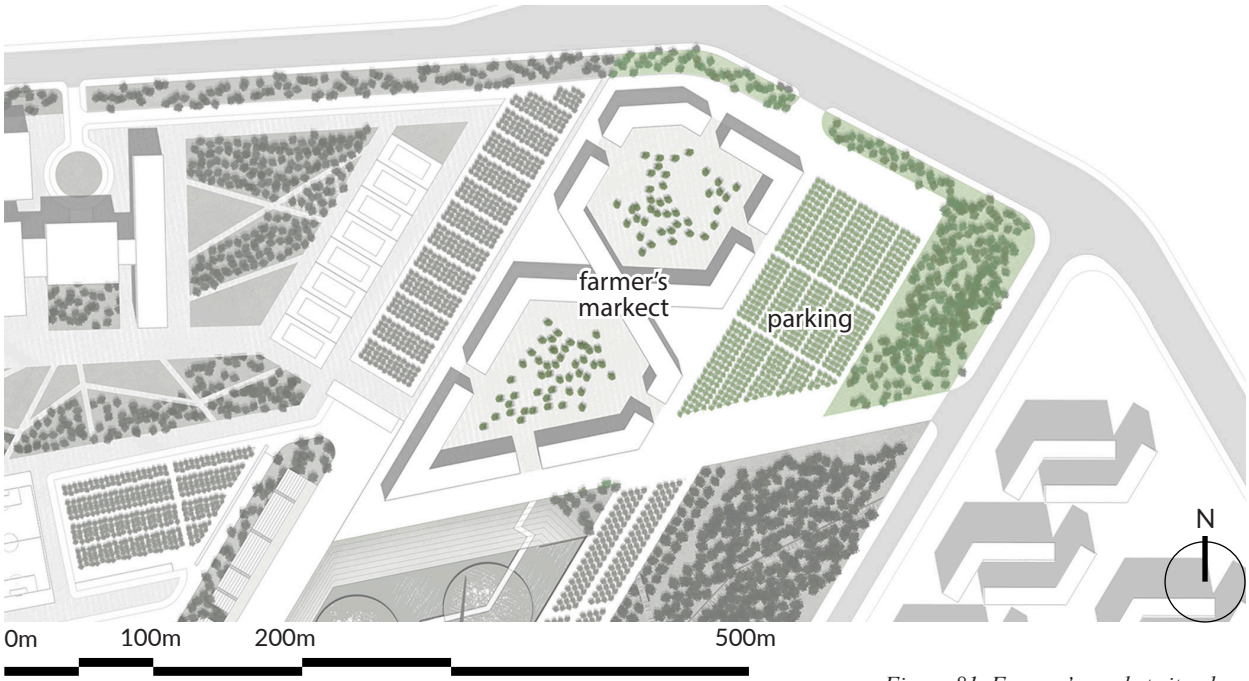


Figure 81. Farmer's market site plan

Figure 82. WWII memorial plaza site plan

WWII Memorial Plaza

On the west side of the sports park was the former apron for the air force, and the remaining command room for the AVG during WWII. The AVG command room is preserved as a historical building facing south towards the airport. Through the design, a linear plaza is formed along the axis of the AVG command room. Geometric shapes formed by linear paths are located along the two sides of the linear plaza. The linear plaza embodies the long and parlous journey of the airlifting mission, which played a significant role in China during WWII. Along the Hump airlifting route many aircraft crashed into the mountain and valley during the mission. The remaining pieces from the crashed planes reflect the sunlight to form a string of beacons to guide the aircraft to fly over the rugged mountains to the destination safely. Polished stainless steel panels embedded along the plaza are embodying the aircraft that crashed along the Hump airlift route and. The Yunnan pin trees (*Pinus yunanensis*) which are planted in rows along the linear plaza, are in memory of the people who sacrificed their life to secure the airlift route. Lattice planted Dawn Redwood trees will cover most of the geometric shapes formed by linear paths. Some of them will be constructed as open space with lawn or hardscape. Retrieved and restored aircraft from the missions will be placed in these open space and explained with interpretive signages for visitors to learn their history.

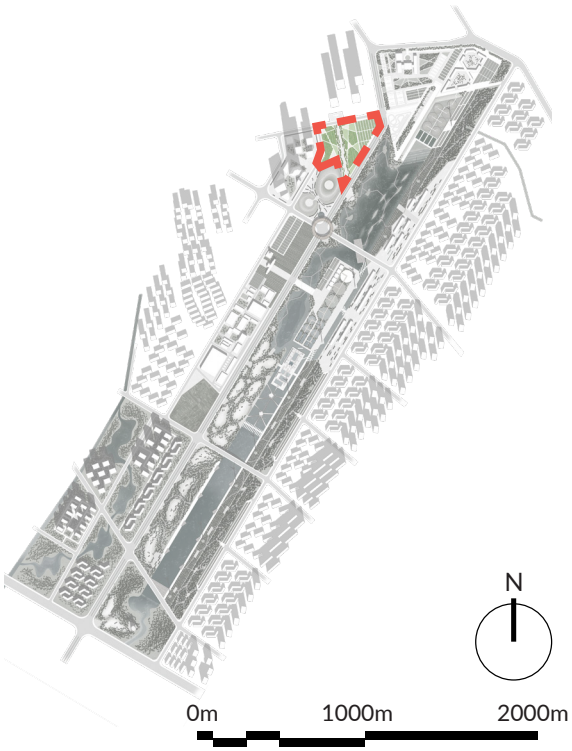


Figure 83. Annotated site plan 3

Event Space

The event space is formed by two crater-shape landforms which use the soil from the excavation of the wetland from the central water management landscape. These two craters create one closed and one semi-closed public event spaces. The center platform is designated for events such as concerts, performances, and exhibitions, and others. The surrounding slope functions as a seating area for audiences. A threshold corridor connects these two craters, and funnels the stream of people from the mixed-use commercial district to the park's central landscape.

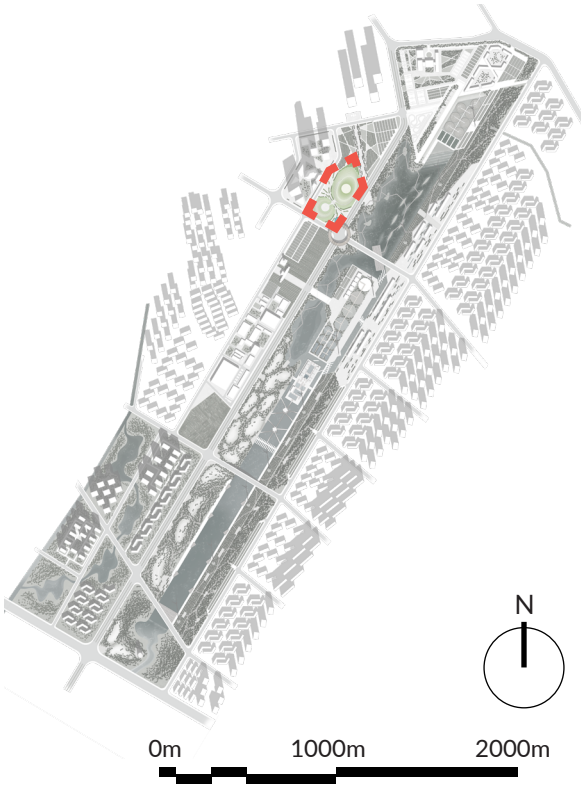
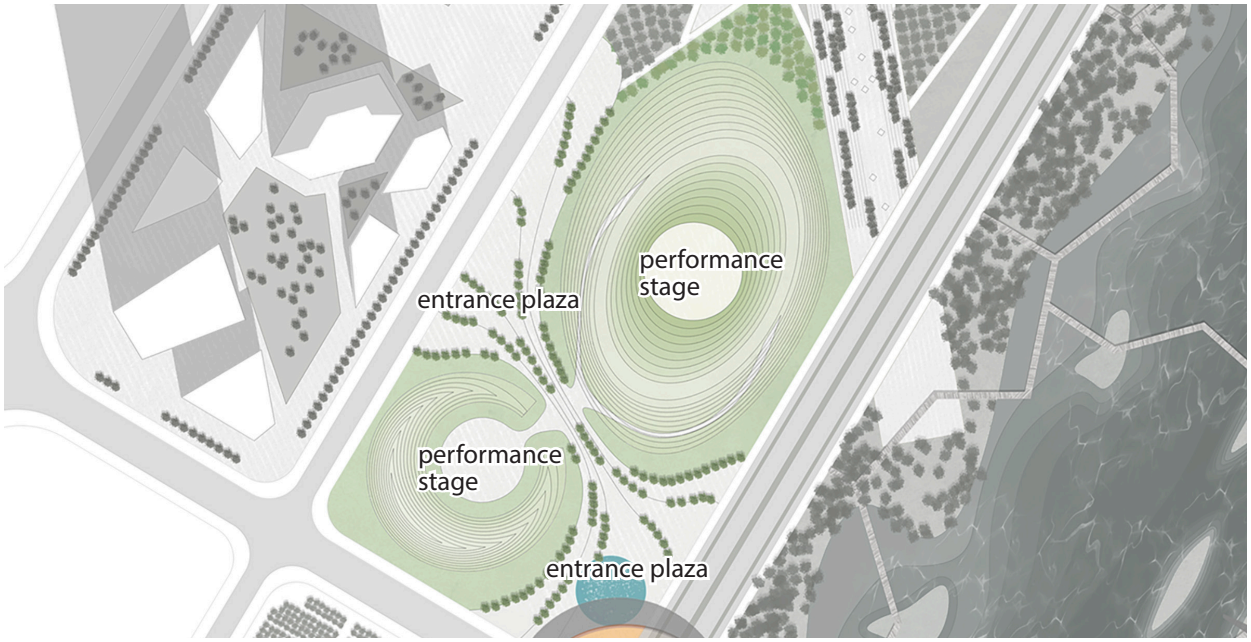


Figure 84. Annotated site plan 4



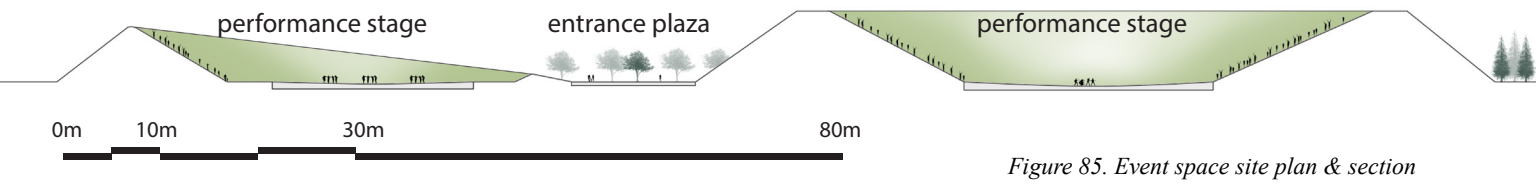


Figure 85. Event space site plan & section

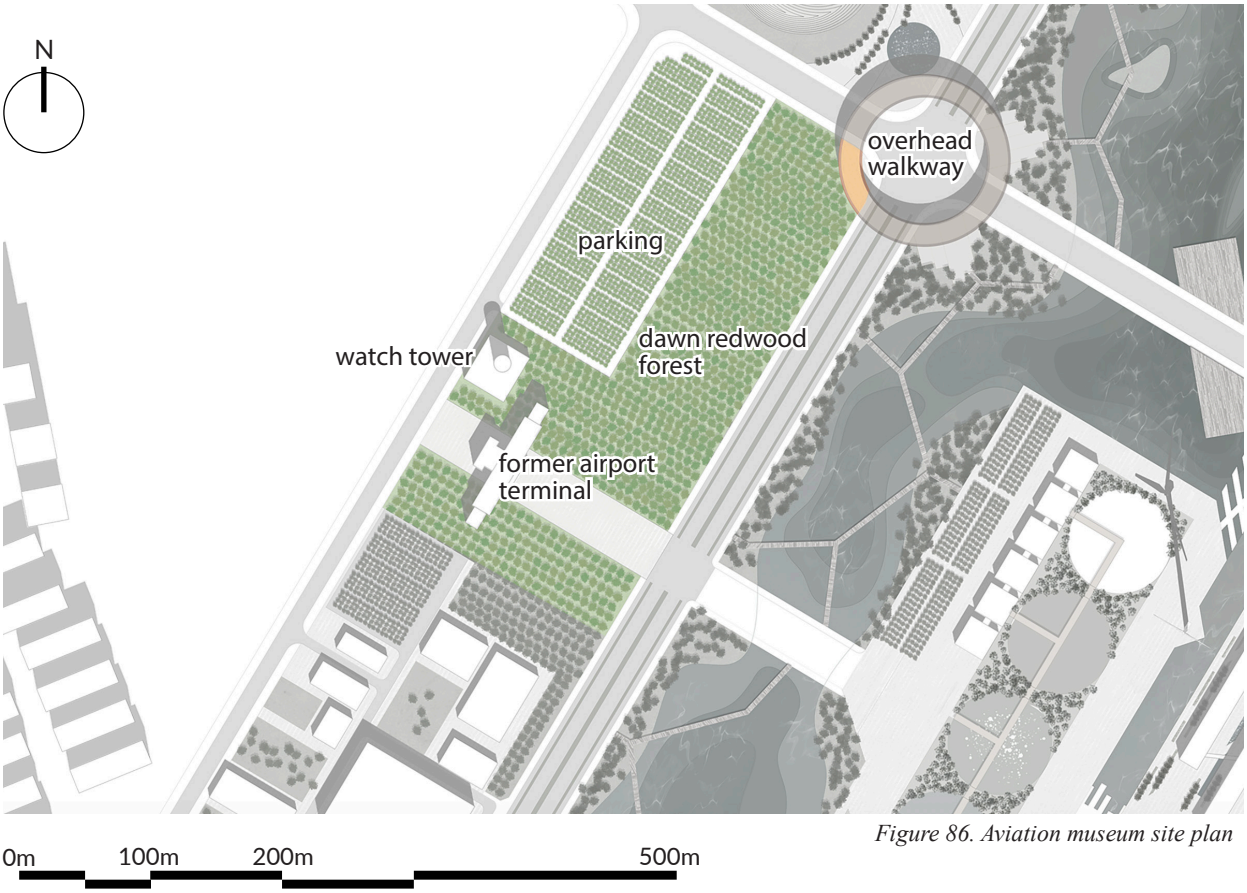


Figure 86. Aviation museum site plan

Aviation Museum

Across the circular pedestrian bridge on the southwest side of the event space is the formal first-generation civil airport terminal building and control tower which have been preserved as historical buildings. The terminal building and control tower will be transformed into an aviation museum to demonstrate the aviation history and the cultural and economic impact of the aviation industry on the development of the province.

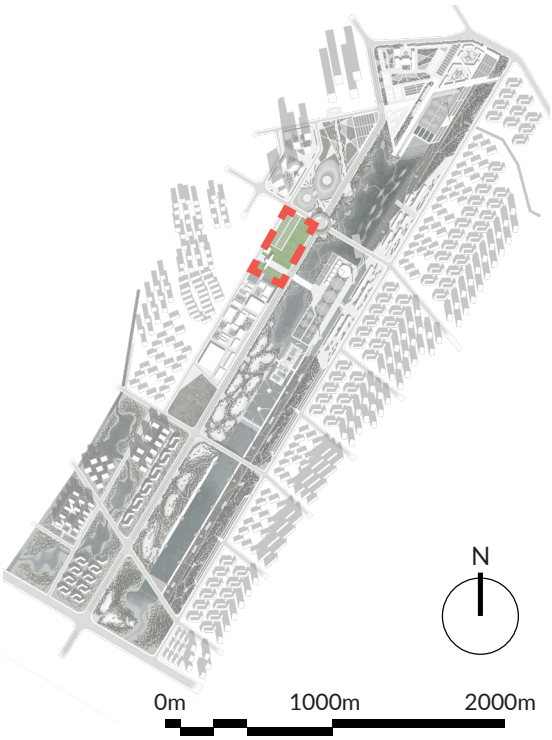


Figure 87. Annotated site plan 5

Cultural and Innovation Park

On the south side of the aviation museum were the former storage and service buildings. Some of the buildings have large structural spans and interior space such as the aircraft hanger and freight terminal. Smaller warehouses and workshops are concentrated around the large buildings. The design will transform these buildings into a cultural and innovation park. The large buildings will be converted into galleries and exhibition space. Some of the smaller buildings will be demolished to form outdoor space. The remaining smaller buildings will be transformed into studios, and offices to house artists, designers, innovation companies, and emerging enterprises. The cultural and innovation park will retain its industrial materiality to project the culture of the aviation industry.

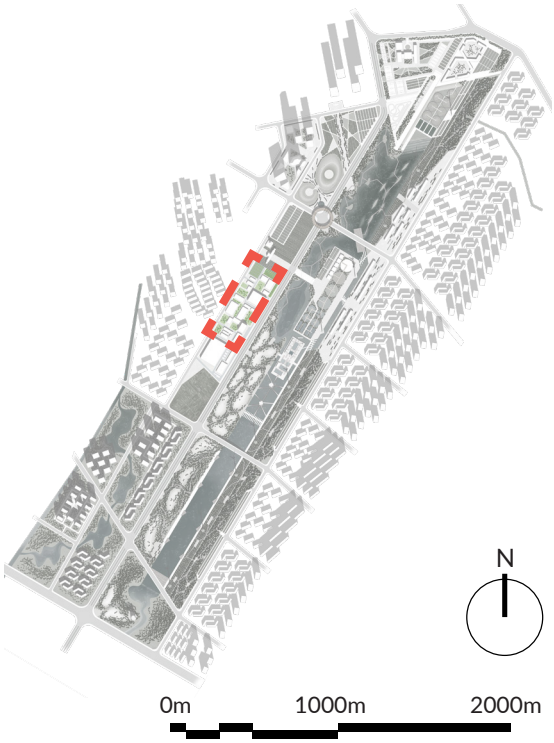


Figure 88. Annotated site plan 6

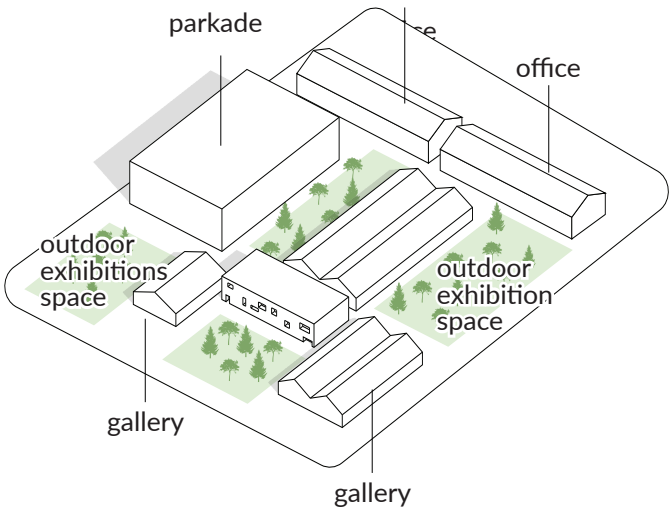


Figure 89. Cultural and innovation park site plan

Community Garden

Moving to the south side of the cultural and innovation park is one of the last farmlands that remained on site. This eight hectare area will be designed as a community garden to experiment with urban agriculture. The design principle of the land follows the local organic farming tradition. The proposed community garden will be divided into smaller patches based on the existing land pattern. Fish ponds are located along the southeast edge of the site. The fish ponds work as the water and nutrition source for the farmland. Runoff and rainwater collected in the ponds will irrigate the farmland. The excrement from the fish and the remains of aquatic species are processed as fertilizer for the farmland. Moreover, the by-products of the community garden such as surplus crops, leftover vegetable stems and fruits can be collected and processed as the food source for the fish. The farmed fish and crops can be sold to generate profit for the community garden's operation.
In addition, this closed-loop agricultural tradition will be promoted through the proposed ecological infrastructure in a suitable area to reflect the lost tradition and culture.

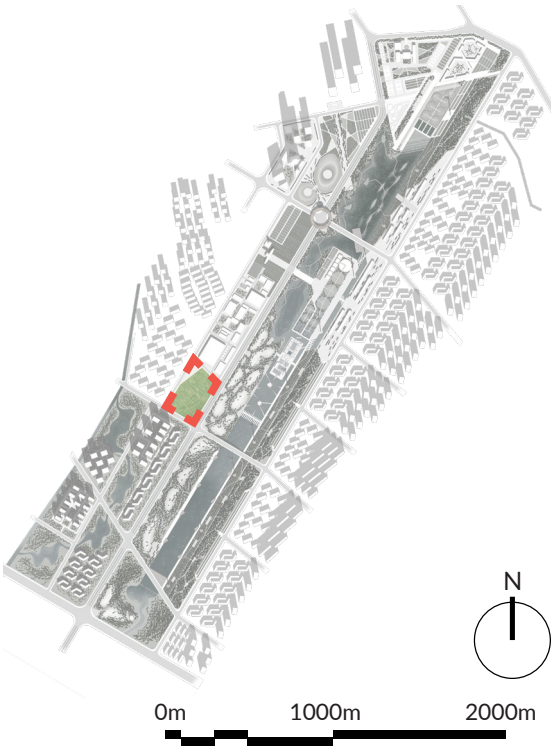


Figure 90. Annotated site plan 7

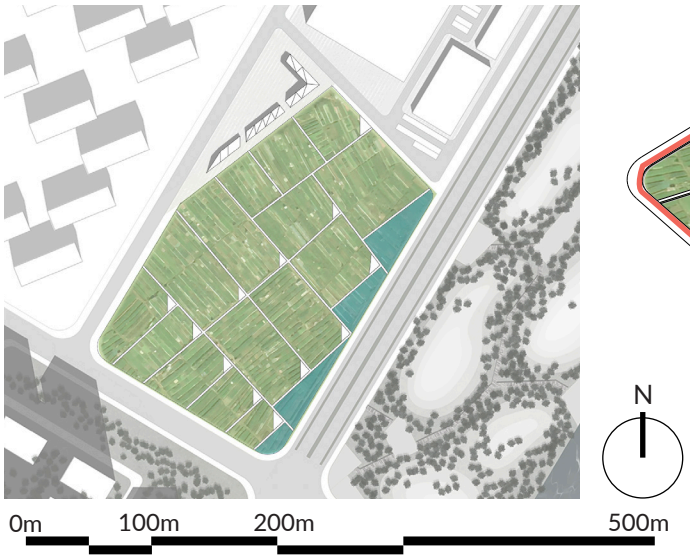


Figure 91. Community garden

Residential Development

At the southwest corner of the site is a group of residential developments which have been built since the airport closed. The planning proposal for this area seeks to adapt the existing development and improve the water management capacity of the site. As the residential area was primarily divided into five sections, each section should be developed with the capacity to manage the stormwater on-site as a form of retention pond or rain garden. In addition, the on-site stormwater management features will connect to each other, and the canal on the west side of the site. A water management corridor will be formed through the residential area, and water from the site and canal will be treated through the corridor and released to the downstream.

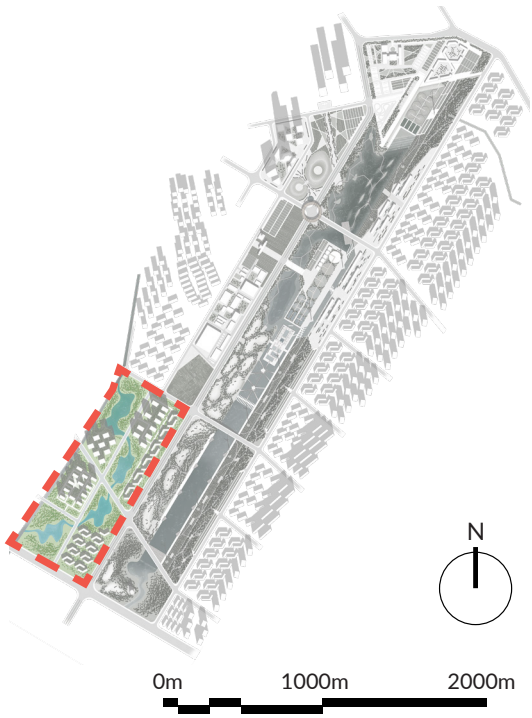


Figure 92. Annotated site plan 8

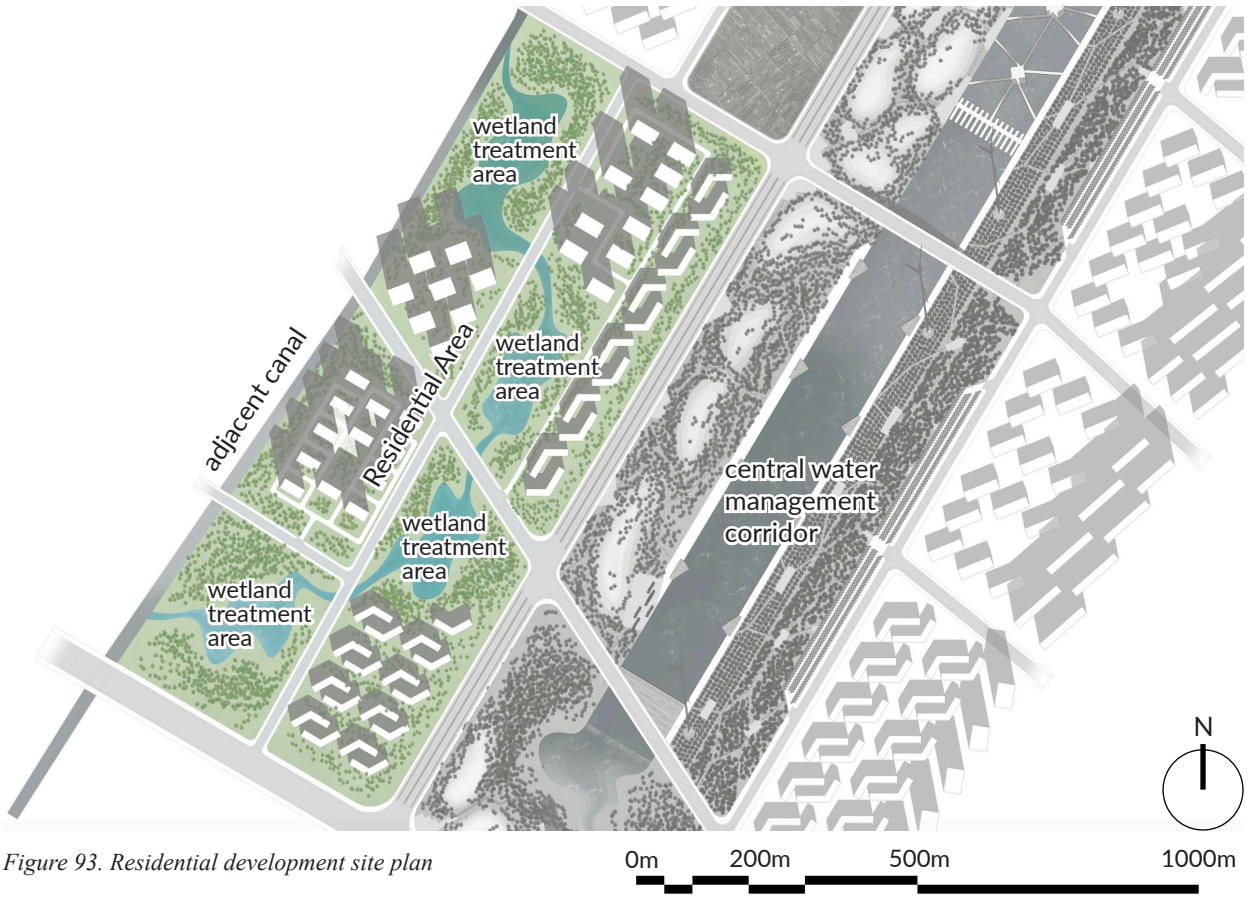


Figure 93. Residential development site plan

Linear Commercial Plaza

On the east side, the linear commercial plaza runs the edge of the site for over 1500 metres. Two to three story linear retail stores will be built along the plaza to form a pedestrian-friendly commercial space. The buildings will be divided into small sections to allow visitors to have access to the central part of the park. Underground parking and additional ground parking for visitors are proposed on the south side. Multiple pedestrian bridges are proposed to provide access from across the street. This linear commercial space will mainly serve the residential development on the east side of the site on a daily base. Also, it functions as one of the major threshold spaces to introduce people to the regional water management park.

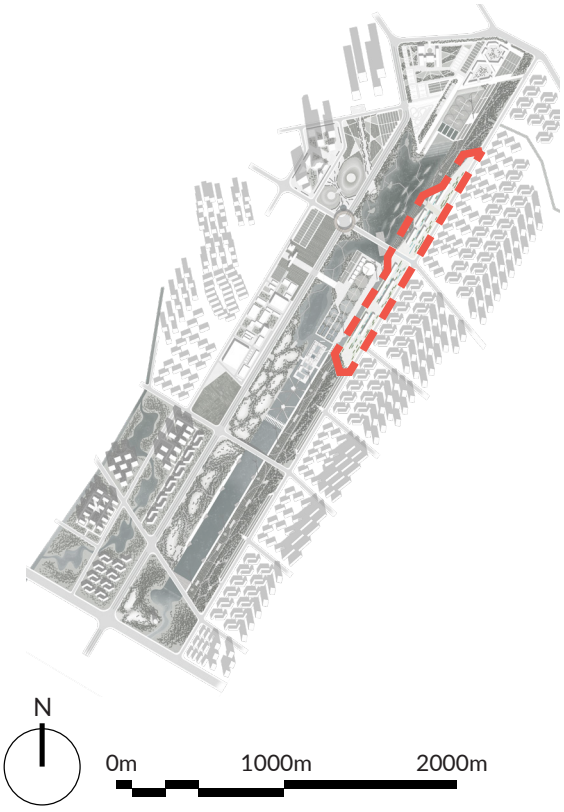


Figure 94. Annotated site plan 9

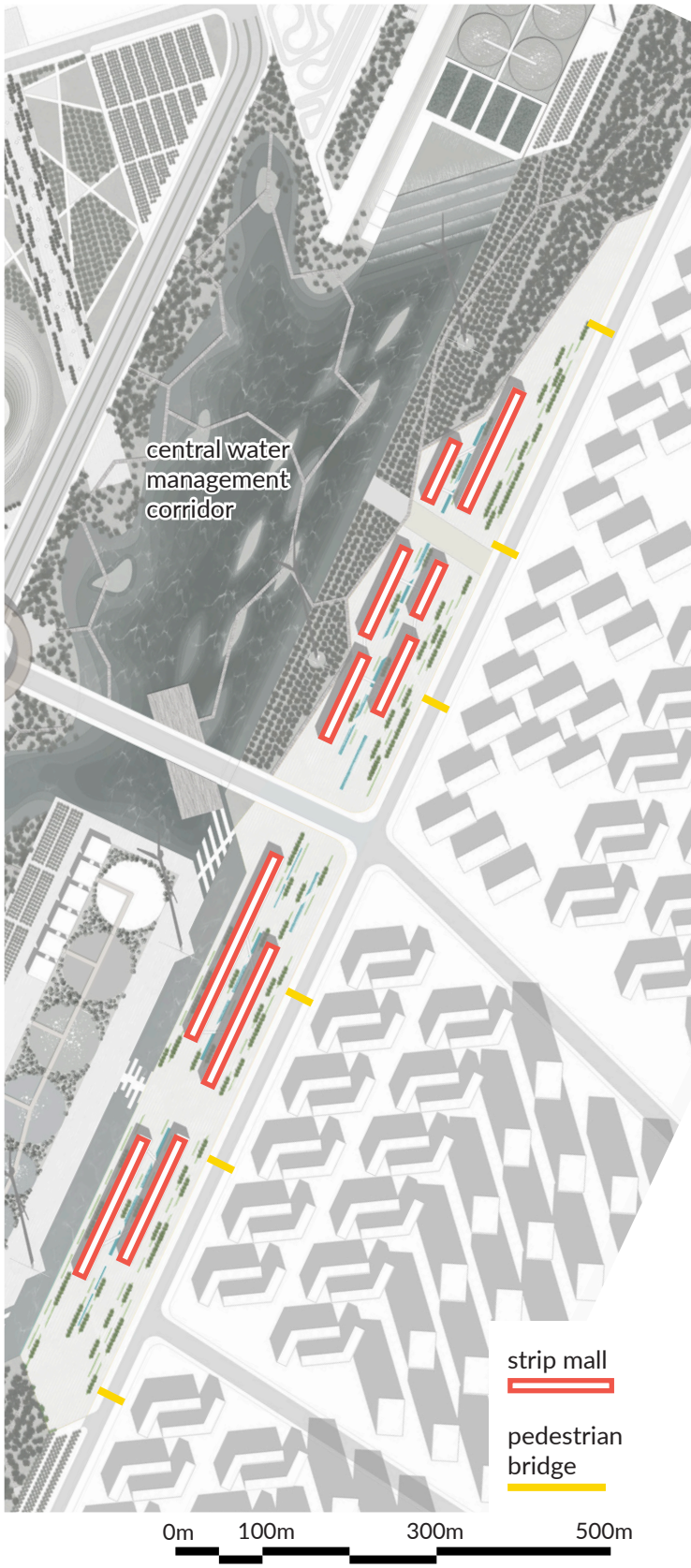


Figure 95. Linear commercial plaza site plan

5.4.2 Central Water Management Corridor

The central water management corridor will be designed and developed into seven sections following the general direction of the runway. Each section of the water management corridor will provide ecological, recreational, or educational functions. As an entity, this corridor will demonstrate the new concept of urban water management through a landscape architecture approach.

Primary Treatment Area

On the south side of the farmer's market is the first section of the central water management corridor. The primary treatment section is constructed with an elevated water treatment basin, which has the capacity to hold up to 380,000 tons of non-treated water. Water from the nearby canal, greywater collected by the wastewater pipes, and stormwater collected from the site will be pumped into the basin. Within the treatment basin, water will be screened to filter out large particles such as rocks in the grit chambers. Then it will go through the primary clarifier to remove particles larger than 10 micrometers. After the primary treatment, the water will flow through a set of phyto-technology experiment basins for nutrition removal. In the experiment basins, common water hyacinth (*Eichhornia crassipes*) will be used to take up nitrogen and phosphorus in the water. Since common water hyacinth is an invasive species with strong growing and spreading capacity, the plants need to be maintained within this area. After the nitrogen and phosphorus take-up, the water will go through the aeration water cascade to enrich the oxygen level for the next stage treatment.

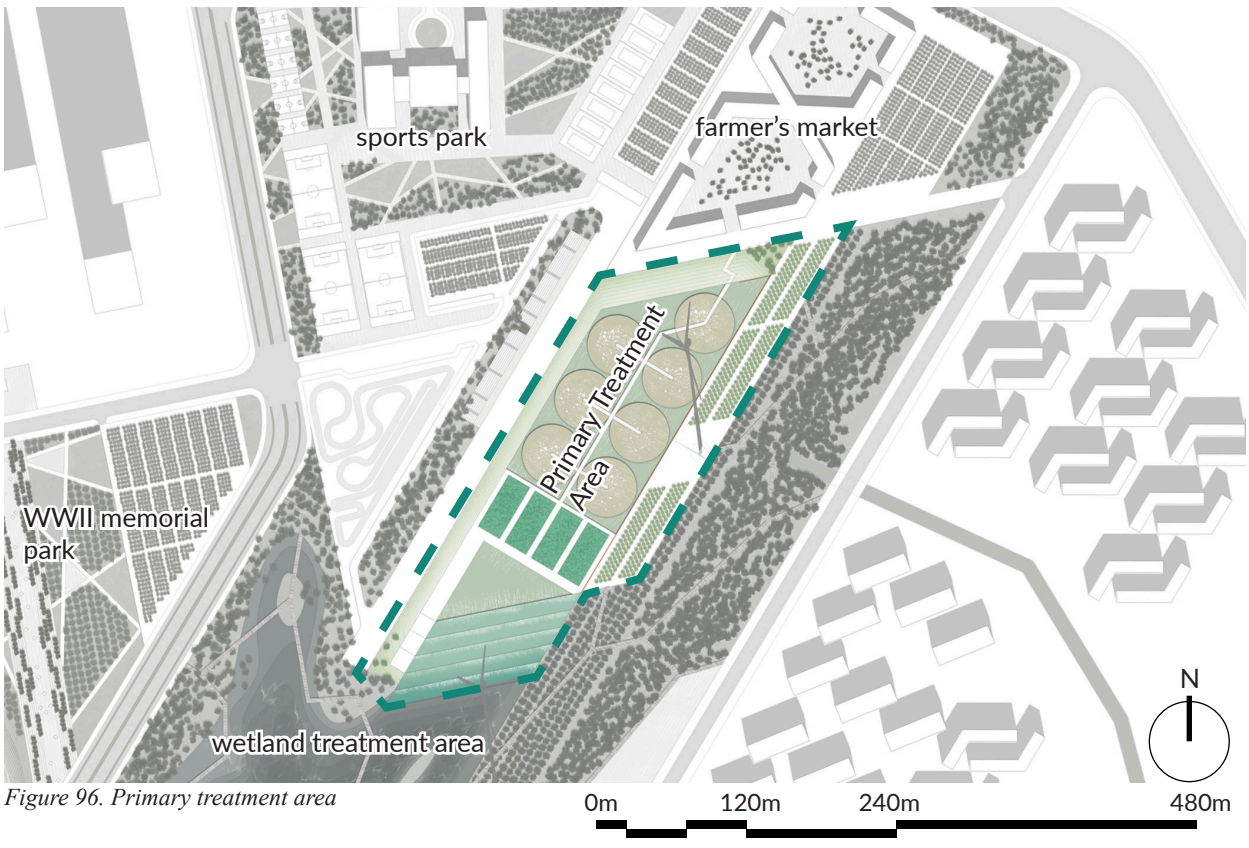


Figure 96. Primary treatment area

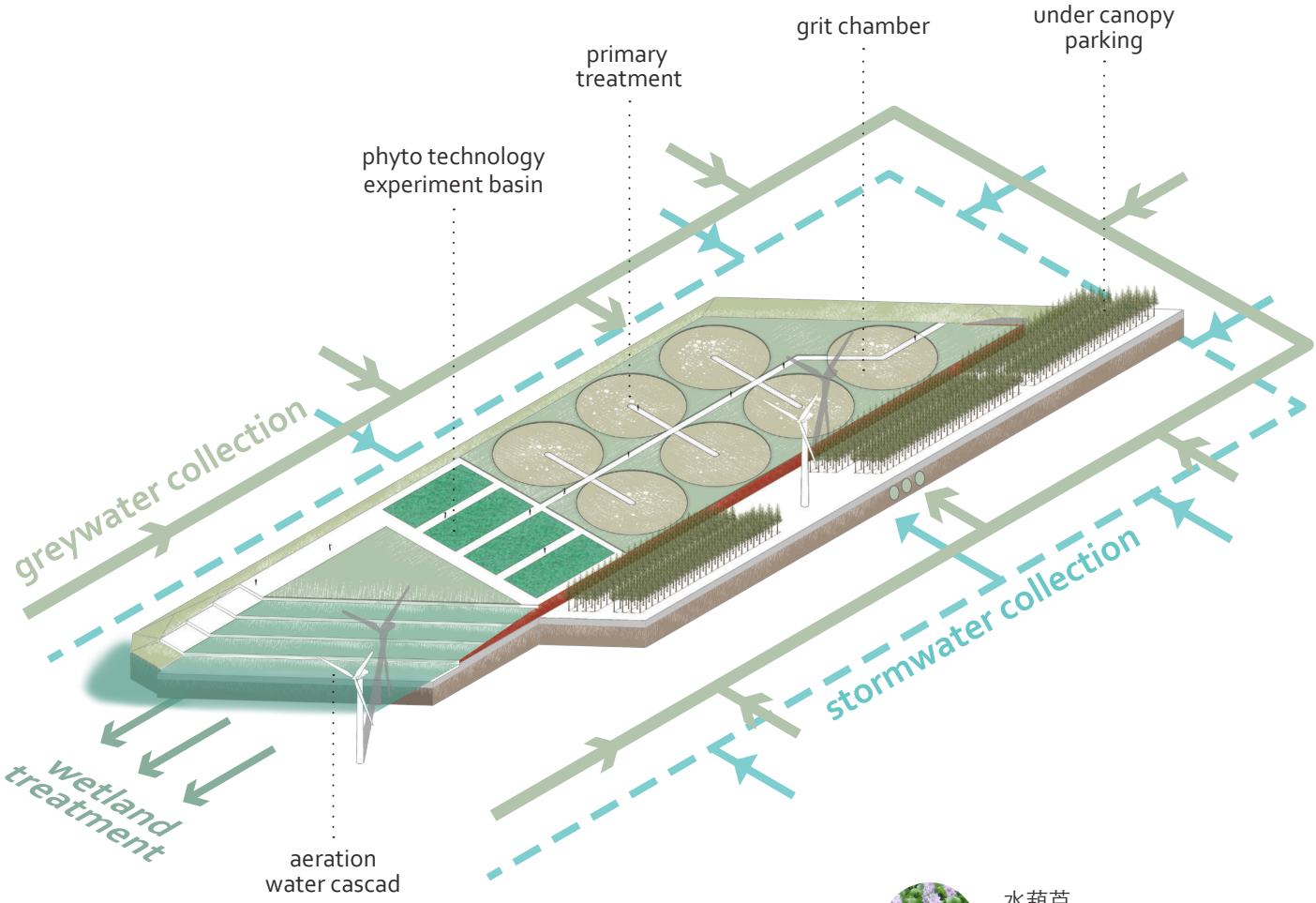


Figure 97. Primary treatment area axonometric

水葫芦
Common water hyacinth
Eichhornia crassipes

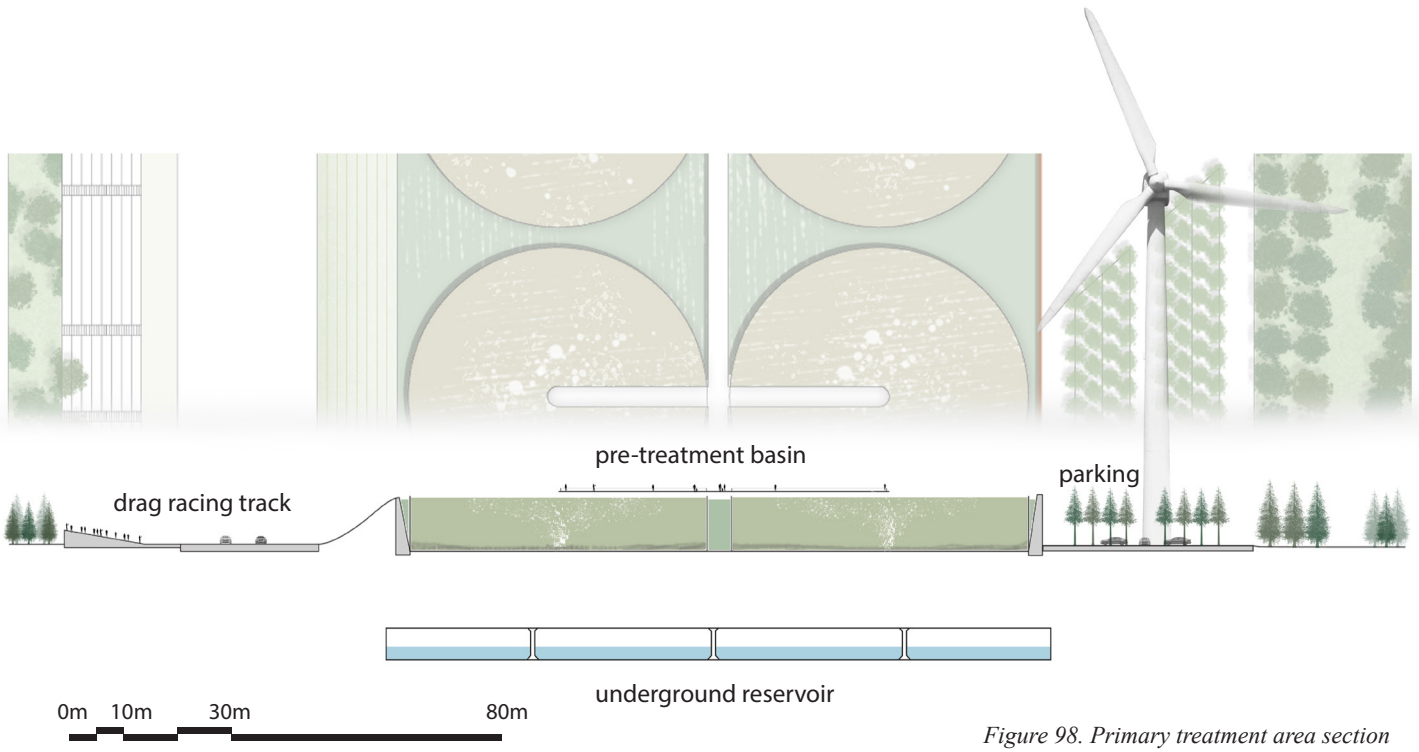


Figure 98. Primary treatment area section

Wetland Treatment Area

The pre-treated water from the primary treatment basin will flow into the phytoremediation-oriented wetland for further treatment. The existing runway and concrete surface will be removed and converted into a wetland. The wetland will occupy over 263,000 hectares with a maximum storage capacity of 1.05 million cubic metres of water. Emergent, floating-leaved, and submerged native aquatic plants with water purification capacity such as cattail (*Typha orientalis Presl*), Manchurian wild rice (*Zizania latifolia*), and whorl-leaf watermilfoil (*Myriophyllum verticillatum L.*) will be established in and around the water body to take up pollutants. Small islands will be built to provide habitats for aquatic animals and wild birds and increase the surface area for water remediation. On the northwest side of the wetland, dawn redwood (*Metasequoia glyptostroboides*) and Zhongshan cypress (*Taxodium 'Zhongshansha'*) will be mass planted to clean up the surface runoff. On the southeast side of the wetland dawn redwood will be organized in a grid to mark out the location of the former runways. Plazas and lookout decks will be built around the wetland and connected by meandering trails and boardwalks. Visitors can walk through the woods and wetland with demonstrative signage to understand how plants are used to treat the water. After being treated through the wetland, the water quality will be able to reach class III or higher. The treated water will be partially pumped into the water quality improvement plant for further treatment for drinking purposes. The surplus amount of water during the wet season will be stored in the underground reservoir. Lastly, during the construction of the wetland, the excavated soil and decommissioned concrete will be used as building materials for the crater-shaped mound at the event space.

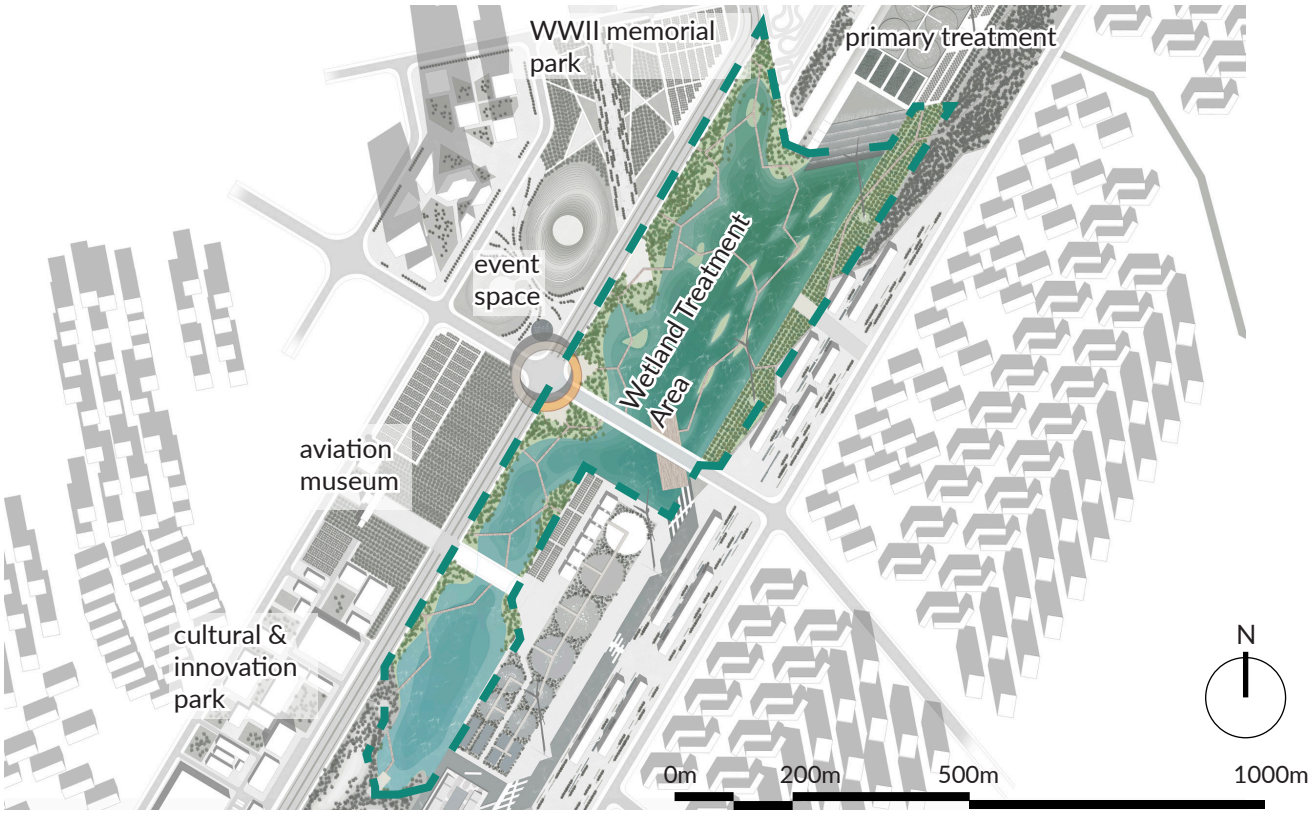
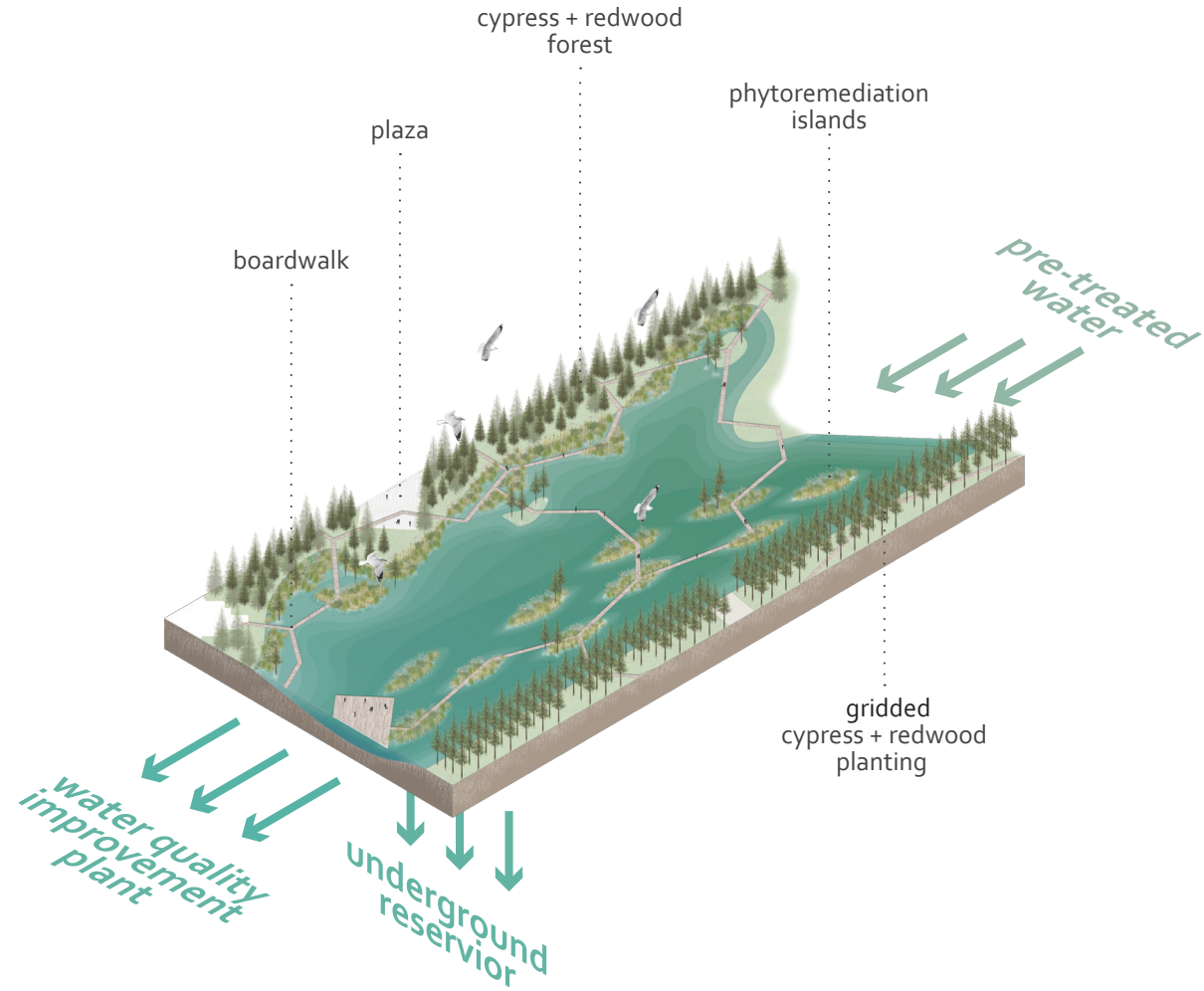


Figure 99. Wetland treatment area




水杉
Dawn redwood
Metasequoia glyptostroboides


中山杉
Zhongshan cypress
Taxodium 'Zhongshansha'


香蒲
Cattail
Typha orientalis Presl


茭草
Manchurian wild rice
Zizania latifolia


旱伞竹
Umbrella papyrus
Eichhornia crassipes


菖蒲
Calamus
Acorus calamus


狐尾藻
Whorl-leaf watermilfoil
Myriophyllum verticillatum L.


菹草
Curled pondweed
Potamogeton crispus


金鱼藻
Hornwort
Ceratophyllum demersum

Figure 100. Wetland treatment area axonometric

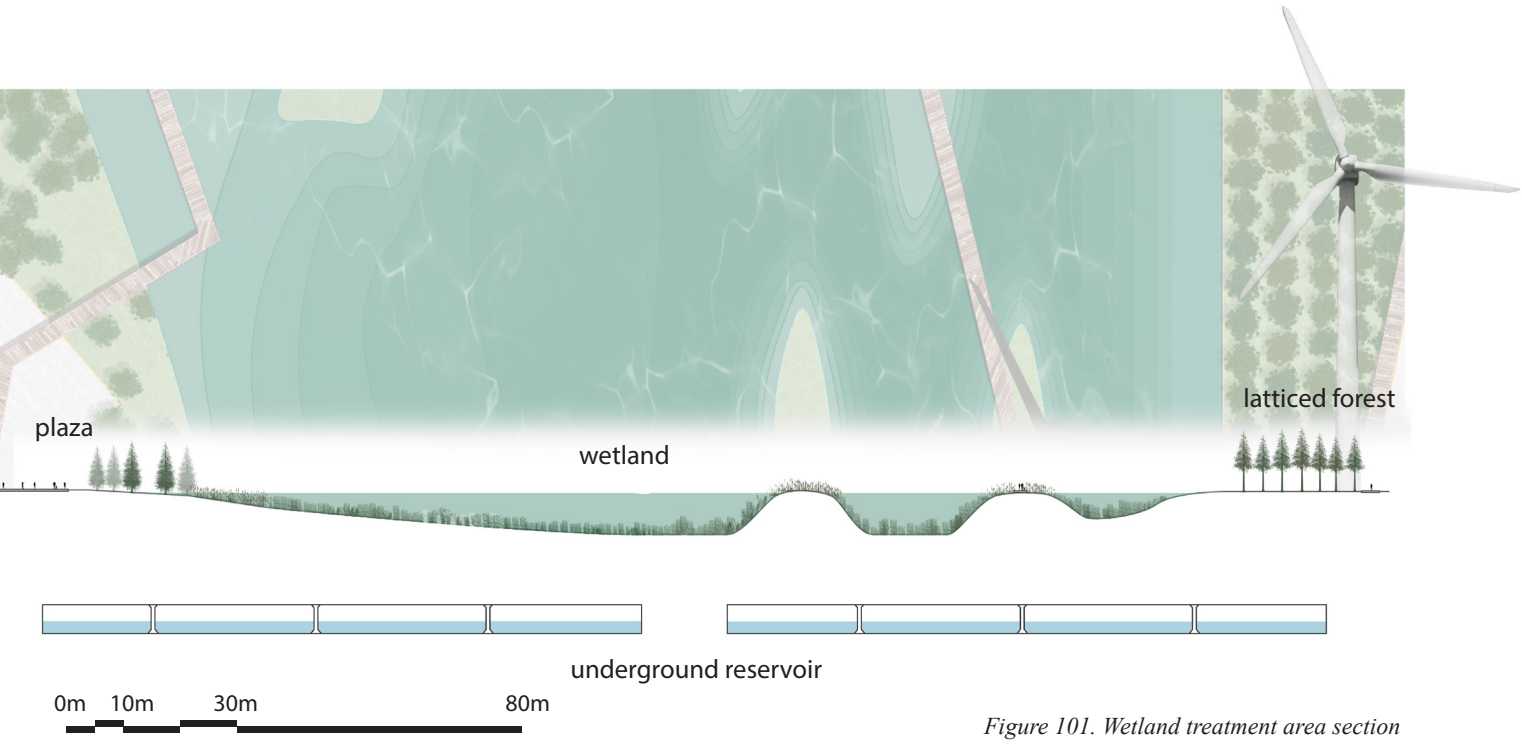


Figure 101. Wetland treatment area section

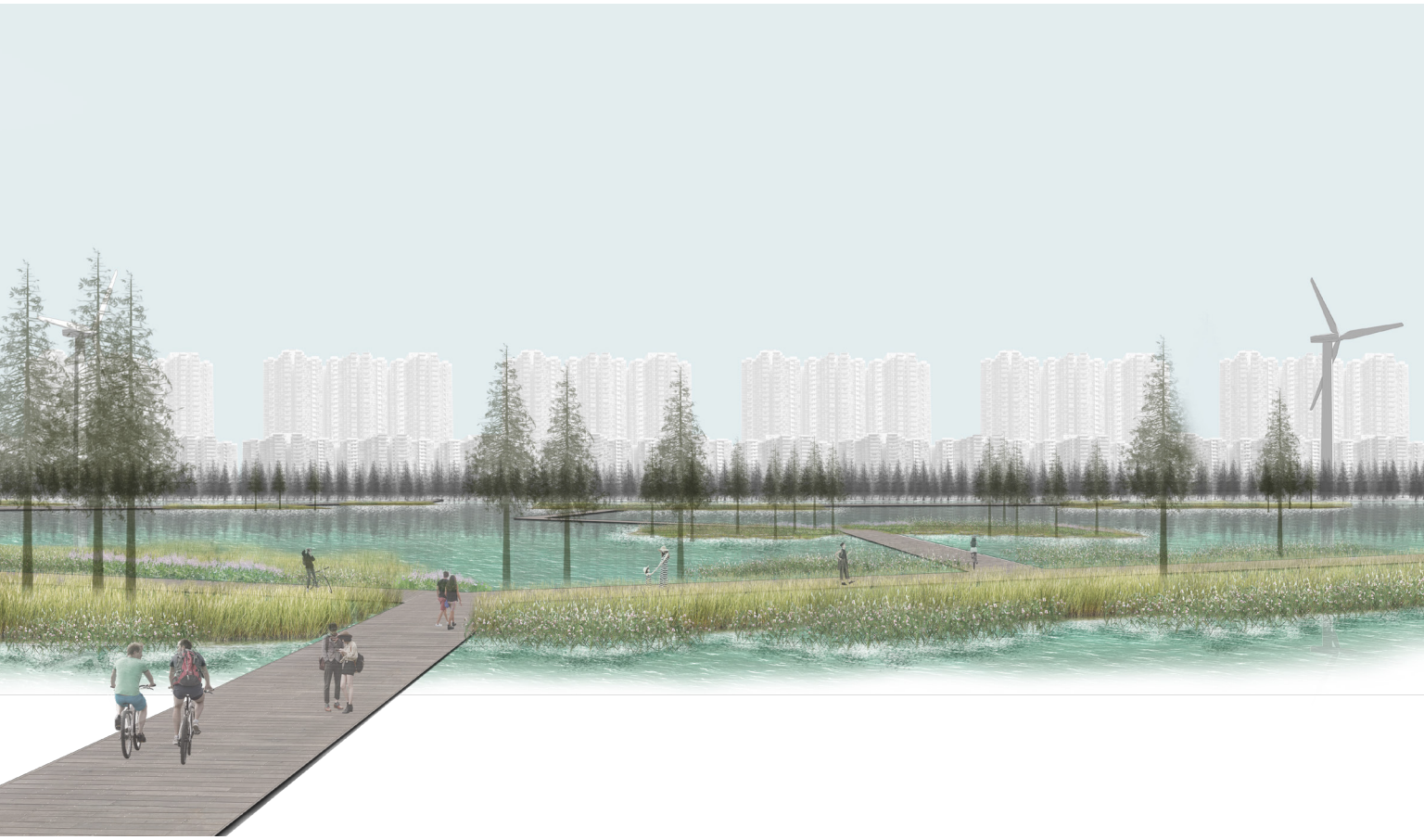


Figure 102. Wetland treatment area perspective

Water Treatment Plant

The water treatment plant will be designed to treat blackwater collected primarily from the domestic sewage system. The blackwater flows into the grit removal chamber to remove large particles and grease. The solid waste will be dried and processed for composting soil. Then the blackwater will be moved into the primary clarifier to remove solids larger than 10 micrometers. In the secondary treatment chamber with the assistance of oxygen, microbes will digest the organic pollutants for the next stage. After the secondary treatment, the treated water will mix with the water from the wetland to be processed in secondary clarifiers. Microbes will be removed from the secondary clarifiers and returned to the secondary treatment chambers. The cleared effluent from the secondary clarifiers is moved into the disinfection basin. Chlorine, ozone, or UV light will be used to kill the disease-causing bacteria. After the treatment, the water quality will reach drinking water quality, and it will go in three directions. The majority of the treated water will go back to the drinking water system for domestic usage; part of the water will be released to flow downstream for recreational uses; during the wet season, the surplus water will be stored underground for emergency water

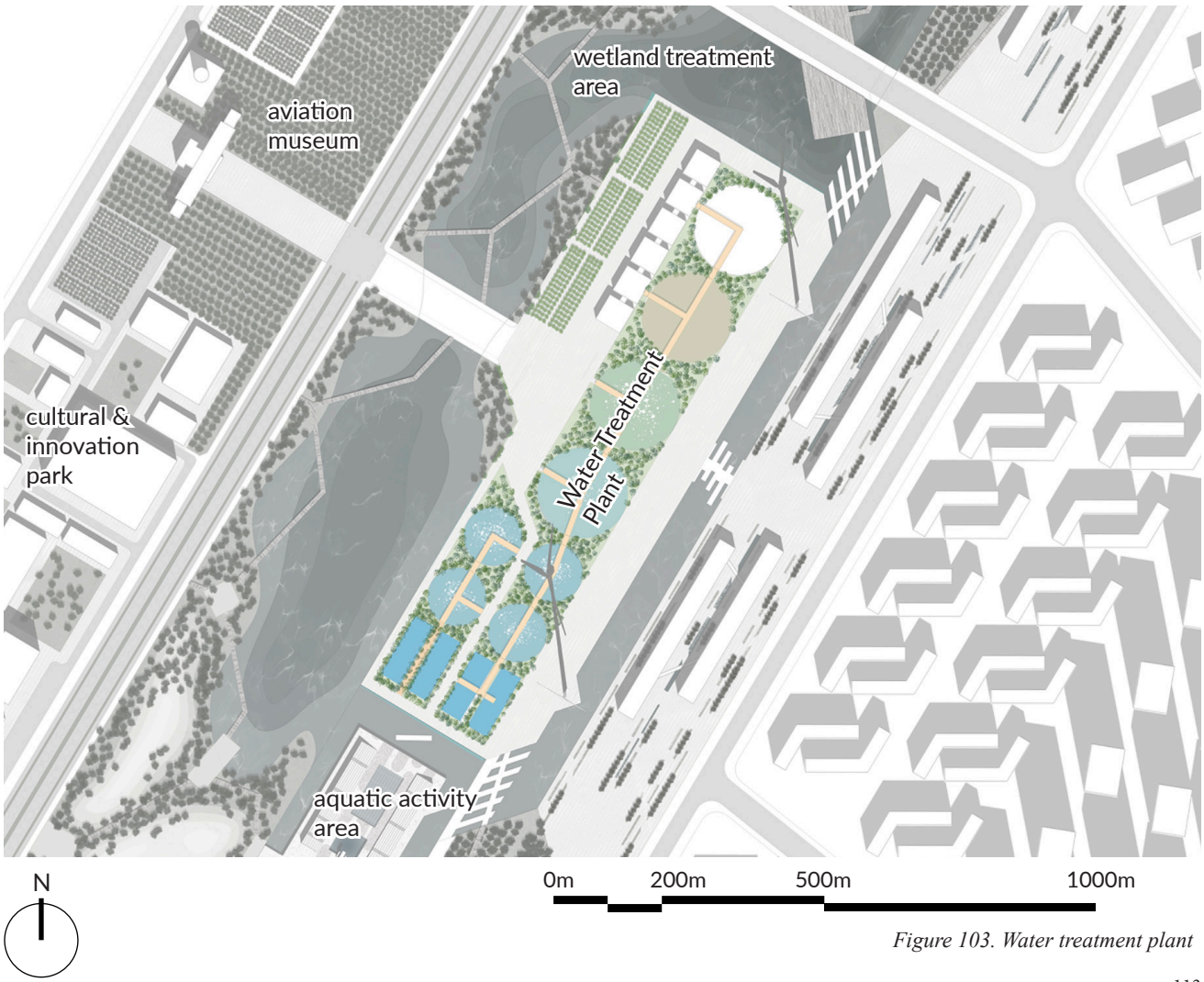
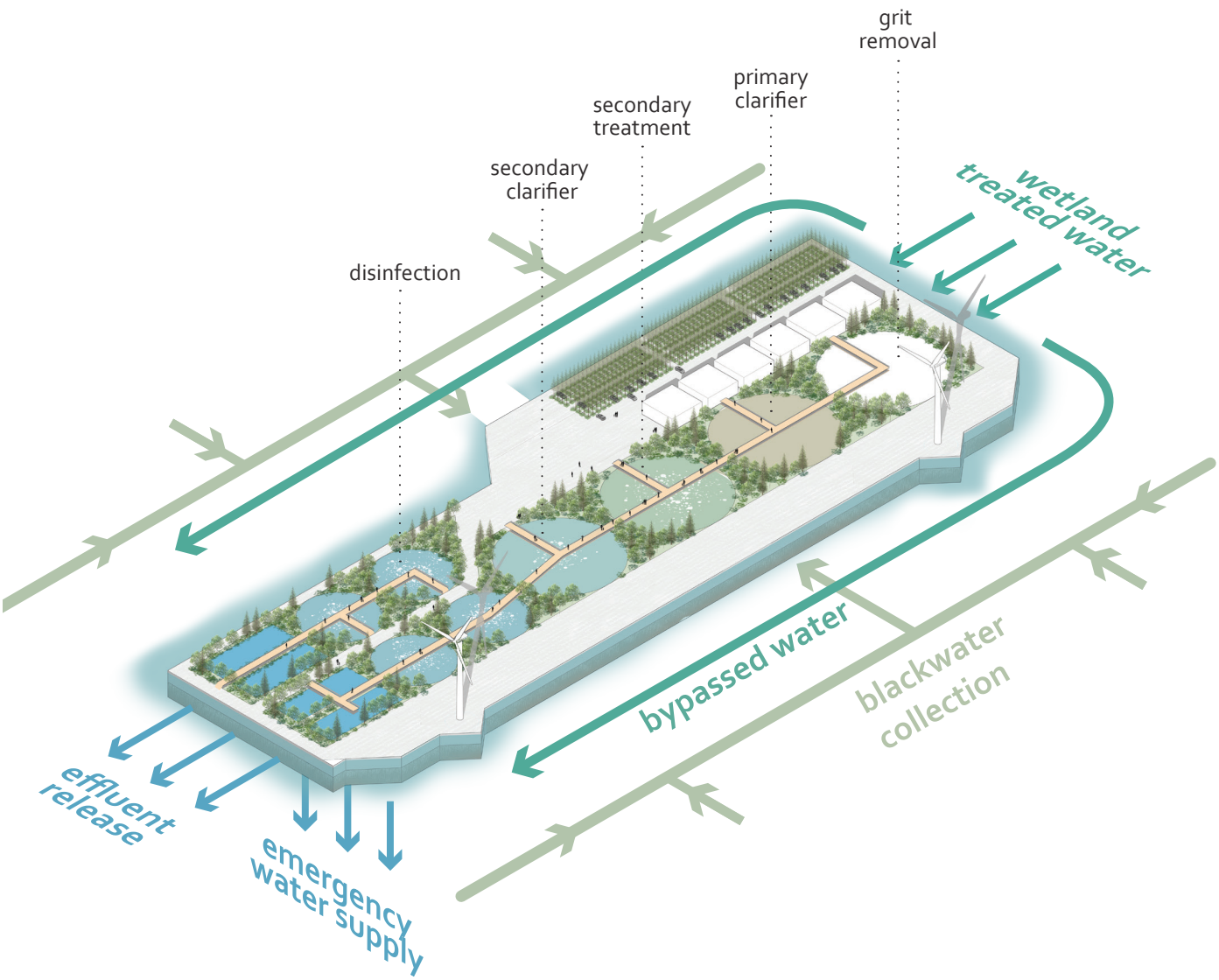


Figure 103. Water treatment plant



水杉
Dawn redwood
Metasequoia glyptostroboides

云南樱花
Yunnan cherry blossom
Cerasus cerasoides (D. Don) Sok. var. rubea (C.Ingram) Yü et Li

蓝花楹
Jacaranda
Jacaranda mimosifoli

Figure 104. Water treatment plant axonometric

supply. Within the water treatment plant visitors are encouraged to walk through the facility. Overhead walkways along the water treatment chambers provide opportunities to the public to understand how the water they use daily was been processed and also to raise the awareness of water-saving. Specimen trees such as dawn redwood (*Metasequoia glyptostroboides*), Yunnan cherry blossom (*Cerasus cerasoides*), and Jacaranda (*Jacaranda mimosifoli*) will be planted around the treatment chambers for visual purposes. The water treatment plant is designed to treat over 200,000 tons of blackwater in one day, with assistance from the wetland, more water can be treated in the treatment plant. Compared with traditional water treatment plants, additional secondary clarifiers and disinfection basins will be constructed to treat the mixed water. The treatment plant can produce more clean water than the blackwater it takes. The maximum volume of clean water yield that the treatment plant can produce is about 250,000 to 300,000 tons per day.

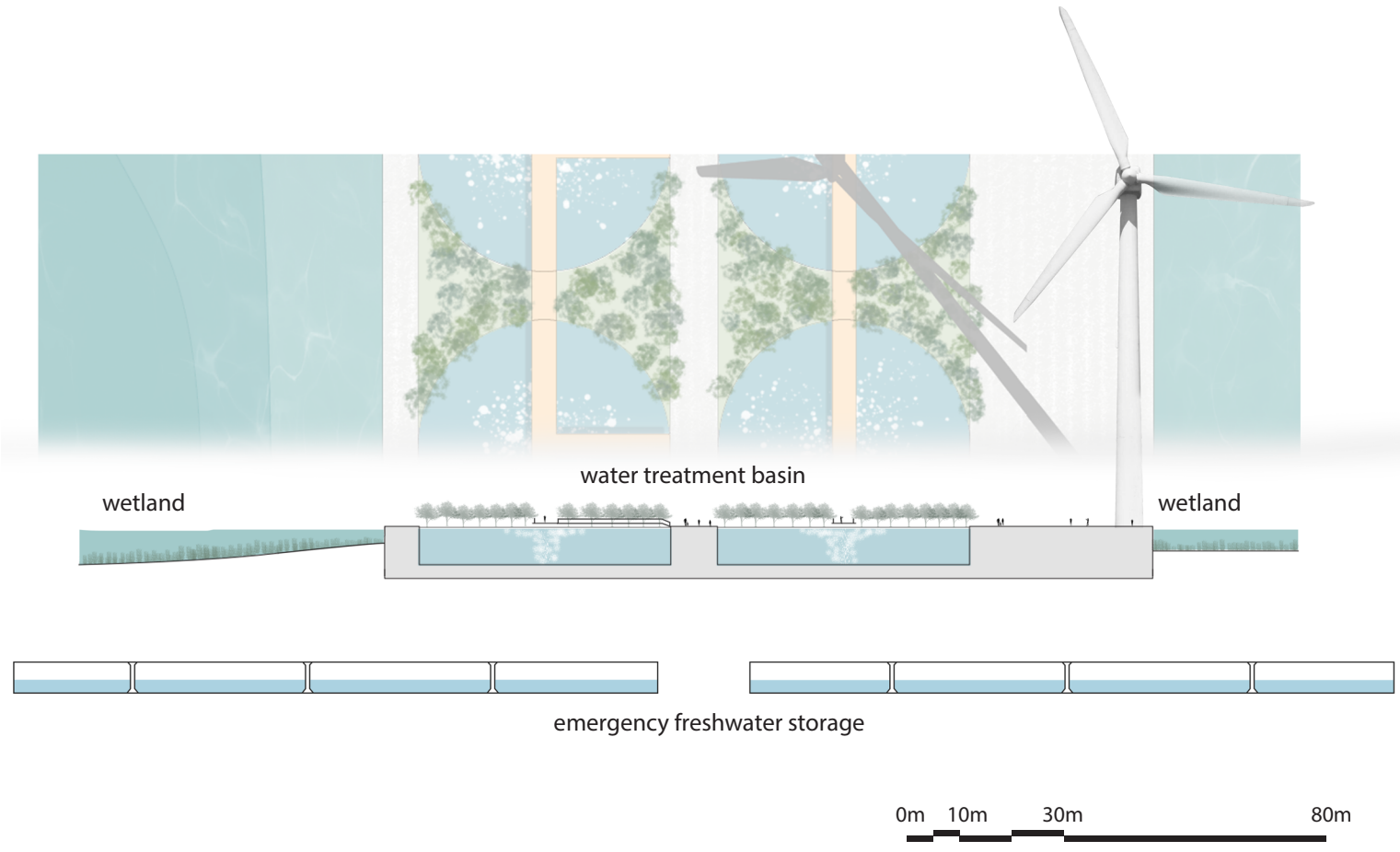


Figure 105. Water treatment plant section

Aquatic Activity Area

The aquatic activity area features a variety of outdoor pools finished with terrazzo surface to accommodate different types of aquatic activities. The island is divided into two parts. The north section is designated for the game events. An Olympic standard swimming pool and diving pool are placed at the center of the space. Grandstands are arranged along the two sides. The south part of the island is designed for recreational use. Two adult's swimming pools and two children's swimming pools are located in this area for public use during the warm sunny summertime. Residents from the surrounding area can access the swimming pool through the bridges located on the two sides of this island. The water used in this island will come from the water treatment plant located on the upper reach. The used water from the pools will be pumped back to the treatment plant to recycle. The water bypassing the island is a mix of the wetland treated water and effluent released from the treatment plant. The water quality will be able to reach class II. Along the canal where the bypassed water flows through, aquatic plants will stabilize the water quality. In addition, one of the native aquatic plants, sea cabbage flower (*orrelia accuminata*) will be planted in the last part of this section. As the plant is sensitive to the water quality, the growth pattern of this plant can be used as an indicator to monitor the water quality and bring the awareness of ecosystem preservation to the public.

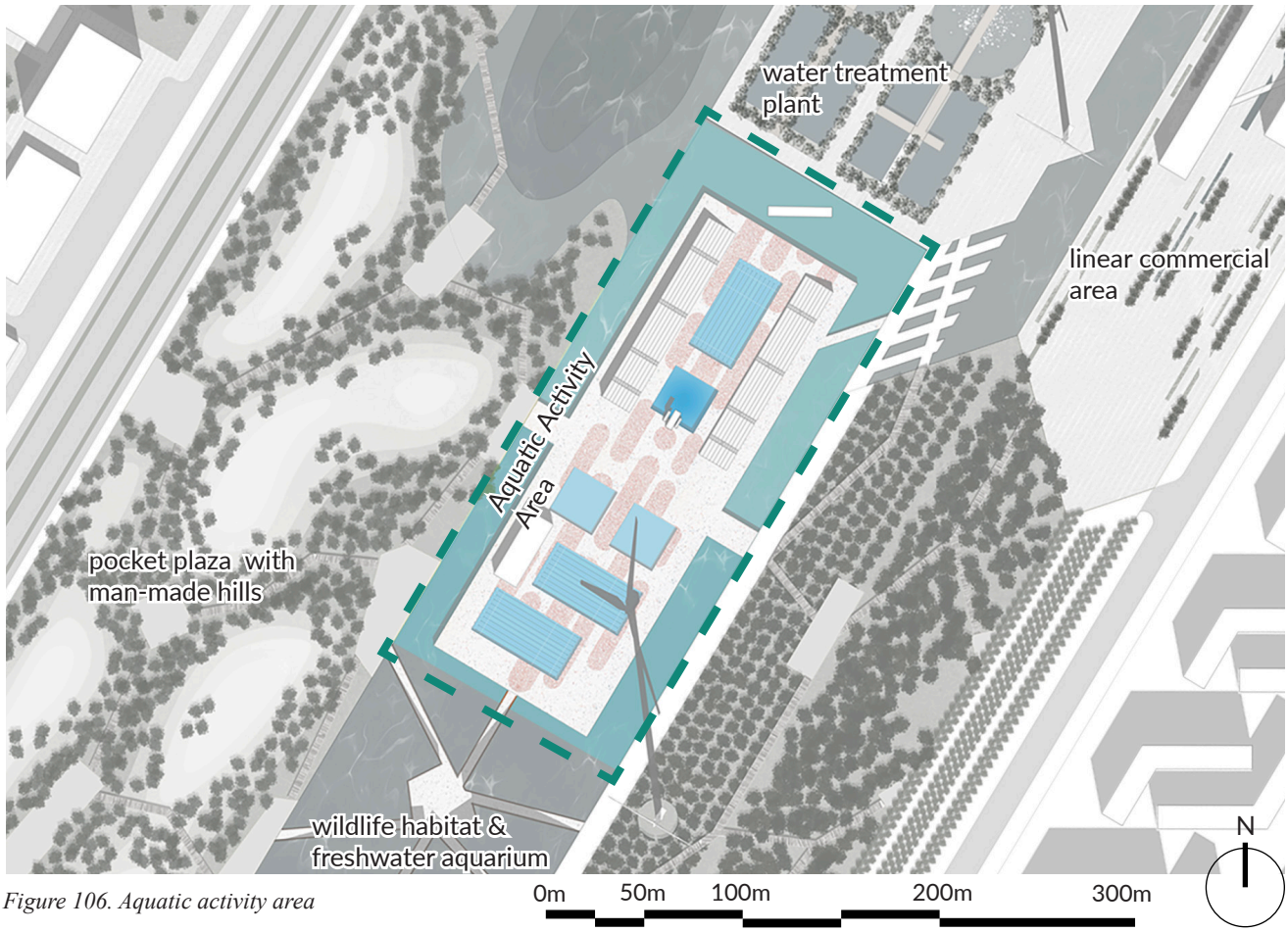
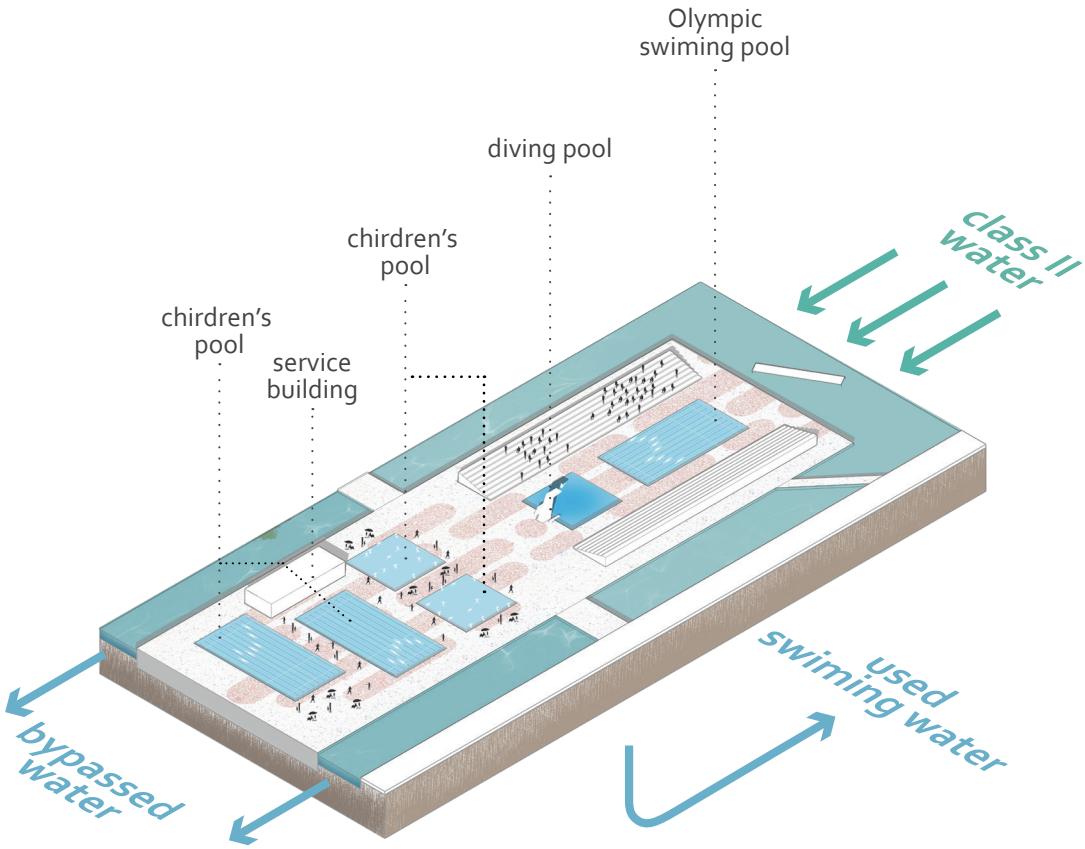


Figure 106. Aquatic activity area



海菜花

Ottelia acuminata (Gagnep.) Dandy

狐尾藻
Whorl-leaf watermilfoil
Myriophyllum verticillatum L.

菹草
Curled pondweed
Potamogeton crispus

金鱼藻
Hornwort
Ceratophyllum demersum

Figure 107. Aquatic activity area axonometric

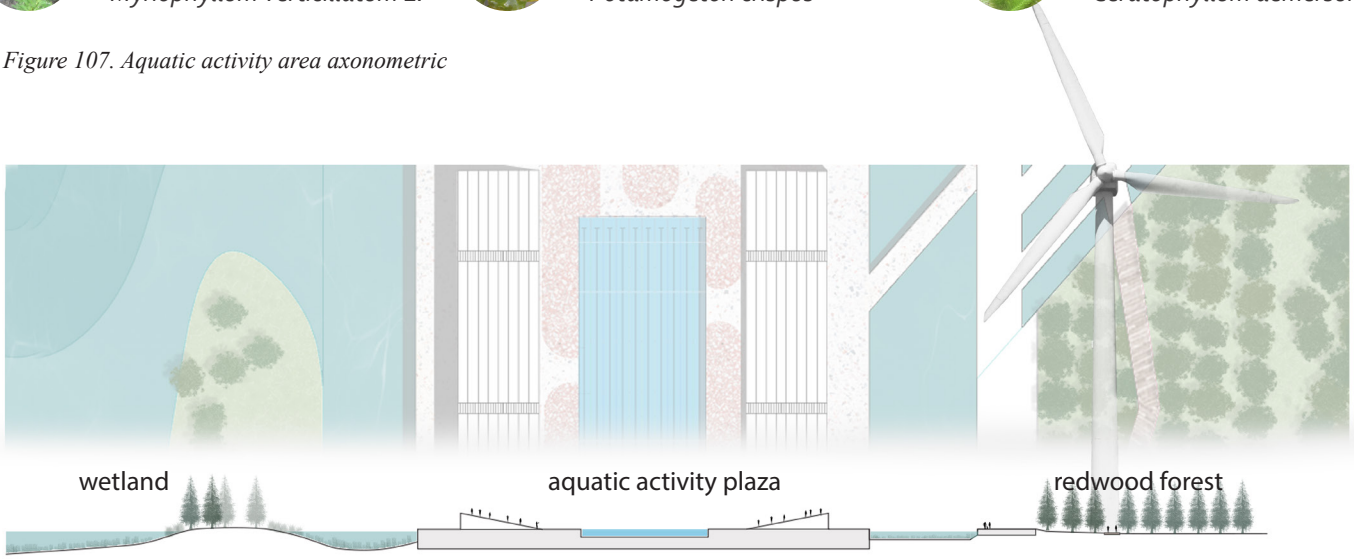


Figure 108. Aquatic activity area section

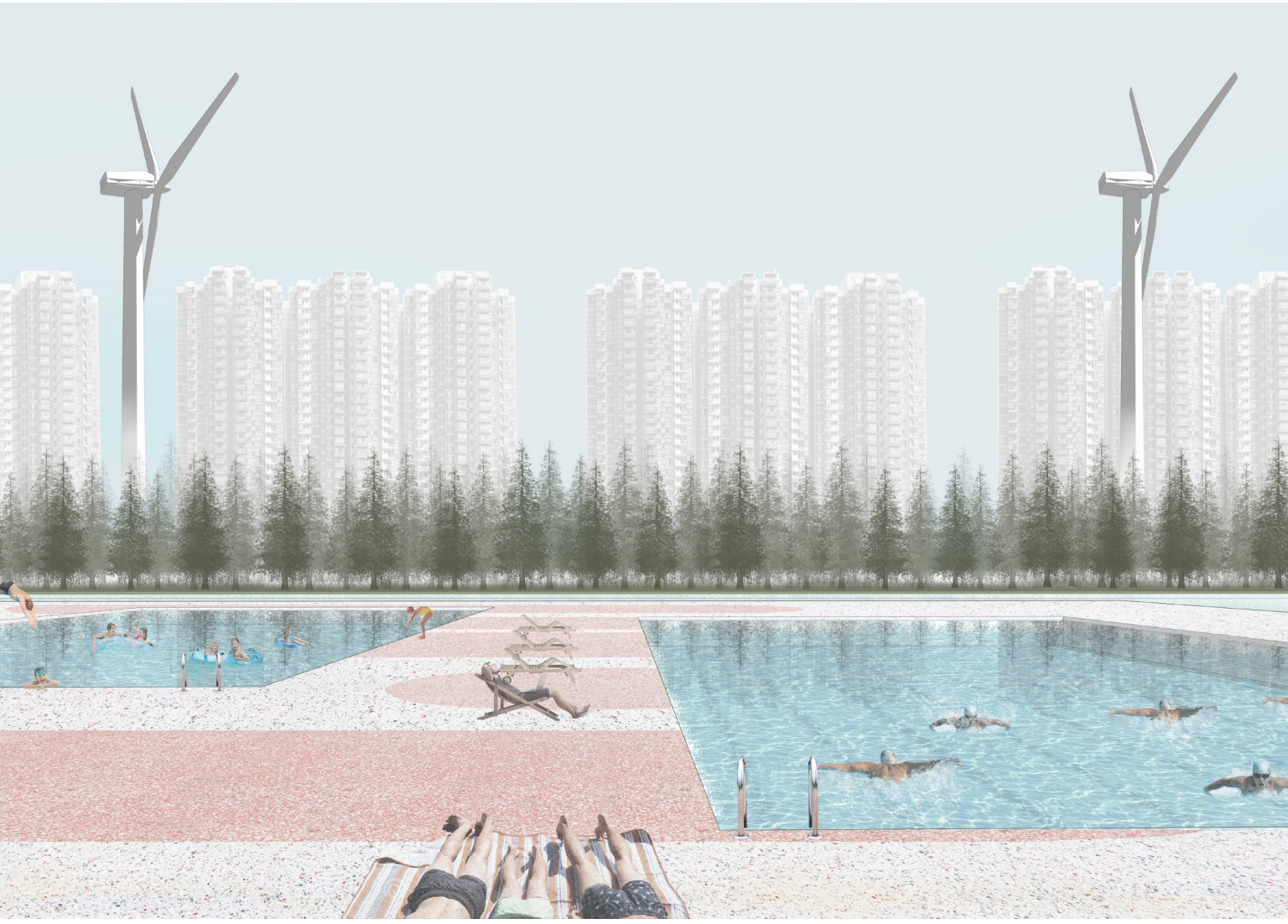


Figure 109. Aquatic activity area perspective

Wildlife Habitat & Freshwater Aquarium

Connected with the aquatic activity area, the wildlife habitat, and freshwater aquarium is the sanctuary for wildlife and the educational platform for the aquatic ecosystem. The treated water reaches class II after all the previous processes, it is then flowing between the decommissioned runway and taxiway. In the middle of the water bodies, two sunken courtyards are connected to the shore with ramps. Native aquatic plants will be used to establish wetland and wildlife habitats. Endangered indigenous fish species such as Kunming catfish (*Silurus mento*), and Dianchi golden-line barbel (*Sinocyclocheilus gahmi*) can be reintroduced in this section (Chen, Yang, Su & Chen, 2000). Along with these star-shaped courtyards, several glass-sealed openings will be placed on the corten steel wall as the display window. The sunken courtyards will become a freshwater aquarium and outdoor classroom to demonstrate the local freshwater ecosystem to the public. Signage and descriptions will be engraved on the weathered steel. As people move along the courtyard, they will be guided into the most extended section of the water management corridor.

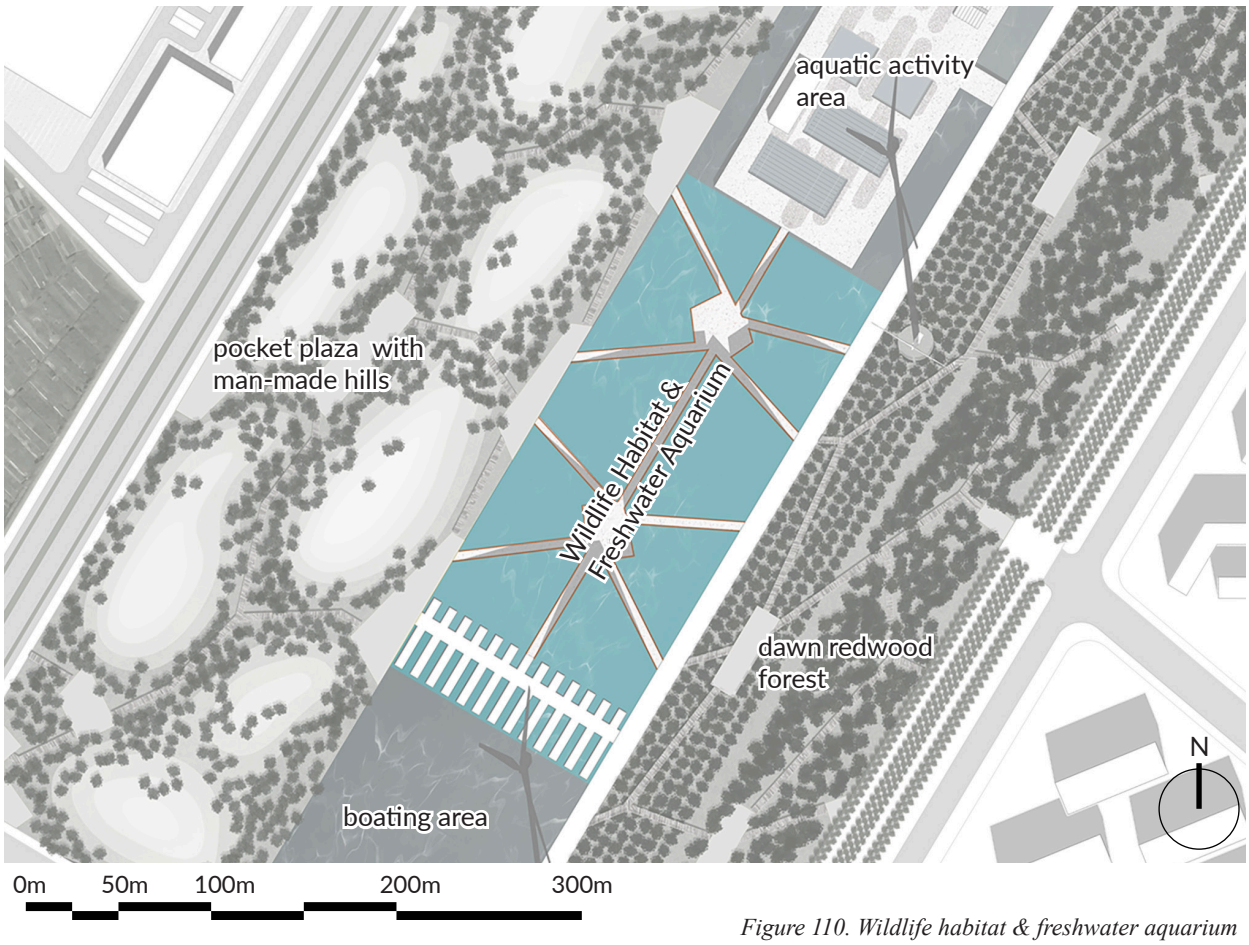
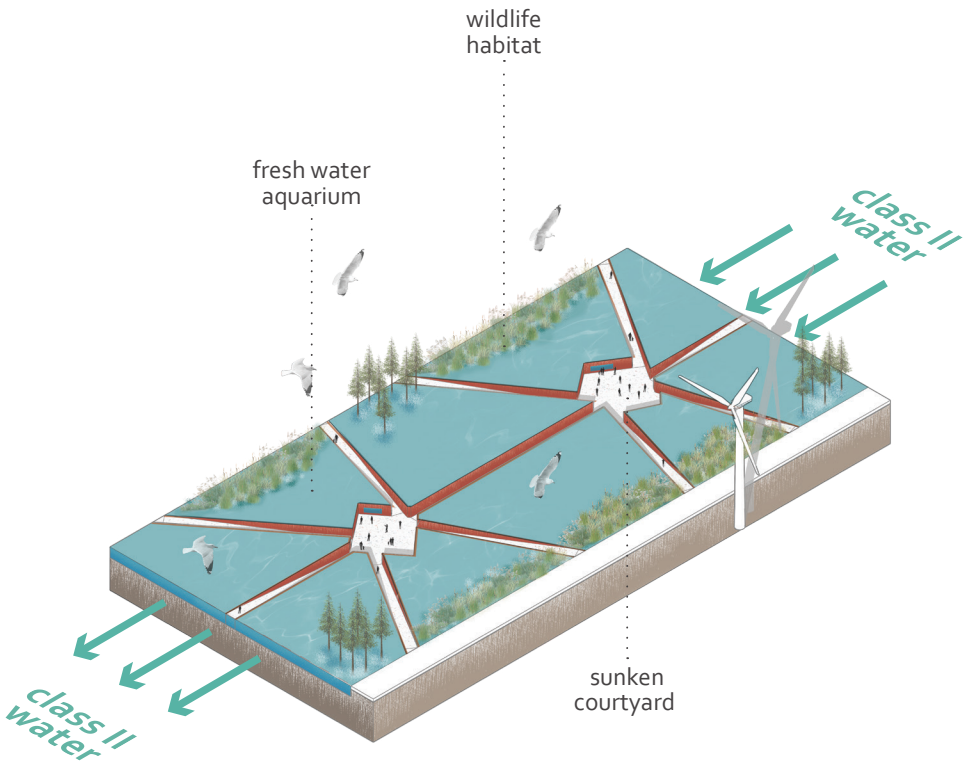


Figure 110. Wildlife habitat & freshwater aquarium



水杉
Dawn redwood
Metasequoia glyptostroboides

中山衫
Zhongshan cypress
Taxodium 'Zhongshansha'

菖蒲
Calamus
Acorus calamus

茭草
Manchurian wild rice
Zizania latifolia

旱伞竹
Umbrella papyrus
Eichhornia crassipes

海菜花
Ottelia acuminata (Gagnep.) Dandy

狐尾藻
Whorl-leaf watermilfoil
Myriophyllum verticillatum L.

菹草
Curled pondweed
Potamogeton crispus

金鱼藻
Hornwort
Ceratophyllum demersum

Figure 111. Wildlife habitat & freshwater aquarium axonometric

Figure 112. Wildlife habitat & freshwater aquarium perspective

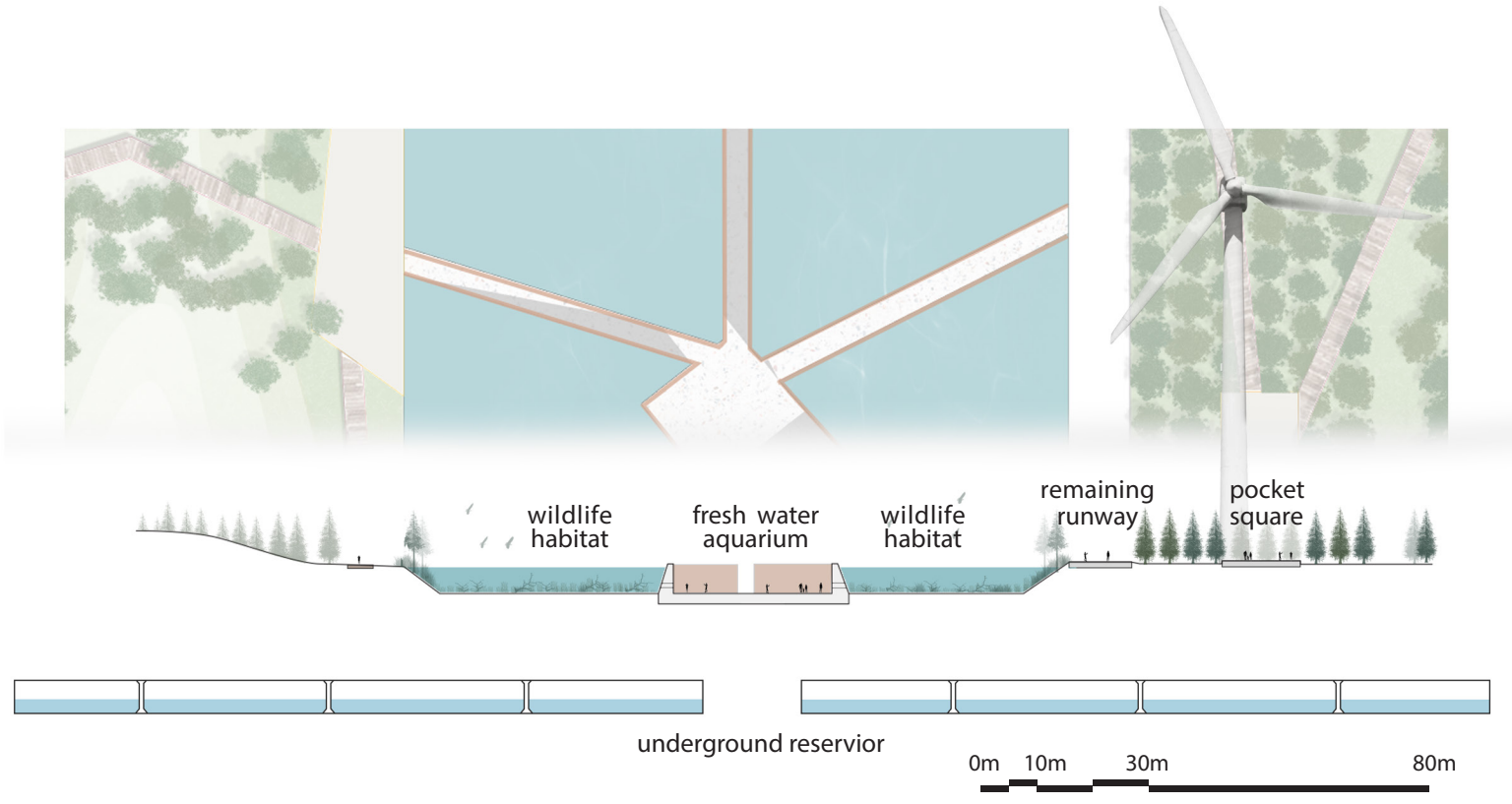


Figure 113. Wildlife habitat & freshwater aquarium section

Boating Area

After people walk up from the aquarium, they will reach the boating area. The 1100-metre-long and 130-metre-wide water strip will be built inbetween the partially decommissioned taxiway and runway. The linear water body can be used for boating, kayaking, and rowing. The remaining taxiway and runway will be converted into a waterfront park for activities such as biking, jogging, and flying kites. Eight boat launching platforms are provided along both sides of the bank. These platforms can also function as a plaza for taichi, folks dancing and singing, and other activities. Moreover, not only the boating area is designed for people's daily visit, but also it is designated to enhance the local culture. On the fifth day of the fifth lunar month of each year, people could hold dragon boat races to celebrate the Dragon Boat Festival and memories the poet Qu Yuan (Chinese:屈原). The boating area will be designated to host events during the festival. The Dragon Boat race track will be marked out with buoys on the water; the waterfront park will provide space for visitors; events and performances can be hosted on the two sides of the central corridor. Not only the Dragon Boat Festival but also other public events and festivals can be hosted in this area.

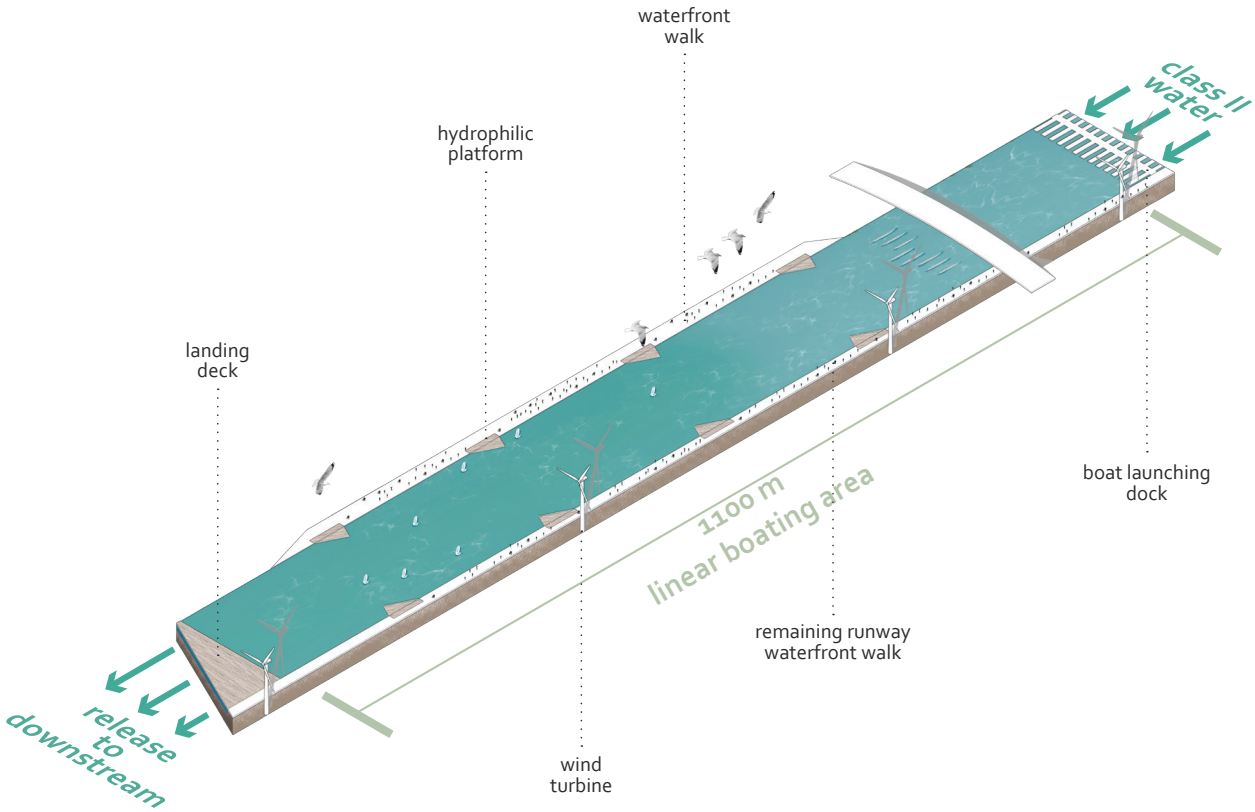


Figure 114. Boating area

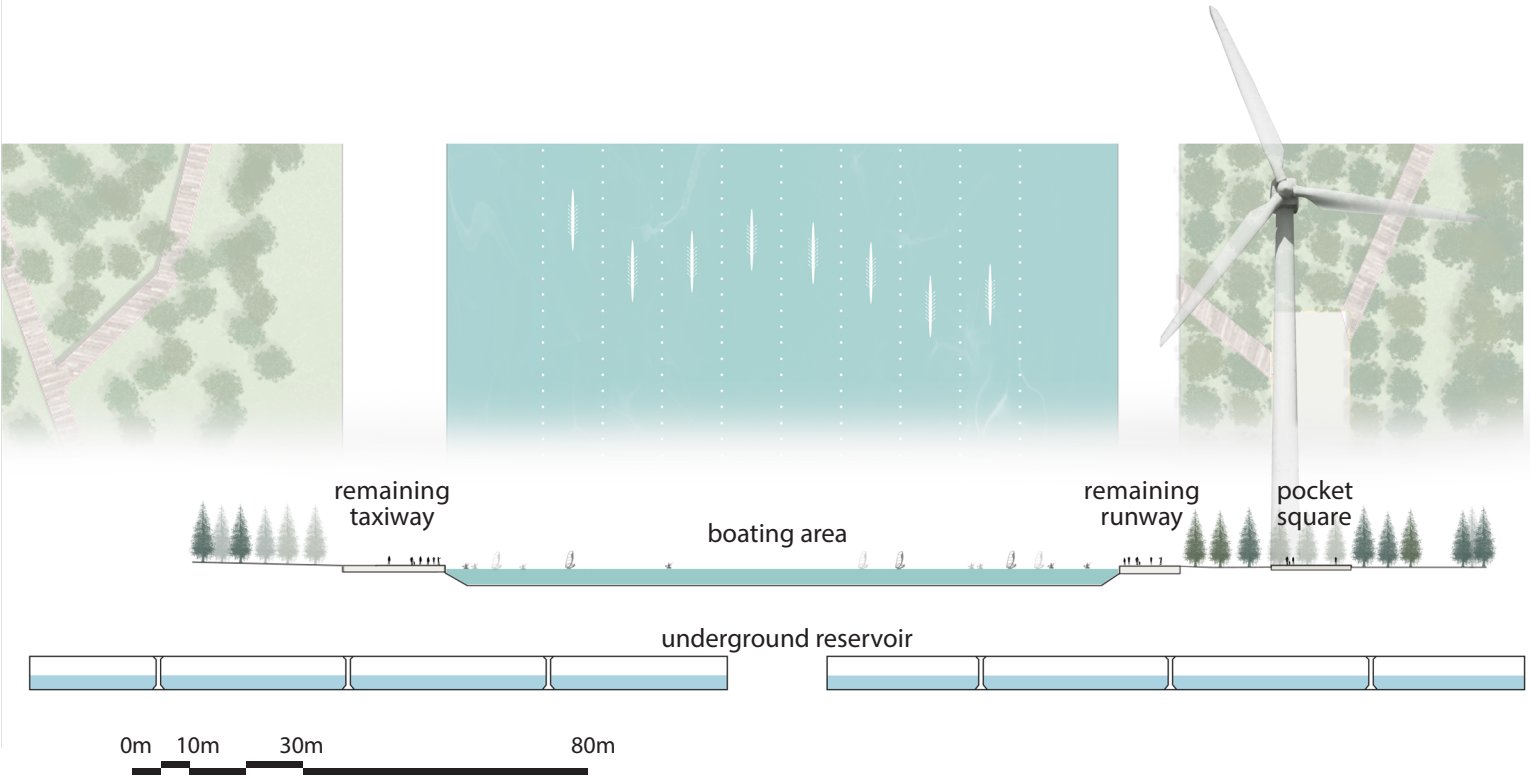


Figure 115. Boating area section

Figure 116. Boating area perspective

5.4.3 Detail Elements

Wind Turbines

Along the partially decommissioned runway, ten wind turbines will be installed to create a visual linkage through the park, as well as generating power for operating the park and for surrounding neighborhoods. Each wind turbine is 70 metres tall with three 42-metres-long blades, and with the capacity to generate 2,000 kW power per hour (Mingyang Wind Power Group, 2019). Based on the electricity consumption of an urban household in South China of about 2100 kW (Guo, Khanna, & Zheng, n.a.), the wind turbines can generate power to supply over 87,000 households for one year. The wind turbines will become beacons of a new solution for energy and water management.

Pocket plaza

As mentioned earlier, the majority of the runway and taxiway will be removed. Some of the removed concrete surfaces will be reused as pavements for pocket plazas and gardens scattered along the two sides of the central corridor. The concrete surface will be cut into one metre by one metre squares and relocated to form plazas along with the trail system in the park. Light fixtures such as runway end identifier lights (REIL), runway centerline lighting system (RCLS), and approach lighting system (ALS) will be reinstalled on the plazas with signage as an illustration to introduce the airfield (Dümpelmann & Waldheim, 2016). Over the time, vegetation will grow through the gaps of the reclaimed concrete tiles. The deterioration of the concrete and the succession of the plants will embody the resignation of the airport from the history of Kunming's development, and the succession of the ecological network.

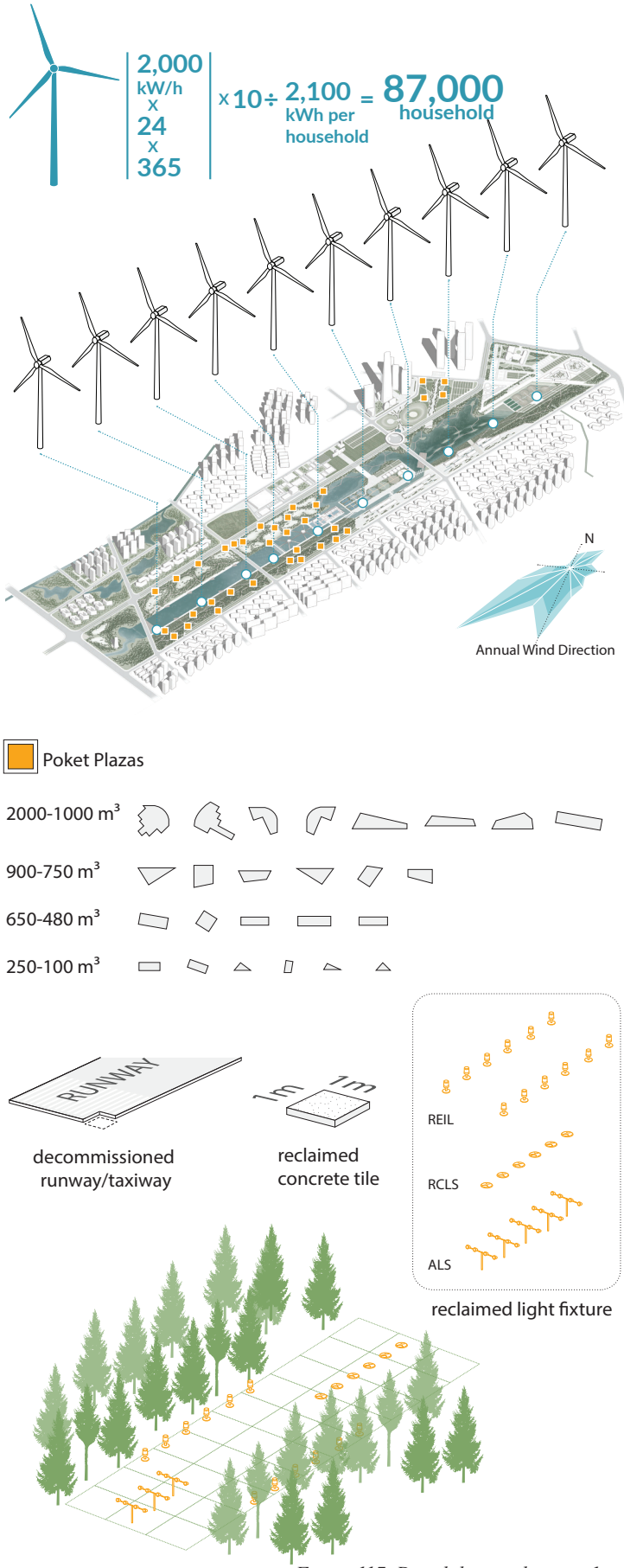


Figure 117. Detail design elements 1

Landforms

Since the design will create a significant number of large water bodies, a large amount of soil will be excavated. In order to minimize the cost of relocating the soil, the majority of the excavation will be piled up to form hills and valleys along the east side of the water bodies. These artificial hills and valleys will frame views and thresholds to guide visitors strolling through the park.

Parking

Over 900 parking stalls are arranged across the site. Instead of paving the parking space with hard surfaces, the design proposes hollow pavers which allow the rain water to penetrate the surface and reduce runoff. The parking stalls are marked with latticed planting dawn redwood (*Metasequoia glyptostroboides*). The tree canopy can provide shade for the car, and the trees will treat runoff water.

Underground Reservoir

Underneath the central water management corridor 62 water storage reservoirs will be constructed to hold excess processed water. The reservoirs are designed to hold 5.8 million tons of treated water from the wetland, and 2.4 million tons of emergency supply fresh water from the water treatment plant. These underground reservoirs expand the capability of the central water management corridor. Water can be collected, treated, stored, and reused through the park.

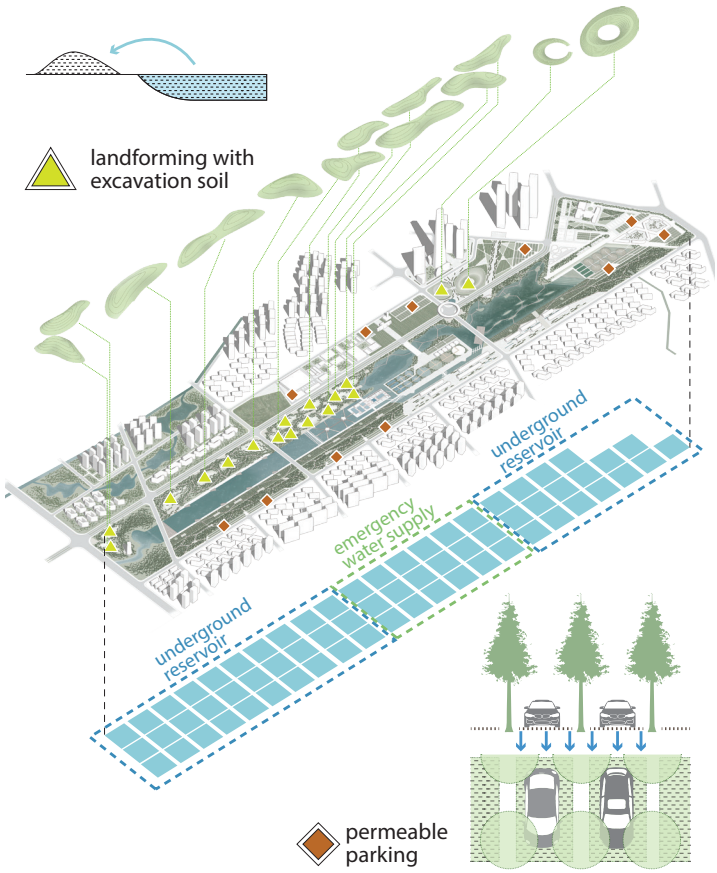


Figure 118. Detail design elements 2

Watchtower

An observation tower will be constructed at the end of the central water management corridor. The elevated panoramic view demonstrates the water management solution from an elevated perspective. It also demonstrates how the site connects to the city-wide ecological infrastructure.

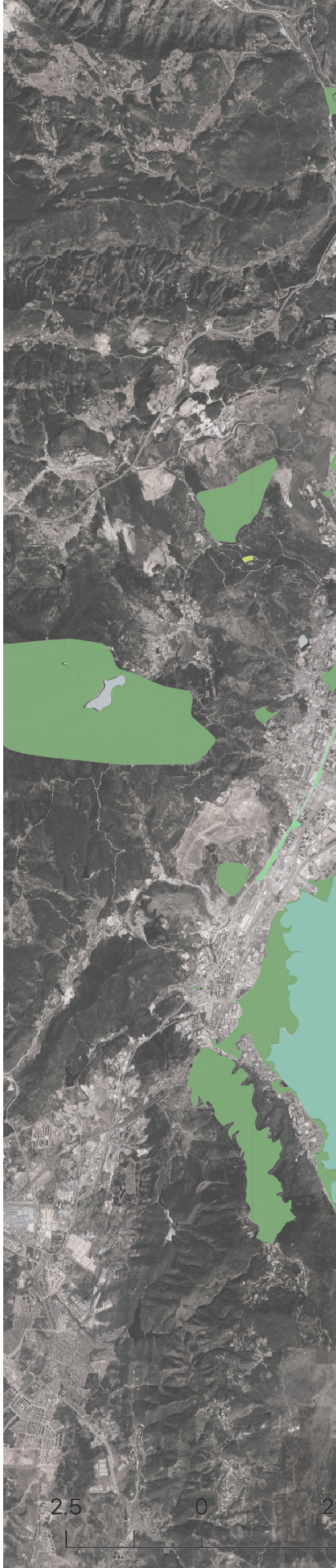
Figure 119. Perspective through watchtower

5.5 Closing

The site is revitalized and naturalized with landscape architectural approaches to create a scenic and functional landscape. The park will capture, convey, clean, store, use, and release the water. In order to operate the park's ecological function, this "naturalized" landscape requires constant monitoring of water quality and periodic replacement and maintenance of the vegetation. At the same time, the public is encouraged to visit the site for a variety of activities, enjoy the landscape, and understand the new urban water management strategy.

The redevelopment of the airport is not only providing opportunities to regenerate this area as part of the city-wide ecological infrastructure, it also demonstrates how this network of blue and green infrastructure can alleviate the tension between the city and water.

In short, Wujiaba airport was built to defend and support Kunming during WWII. It expanded to bring in business opportunities and promote cultural identity for Kunming during current times. In the future, the airfield will be transformed to serve the city in a new way. It will serve as part of the ecological infrastructure to bring opportunities to balance the relationship between the city and water. It will become the beacon to demonstrate the new urban water management strategy.



PROPOSED ECOLOGICAL INFRASTRUCTURE

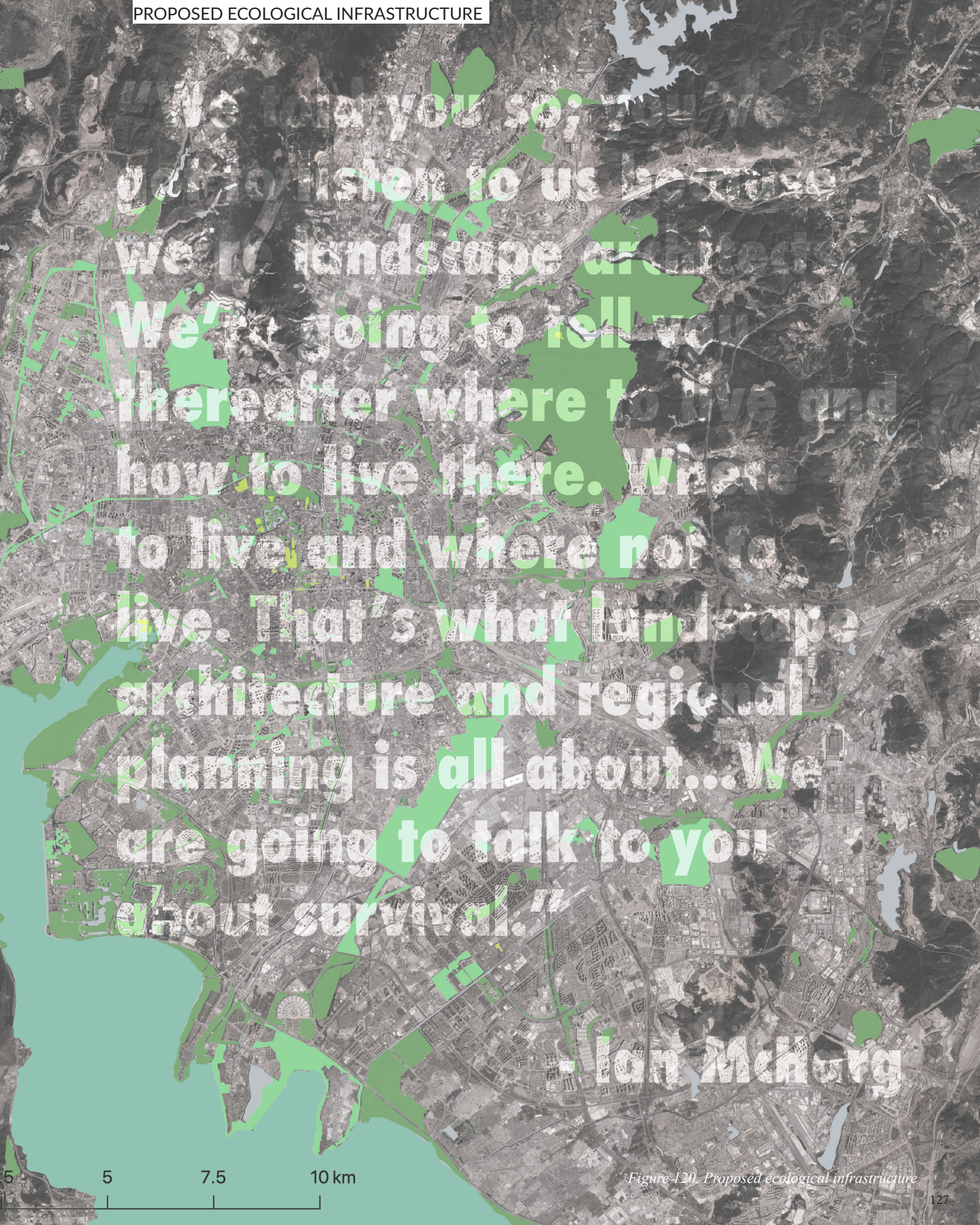


Figure 120. Proposed ecological infrastructure

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Photographs and drawings have been produced by the author, unless otherwise stated.

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Figure 55:
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Figure 56:
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Figure 57:

Yunan Airport Group editorial department of magazine, n.d. *AVG at Wujiaba Airport* .[photograph] (Kunming, One Hundred Years of Wujiaba Airport).

Figure 58:
Yunan Airport Group editorial department of magazine, n.d. *People Travel Through Wujiaba Airprot During 1980s.* [photograph] (Kunming, One Hundred Years of Wujiaba Airport).

Figure 59:
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Figure 63:
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Figure 64:
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Figure 65:
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Figure 67:
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Figures 71-120
The following images are composites of the following sources. All other images are produced by Wei Zou (2019) unless stated otherwise.

Satellite imagery:
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Figure 51-52
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